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Summary of Research Related to the Potential Physical and Biological Impacts of Dredging to Channelize the Grand River

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Sea Grant Michigan

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Introduction

The Grand River Waterway proposal is not a typical harbor dredging project, but rather a river channelization project that would remove roughly 50 acres of shallow habitat through dredging portions of the Grand River in Kent and Ottawa counties. The project seeks to create a 7-foot deep channel through a 22.5-mile stretch of the Grand River between Grand Rapids and Bass River State Recreation Area near Eastmanville.

The Grand River Waterway economic impact study stated that river channelization via dredging will "help return the river to its natural state" and that "increased recreational opportunities and improved water quality may generate up to 49,000 net new visitor days annually … and an annual net new economic impact of up to $5.7 million." Research suggests that dredging will not improve water quality. A more likely scenario is reduced water quality, increased erosion of private and public land, increased deposition of sand and silt in certain areas, and harm to fish and wildlife populations. This paper deals specifically with physical and biological impacts, but it is important to note that these have economic implications, as well.

The physical and biological impacts of the Grand River Waterway project would likely extend far beyond the 50 acres that would be removed initially. Dredging to channelize a river causes radical changes to the way a river functions, affecting the shape of the channel and patterns of erosion and sediment deposition. Channelization typically harms water quality and destroys or reduces the quality of fish and wildlife habitat. It can be difficult to predict the severity of these impacts and specific locations that will be affected. However, the general pattern of negative consequences for the river environment are very well documented and supported by scientific research from around the world.

Summary of Key Points

- The Grand River Waterway plan is fundamentally different than harbor dredging projects in river mouth areas. It is a **river channelization** plan that would deepen portions of the Grand River to form a continuous 22.5-mile channel.

- River channelization will **not return the Grand River to its natural state**. This reach of the Grand River was shallow prior to dredging attempts that began in 1886. Michigan's Wildlife Action Plan notes channelization as one of the most serious threats to big river habitats including the Grand River.

- The Grand River Waterway plan is not the first attempt to channelize the Grand River between Grand Rapids and Eastmanville and improve conditions for navigation. The first attempt was a failure, and **reasons for that failure have not been fully addressed** by the Grand River Waterway plan.

Summary of Physical Impacts

- Available scientific literature suggests that **dredging will not improve water quality** in the Grand River. In fact, dredging to channelize a river typically leads to increased turbidity and dirtier water.

- Channelization often leads to **increased erosion of the stream bed** even after dredging is completed. The Grand River Waterway plan does not quantify the additional erosion and downstream sedimentation that would likely occur for many years after dredging.

- Channelization and increased boat traffic often lead to **increased erosion of the riverbanks**. The Grand River Waterway plan does not quantify the additional bankside erosion and loss of land, vegetation, and cultural resources that could occur.

- Channelization lowers the bottom of the river and therefore lowers the surface of the river, as well. This makes all non-dredged (off-channel) areas of the river shallower. The Grand River Waterway plan does not address the **loss of off-channel, wetland, and island areas** that could result from lowering the surface of the river.

- Plans for river channelization often fail to consider how **dredging can create more erosion upstream** of the dredged area and in tributary streams that flow into the dredged area. The Grand River Waterway feasibility study did not consider the potential impact of this upstream erosion (known as head-cutting) in areas including the Grand River in downtown Grand Rapids and in the lower end of tributaries such as Plaster Creek, Sand Creek, Buck Creek, and Deer Creek.

Summary of Biological Impacts

- Channelization has profound negative impacts on bottom-dwelling creatures that form the base of the food chain in rivers. The Grand River Waterway plan would almost certainly do **great harm to benthic macroinvertebrates** that include snails, rare native mussels and larval insects that provide fish food.

- Channelization destroys shallow riffles and gravel bars that many fish species require for successful spawning. The Grand River Waterway plan specifically includes **dredging of a gravel bar area that provides high-quality spawning habitat** for state-threatened river redhorse. The same gravel bar area is a known destination for walleye, steelhead, and smallmouth bass anglers and provides habitat for northern pike, muskellunge, and possibly lake sturgeon.

- Channelization harms valuable gamefish and sensitive threatened and endangered fish species, leading to low-quality fish communities and **reduced fishing opportunities**.

- Even after maintenance dredging stops, a **river may not fully recover for several decades**. Even if the river does return to a new equilibrium state it will be different from the river as it was before channelization.

Key Points

The Grand River Waterway plan is fundamentally different than harbor dredging projects in river mouth areas. It is a **river channelization** plan that would deepen portions of the Grand River to form a continuous 22.5-mile channel.

- River channelization involves “straightening, widening, and/or deepening of stream channels, as well as bank stabilization and clearing or snagging operations” according to Mattingly et al. (1993). The Grand River Waterway proposal specifically involves both deepening of the stream channel and the removal of snags and other obstructions.

River channelization **will not return the Grand River to its natural state**. This reach of the Grand River was shallow prior to dredging attempts that began in 1886. Michigan’s Wildlife Action Plan notes channelization as one of the most serious threats to big river habitats including the Grand River.

- The Grand River was not naturally deep enough for deep draft vessels to navigate. That is why dredging of a 4.5-foot deep channel was attempted in 1886 (USACE 1978).

- The predictably negative impacts of dredging for river channelization were summarized in Michigan DNR’s Grand River Assessment (Hanshue and Harrington 2017). “As a result of channelization, the stream becomes incised and is cut off from its adjacent floodplain. Therefore, the channel is forced to convey discharges that exceed original bankfull conditions. The kinetic energy that would normally be dissipated in the vegetated floodplain is directed to the stream bank, resulting in higher sheer stress and bank instability. As the banks begin to fail, sediment loads increase, resulting in increased bar deposition, further acceleration of bank erosion, increased sediment supply, channel widening and aggradation. The stream channel will continue to evolve toward a balance between the slope and valley and will ultimately form a new floodplain at a lower elevation. As these adjustments occur, subsequent responses to tributary morphology can be expected.”

- Michigan's Wildlife Action Plan (DeRosier et al. 2015) lists channelization as one of the most serious threats to big rivers including the Grand River, stating that "channelization often results in decreased habitat diversity and increased channel instability."

- Like all rivers, the Grand River is a complex and dynamic system that involves four types of connections (lateral, longitudinal, vertical, and temporal) and changes to any of these dimensions can have ripple effects throughout the system (Ward 1989). Dredging to channelize a river increases its depth (a vertical change) and therefore has the potential for impacts up and down the river (longitudinally), to the side of the river in floodplains (laterally) and through time (temporally).

The Grand River Waterway plan is not the first attempt to channelize the Grand River between Grand Rapids and Eastmanville and improve conditions for navigation. The first attempt was a failure, and **reasons for that failure have not been fully addressed** by the Grand River Waterway plan.

- A 60-foot wide channel 4.5 feet deep was dredged in 1886. This channel extended for 11.25 miles downstream of Grand Rapids and was never completed. Highly variable water flows and shoaling that resulted from excessive erosion and deposition of sediment made it impossible to maintain the 4.5-foot depth. In 1887, a report concluded that a deep-water connection between Lake Michigan and Grand Rapids was impossible within the channel of the Grand River (Hanshue and Harrington 2017).

- The U.S. Army Corps of Engineers (USACE) is no longer responsible for dredging the Grand River between Grand Rapids and Bass River State Recreation Area. This reach (section) of river was officially abandoned as a commercial channel when Congress adopted the River and Harbor Act of 1930. The feasibility of re-opening this reach of the Grand River to federal dredging was investigated by USACE in 1978. Five alternative plans were addressed, including a "No Action" plan and a "Channel Dredging Plan" very similar to the 7-foot channel proposed by Grand River Waterway (USACE 1978). Ultimately, no action was taken to re-open this reach of river to dredging.

- The Army Corps' study concluded that the Channel Dredging Plan would both: 1) require removal of pilings and wingwalls that were originally placed in the river to aid navigation in 1930, and 2) likely require addition of new wingwalls to maintain the depth of the new channel (USACE 1978).

- The 2017 Grand River Waterway feasibility study (Edgewater Resources, LLC 2017) does not address the potential need for construction of new wingwalls identified in the 1977 study or the demonstrated inability of channelization and wingwall construction to maintain a 4.5-foot depth in 1886.

Physical Impacts

Available scientific literature suggests that **dredging will not improve water quality** in the Grand River. In fact, dredging to channelize a river typically leads to increased turbidity and dirtier water.

- A study of economic benefits of the Grand River Waterway used dredging of toxic contaminated sediment from the Toledo harbor as evidence that dredging can improve water quality (Benton and Bowers 2018), but the dredging in Toledo occurred from the mouth of the Ottawa River at Lake Erie upstream for 5.5 miles. This Ottawa River Cleanup was funded by the EPA and designed to remove PCBs and PAHs from the lower river (USEPA 2009). Channelization of 22.5 miles of the Grand River for navigational purposes is not at all comparable to the carefully designed removal of contaminant sediments from Toledo's harbor.

- While carefully designed dredging projects at river mouth areas can be an effective way to remove contaminants from the environment, dredging projects designed only to facilitate navigation are more likely to have the opposite effect. A review of research on the subject (Seelye and Mac 1984) concluded "The annual movement of over 10 million cubic meters of sediment by dredging activities in the Great Lakes is potentially harmful to the biota of the Great Lakes, not only due to the physical disruption of the habitat associated with dredging and dredged material disposal … but also the relocation and resuspension of sediments often contaminated with toxic organic and inorganic chemicals."

- Channelization of the River Main in Ireland led to greatly increased peak sediment loads (Wilcock and Essery 1991). Although toxic sediments were not an issue, the median amount of sediment in the water increased sevenfold after channelization destabilized the river bed and river banks, leading to increased erosion. The authors noted that "dirty water is not therefore an infrequent event during channelization."

- Mainstem habitats in channelized sections of the Missouri River in Nebraska had turbidity values 4.5 times higher than un-channelized sections. Side-channel habitats with lower current velocity had turbidity values 2.5 times higher in channelized versus un-channelized sections (Morris et al. 1968).

Channelization often leads to **increased erosion of the stream bed** even after dredging is completed. The Grand River Waterway plan does not quantify the additional erosion and downstream sedimentation that would likely occur for many years after dredging.

- In a summary of the effects of channelization, Brooker (1985) wrote, "in a natural system, channel width and depth are also adjusted to flow regime … any destruction of this equilibrium may lead to the erosion of bed and bank material."

- The increased net erosion and downstream sedimentation that results from destroying this equilibrium state through deepening of the river is very different from the one-time impact of dredging itself. The disturbed river bottom can continue to erode for years as the river attempts to return to a state of dynamic equilibrium (Lane 1955; Langbein and Leopold 1964).

- An incised river can develop either from the direct result of dredging or from ongoing erosion post-channelization. The incised river channel has been cut so deeply that floodplains are abandoned, adjacent wetlands are drained, and formerly wetted banks are left exposed for much of the year (Rosgen 1997).

- In extreme examples, rampant erosion following de-stabilization of the stream bottom can be devastating to the entire river channel, bridges, and other riparian infrastructure. The Homochitto River in Mississippi was degraded to such an extent that the level of the river bottom eroded to drop 15 feet in elevation while the width of the river increased from an average of 96 feet to 328 feet, while deposition of sediment along the shore after floods left a sand-filled flood channel over 3,000 feet wide (Hartfield 1993).

- In a case study of channelization impacts on the Blackwater River and its tributaries in Johnson County, Missouri, Emerson (1971) found that "most bridges in Johnson County have been replaced or lengthened and have had vertical extensions added to the lower supports. In most cases the ends of the present bridges are threatened by bank erosion." Emerson also noted increased flooding following channelization and the deposition of eroded sediment on riparian land after floods, which amounted to "about 2 m {over 6.5 feet} of deposition in 50-60 years."

- The Grand River Waterway project area is particularly vulnerable to the effects of increased erosion after dredging. Substrate in this reach is primarily composed of sand and silt, which are very unstable and prone to erosion (Allan 1995; MDEQ 2011). Furthermore, many of the obstructions that would be removed under the Grand River Waterway plan are training walls (USACE 1909), some of which are still functioning to hold massive quantities of sand and sediment between the training wall and the bank.

- The feasibility study (Edgewater Resources, LLC 2017) did not fully account for the long-term erosion that would likely occur following dredging removal of training walls (which are referred as wingwalls in the feasibility study).

Channelization and increased boat traffic often lead to **increased erosion of the riverbanks**. The Grand River Waterway plan does not quantify the additional bankside erosion and loss of land, vegetation, and cultural resources that could occur.

- Dredging lowers the level of the river bottom, which also lowers the surface of the river. Continuing erosion can lead to development of an incised river, which forms new banks and leaves the old riverbank dry during periods of base flow. Periodical exposure of the riverbank, along with increases in current velocity, can result in extensive streambank erosion in channelized rivers (Brooker 1985; Rosgen 1997).

- A study of boat wakes in the Waikato River, New Zealand (McConchie and Toleman 2003), found that wakes from small boats (less than 18 feet long) generated wakes in excess of 100 times more powerful than natural background waves. Wakes from small boats generated far more suspended sediment than natural waves (up to 740 mg/l as opposed to 31 mg/l or less) due to increased streambank erosion.

- In the Grand River Waterway, boats could potentially be much larger than 18 feet, and larger boats generate far more erosive power (Parchure et al. 2001).

- Narrow channels are more subject to erosion than wide channels because the power of a boat's wake begins to decay as the wake moves away from the sailing line of the boat. If a channel does not allow for a wake to travel 4-6 times the length of the boat before hitting the shore, the riverbank will be subject to maximal erosion (McConchie and Toleman 2003).

- Based on the criteria above, the design vessel for the Grand River Waterway feasibility study (26 feet long with 8.5-foot beam; Edgewater Recourses, LLC 2017) would require a river 216.5 to 320.5 feet wide if it were travelling in the dead center of the river. Many areas of the Grand River in the project area are narrower than this (particularly areas where the channel is adjacent to an island).

- The dredged section of the Grand River below Bass River State Recreation area already experiences damaging and costly problems associated with erosion caused by boat wakes. Riverside Park in Ottawa County is one example where boat wakes are implicated in bank failure, substantial loss of park land, and the loss of many mature trees.

Channelization lowers the bottom of the river and therefore lowers the surface of the river, as well. This makes all non-dredged (off-channel) areas of the river shallower. The Grand River Waterway plan does not address the **loss of off-channel, wetland, and island areas** that could result from lowering the surface of the river.

- Portions of the Grand River are wide, shallow, sandy, and split into channels that form islands in the river. These areas may be susceptible to dewatering of the natural river channel and side-channels during periods of low flow if channelization lowers the river bottom too much.

- It is possible that portions of the current river channel, riverine wetlands, and side channels adjacent to islands would be seasonally dewatered if the Grand River is channelized. Over a relatively short period of time, some of these seasonally dry areas would be colonized by vegetation and converted to terrestrial habitat. Vegetation further reduces current velocity during high water and promotes accelerated accretion of silty sediment. On the Missouri River, side-channel “chute” habitats were almost completely eliminated from channelized sections due to the accumulation of silt (Morris et al. 1968).

- Loss of side-channels has the additional effect of connecting islands permanently to the mainland, with the possibility of connecting an island that is the property of a landowner on one side of the river to the property across the river.

- An incised river channel develops when erosion of the streambed is so severe that the river abandons its natural floodplain (Rosgen 1997). If an incised river develops after dredging of the Grand River, some connected bayous could become disconnected from the river, with potential impacts to fish and wildlife.

Plans for river channelization often fail to consider how **dredging can create more erosion upstream** of the dredged area and in tributary streams that flow into the dredged area. The Grand River Waterway feasibility study did not consider the potential impact of this upstream erosion (known as head-cutting) in areas including the Grand River in downtown Grand Rapids and in the lower end of tributaries such as Plaster Creek, Sand Creek, Buck Creek, and Deer Creek.

- Dredging lowers the bottom of the river. This can create an incised river channel and lead to head-cutting. According to Watters (2000), “headcuts are regions of disturbance moving upstream in zipper-like fashion, as the result of the upper boundary of the modification collapsing. Headcuts may move miles upstream.”

- According to Hartfield (1993), “a stream that is actively, or that has been recently, headcut may be identified by combinations of the following characteristics: extensive bank erosion; wide, degraded channels; meander cutoffs; uniform, shallow flows; chute formation; numerous whole trees within the channel; quicksand, or otherwise loose, unstable sediments; perched tributaries at low water.”

- Channelization of the Tombigbee River to form the Tenn-Tom Waterway in Mississippi and Alabama created headcuts in streams that flowed into the waterway. One of these streams was Magby Creek where a drop-control structure was necessary to prevent upstream erosion and stream degradation (USACE 1985).

- Dredging the lower four miles of Luxapalila Creek required the construction of grade control structures (small dams) to prevent head-cutting that would have eroded the stream farther upstream (Hartfield 1993).

- In tributaries of the Blackwater River, Missouri, Emerson (1971) noted that “the widening and deepening of the streams have caused serious erosional problems along their banks and headward erosion of gullies that lead into the tributaries.”

Biological Impacts

Channelization has profound negative impacts on bottom-dwelling creatures that form the base of the food chain in rivers. The Grand River Waterway plan would almost certainly do **great harm to benthic macroinvertebrates** that include snails, rare native mussels and larval insects that provide fish food.

- A study of channelized and un-channelized sections of the Missouri River in Nebraska (Morris et al. 1968) concluded that “channelization of the river has reduced both the size and variety of aquatic habitat by destroying key productive areas.” Channelization reduced the area of productive benthic habitat by 67%. The biomass of benthic macroinvertebrates drifting in the current was found to be 8.5 times higher in un-channelized versus channelized areas of the Missouri River.

- Macroinvertebrate communities in Ottawa County waters of the Grand River were characterized as “poor” based on sampling of river sediments in 2009. The study concluded that this reach of the Grand River still has not fully recovered from historic dredging (MDEQ 2011).

- Channelization reduced benthic macroinvertebrates by 90% in the River Moy, Ireland (McCarthy 1981).

- The removal of snags and other obstructions from the Grand River would include pilings and wingwalls that were initially placed in the river to improve navigation in addition to submerged logs and other natural large woody debris (Edgewater Resources, LLC 2017). Large woody debris is extremely important for sandy rivers like the Grand. Benthic macroinvertebrates that provide food for fish often have difficulty living on sand. Because of this, large woody debris can support 20 to 50 times more biomass (weight of fish food) than sandy habitat of similar area (Benke et al. 1984).

- By lowering the surface of the river, channelization would also affect the hyporheic zone (Ward 1998). This sub-surface zone of interaction between surface and groundwater provides habitat for a variety of insects and microbes that are important for nutrient cycling (Boulton et al. 1998).

- Dredging, channelization, and the excessive erosion and deposition of sediment that result are recognized as major threats to native mussels (Family: Unionidae). Mussels are directly destroyed and/or removed from the river by dredging, and mussels that remain in the river are subject to being smothered by silt deposition (Watters 1999).

- Dams and channelization are leading causes of extinction for freshwater mollusks in North America and have contributed to the extinction of at least 12 species of mussels and 45 species of snails (FMCS 2016).

Channelization destroys shallow riffles and gravel bars that many fish species require for successful spawning. The Grand River Waterway plan specifically includes **dredging of a gravel bar area that provides high-quality spawning habitat** for state-threatened river redhorse. The same gravel bar area is a known destination for walleye, steelhead, and smallmouth bass anglers and provides habitat for northern pike, muskellunge, and possibly lake sturgeon.

- The River Main was one of the best Atlantic salmon fishing rivers in Northern Ireland. Channelization destroyed gravel habitat where salmon and brown trout built their nests (which are called redds), leading to declines in redd counts after the river was channelized (Wilcock and Essery 1991).

- The 1978 U.S. Army Corps of Engineers study acknowledged that a Channel Dredging Plan similar to the Grand River Waterway plan would cause the greatest environmental impacts including destruction of fish spawning habitat (USACE 1978).

- Channelization removes shallow riffle habitats and reduces the depth in pool habitat. This creates a more uniform river environment. A study of 40 streams in east central Indiana found that the loss of riffle and pool habitat was the main reason for the loss of several fish species from channelized streams (Lau et al. 2006).

- Research conducted during 2018 revealed a large congregation of spawning river redhorse at a gravel bar slated for dredging under the Grand River Waterway plan (Nick Preville, Grand Valley State University, unpublished data). The same gravel bar is a known destination for walleye, steelhead, and smallmouth bass anglers and provides habitat for northern pike, muskellunge, and possibly lake sturgeon.

Channelization harms valuable gamefish and sensitive threatened and endangered fish species, leading to low-quality fish communities and **reduced fishing opportunities**.

- A summary of research on channelized rivers concluded that channelization typically results in substantial detrimental effects on fish populations (Brooker 1985).

- In the Luxapalila River, Mississippi and Alabama, the average weight of largemouth bass was eight times higher in un-channelized segments of the river versus channelized segments. The lengths of largemouth bass in the channelized segment were highly skewed toward smaller size-classes with very few catchable bass present (Arner et al. 1976).

- Fish communities in channelized sections of the Luxapalila River were dominated by migratory fish species that were just passing through the poor-quality habitat. Un-channelized sections of the Luxapalila River supported a wider variety of sport fish (Arner et al. 1976).

- Electrofishing in 20 channelized and 20 natural streams in Indiana found that natural streams had higher quality fish communities with higher IBI (Index of Biotic Integrity) scores. Natural streams held, on average, 4.2 environmentally sensitive fish species and channelized streams held an average of only 2.2. Species lost from channelized streams included valuable gamefish like smallmouth bass along with environmentally sensitive species like black redhorse and rainbow darter (Lau et al. 2006).

- Un-channelized sections of the Chariton River, Missouri, were home to 21 species of fish. Channelized sections held 13 species of fish, with biomass (the weight of all fish) reduced by 80% in channelized sections (Congdon 1971).

- In the River Boyne, Ireland, the ratio of salmonines (salmon and trout) to other less-valuable species was 14:1 before channelization. Erosion of and deposition of silty sediments degraded salmon and trout habitat, dropping this ratio to 5:1 following channelization (McCarthy 1981).

Even after maintenance dredging stops, a river **may not fully recover for several decades**. Even if the river does return to a new equilibrium state it will be different from the river as it was before channelization.

- In summarizing literature on river channelization, Brooker (1985) stated that “the rate of recovery for fish populations from the effects of channelization has been shown to be extremely slow, some streams showing no significant recovery after 30–40 years.

- Salmon and trout take the longest time to recover following disturbance, while species in the family Cyprinidae (including invasive common carp and native minnows) tend to recover in the shortest amount of time. Fishes in the sucker and perch families recover at intermediate rates (Detenbeck et al. 1992).

- A review of case histories from 49 rivers and streams around North America characterized channelization as a “press disturbance.” This is in contrast to “pulse disturbances” that included chemical spills, major flooding, and other one-time disturbances. Fish recovered from pulse disturbances within one year 70% of the time. However, fish communities took 5 to 52 years or more to recover from the long-term impacts of channelization and other press disturbances (Detenbeck et al. 1992).

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