

## MEMORANDUM

**To:** Bridget Rohn, Project Manager, USACE Detroit District

**From:** John Swenson, Associate Professor, Department of Earth and Environmental Sciences, University of Minnesota Duluth and Science Advisor to the City of Duluth

**Date:** August 1, 2025

**Subject:** Treatment of subsidence and wind-blown sand in Minnesota Point Section 111 study in calculations of culpability for beach erosion

### For review and comment by USACE

0. **Terms of reference:** USACE provided a Program Fact Sheet for the Section 111 process (<https://duluthmn.gov/media/14335/section-111-fact-sheet.pdf>). The excerpt below provides a general summary of scope:

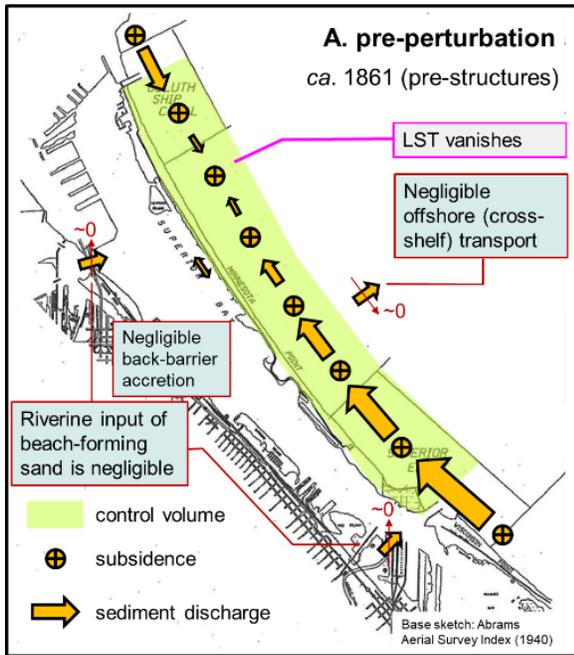
**Authority and Scope:** Section 111 of the 1968 River and Harbor Act, as amended, provides authority for the Corps of Engineers to develop and construct small projects for the purpose of mitigation of shoreline erosion or accretion problems directly influenced by the construction of a Federal navigation project. The amount of mitigation is limited to the level that would have existed without the influence of the navigation project. Each project is limited to a Federal cost of \$12,500,000 and must be economically justified, environmentally sound and engineeringly feasible.

The City's Plain English interpretation of the project scope is as follows:

- a. If the Duluth / Superior breakwaters can be shown to *perturb* sediment dynamics on the lakeward side of Minnesota / Wisconsin Points, then Section 111 provides funding to mitigate the perturbation.
- b. Perturbation refers to a deviation from ambient (*pre-breakwater*) conditions.
- c. The perturbation is *cumulative*, integrating over time from the moment of Federal ownership to present.
- d. The *metric* for quantifying the perturbation to sediment dynamics is the net change (divergence) in the supply of beach-forming sediment that can be ascribed directly to the presence of the breakwaters.
- e. This divergence ('budget') is measured on an *appropriate Control Volume* (CV).
- f. The *unperturbed state* of the barrier's sediment dynamics, as measured in the appropriate control volume, is *irrelevant* to the Section 111 process. It matters not whether the barrier was net progradational or sediment starved (drowning) prior

to construction of the breakwaters. Corps culpability is based solely on the perturbation to this background (ambient) state.

1. **Pre-perturbation** (pre-breakwaters) **scenario A**: Figure 1 shows the City's conceptual model for the gross sediment budget prior to the breakwaters. The area shaded light green (curvilinear quadrilateral) is the footprint of the appropriate control volume for analyzing the effects of the Federal structures. This control volume extends landward to the 'back' (harbor) shoreline of the barrier and lakeward to the closure depth; the northwest and southeast edges of the CV align with the modern breakwaters.



We assume *riverine input to the harbor* (St. Louis and Nemadji Rivers, in particular) and *offshore transport* of beach-forming sediment have negligible impact on the lakeside budget. Beach-forming sediment from north- and south-shore sources enters the control volume as **LongShore Transport (LST)** across the northwest and southeast boundaries. Subsidence drives sedimentation within the CV: If LST input to the CV is sufficient to offset fully the demands of subsidence, then the excess (residual) sediment supply drives progradation of the barrier; conversely, if LST cannot satisfy subsidence in full, then the barrier slowly drowns. In either scenario—progradation or

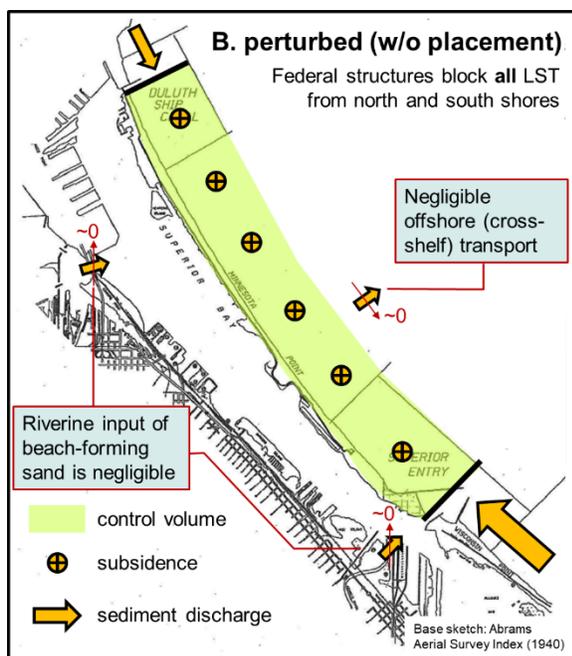
drowning—no sediment leaves the CV as LST. Note the existence of a zero-LST node (pink), which denotes the point of exhaustion for (convergent) southeast- and northwest-directed LST.

Eolian processes result in some net landward transfer of beach sand but negligible loss from the CV to the adjacent harbor. Eolian transport on the north end of the CV is negligible, given the coarse-grained (gravel, cobbles) nature of north-shore-sourced LST.

To summarize the unperturbed (ambient) state, the sediment budget for the CV in Figure 1 is well approximated as a simple balance between LST input from north- and south-shore sources and 'loss' (sequestration) to spatially integrated subsidence across the full barrier width. **Subsidence drives deposition**. The barrier may be prograding or drowning; eolian processes redistribute some fraction of the LST input across the

barrier. Importantly, the CV is *net depositional*, as no sediment leaves the CV across its lateral boundaries.

**2. Perturbed, zero-placement scenario B:** Here, the breakwaters are in place and—as confirmed by Barr-Bergmann’s sediment-transport modeling—trap the *entirety* of sediment supply (LST) from both the north- and south-shore source areas. The only significant *source* of sediment for the entire control volume (LST) is thus extinguished; starvation is complete. As in scenario A (above), transfer of beach-forming sand from the harbor to the lakeside shoreface is negligible. (Notably, the sand input from the Nemadji River is trapped in the harbor and subsequently dredged by the Corps.) Offshore transport is negligible. The atmospheric forcing that drives eolian transport is unchanged, though, in response to overall sediment starvation, the magnitude of sand transfer landward from the beach likely is perturbed. Most importantly, subsidence is unaffected, and no dredged sediment is placed on the lakeside beach to offset this natural sediment *sink*. Inputs to the control volume are zero.



For this hypothetical scenario, it is the City’s position that USACE would be 100% culpable for the *perturbation* to sediment dynamics within the control volume. With sediment discharge as the metric of culpability, USACE would be responsible for the cost of (somehow) supplying to the CV 100% of the north- and south-shore sand discharges (LST) being trapped by the Duluth and Superior breakwaters, respectively.

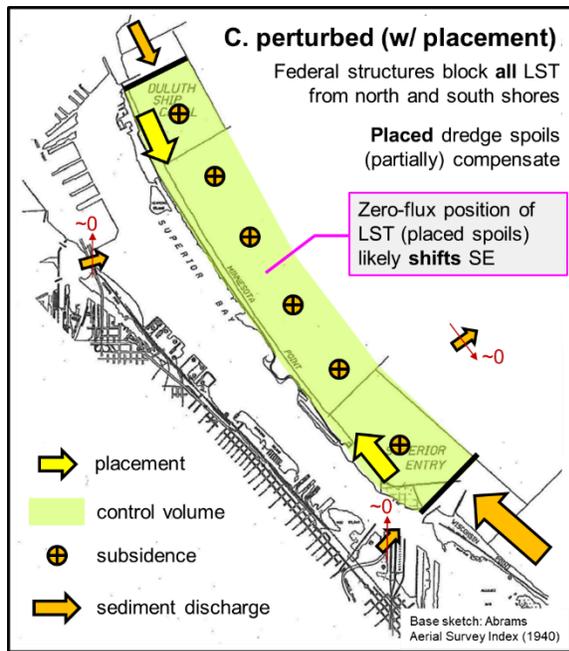
**NB:** It is our understanding that USACE accounting would consider sediment lost to subsidence within the CV as a ‘natural loss’ to be subtracted from the culpability budget, thus lessening the Corps responsibility.

For the sake of argument, as a reasonable approximation, suppose the pre-perturbation barrier was in a state of dynamic equilibrium, in which LST balanced spatially integrated subsidence. Applying the Corps method (as we understand it—or not), USACE is 100% responsible for the LST trapped by the breakwaters. But the spatially integrated loss of sediment to subsidence would offset the USACE responsibility. Because the total input of sediment via LST (counted ‘against’ the Corps) is balanced by integrated subsidence (counted ‘against’ the City, as a natural process), **the net culpability is zero**. This accounting is nonsensical, as the Federal breakwaters are entirely responsible for the

**perturbation** in the barrier's sediment dynamics. Is this interpretation of your methodology correct? Please advise.

**3. Perturbed, with-placement scenario C:** Identical to the previous scenario, but the Corps regularly places (non-native) dredged sand within the control volume. From the recent phone conversation—for illustrative purposes only—assume the historical average placement of dredged sand is  $\sim 10,000 \text{ m}^3/\text{a}$  and the combined (north- and south-shore) LST is  $\sim 35,000 \text{ m}^3/\text{a}$ . Per modeling results, all the LST input is trapped updrift of the breakwaters.

City's position: If the dredged sediment placed in the CV were **fungible** with native LST from the north- and south-shore sources, then the Corps is approximately 70% culpable ( $1 - 10/35$ ) for the perturbation to the barrier's sediment budget caused by the Federal structures. Note that we exclude subsidence from our analysis, as its demand on the beach-forming sediment supply exists with or without the breakwaters, i.e. it is a component of the ambient state. Simply stated, with fungible sediment, the Corps is replacing about 30% of the ambient sediment supply to the CV and, as such, is responsible for the 70% deficit.



In our understanding of the Corps accounting, this 70% culpability would be *reduced* by the 'natural losses' of sediment to subsidence-driven demand. If, for illustrative purposes, we retain from the previous scenario the simplifying assumption of dynamic equilibrium in the pre-perturbation state of the barrier, then the Corps culpability would be -30%, i.e. the City would 'owe' the Corps sediment. (Logic: Breakwaters trap 100% of LST that *was* balanced by spatially integrated subsidence; Corps replaces 30% of LST within the now-starved CV *and* then discounts for subsidence losses, which amount to the entirety of the pre-breakwater LST input.) As before, this accounting is

nonsensical. Please advise.

4. **Eolian ‘losses’**: It is the City’s understanding that 1) the landward boundary of the budget CV (or CVs) was drawn near the base of the ‘dune’ (i.e., the swash limit, or thereabouts) and 2) the Corps sediment accounting treats the *landward transfer* of beach sand across this boundary as a ‘natural loss’ from the beach and—much like subsidence—subtracts such a loss from its culpability. We are uncomfortable with this approach and ask that the Corps consider the following points:

- a. Like subsidence, eolian transport occurs in the presence or absence of the breakwaters—see Scenario A (#1) above. Unlike subsidence, which is controlled by asthenospheric dynamics 100+ km below our feet, construction of the breakwaters and the Corps subsequent actions ***substantially perturbed*** eolian processes on the barrier. Accurate accounting for eolian transfer in culpability calculations must quantify the ambient (pre-breakwater) conditions and, by extension, the totality of impacts to eolian transfer deriving from the Federal structures and related Corps actions.
- b. The dredged sediments are ***not fungible*** with the native LST delivery to the pre-perturbation barrier. In general, the dredged sediment placed by USACE over the last century is finer-grained and ***substantially more mobile*** than native sediment delivered to the pre-breakwater barrier via LST from north- and south-shore sources.
- c. This mobility difference is most acute at the north end of the barrier, where pre-breakwater beaches unequivocally consisted of immobile (via eolian processes) cobbles, gravel, and coarse sand.
- d. The Corps schedule and spatial distribution of dredge placement altered significantly the pre-breakwater pattern of eolian transport on the barrier. Relative to the ambient proportion of north- vs south-shore input to the CV via LST, dredge placement likely is biased substantially to the north end, creating ‘dunes’ where none existed previously and generally shifting the loci for deposition of wind-blown sand. (Note: This spatial shift in eolian transport / deposition likely is echoed in nearshore transport.)

Thank you for considering our concerns and we look forward to your response.