North Carolina Chapter of the American Fisheries Society

Position Paper on Instream Sand and Gravel Mining Activities in North Carolina

6 February 2002

A. Issue Definition

The two major forms of sand and gravel mining are instream dredging of a streambed and land surface mining, which includes floodplain excavations. Instream mining operations remove accumulated sand and gravel directly from stream channels in increasingly larger quantities in the U.S. (EPA 1995), primarily for construction and industrial uses. Instream mining is prohibited in the United Kingdom, Germany, France, the Netherlands, and Switzerland and is restricted in select rivers in Italy, Portugal, and New Zealand (Kondolf 1997). In addition, instream mining is not allowed in Saskatchewan or most of Canada (Starnes and Gasper 1996). Sand and gravel are mined commercially in every state in the U.S.; however, due to numerous research studies that have demonstrated long lasting environmental effects from instream mining, many states have imposed strict regulations on instream mining, and some no longer allow it (Roell 1999). Some of the more detrimental effects of instream mining include channel degradation and erosion, headcutting, increased turbidity, stream bank erosion, and sedimentation of riffle areas. All of these changes can adversely affect fish and other aquatic organisms, either directly by damage to the organisms or through habitat degradation, or indirectly through disruption of the food web. Further, effects on stream geomorphology (e.g., channel incision) can result in infrastructure damage such as undermining bridge piers and exposure of buried pipeline crossings and water supply intakes (Kondolf 1997). Each mining operation not only exerts an individual effect on the stream, but effects of multiple mining operations within a river system may be cumulative. Therefore, individual extraction operations should be evaluated in the context of their spatial and temporal cumulative impacts.

B. Background

Sand and gravel are used to produce concrete, asphalt, and bricks, which are essential building materials for residential, commercial, and industrial buildings, and in most public work projects such as roads and bridges. Even though sand and gravel mining is a common practice, the industry may be the least regulated of any form of mining (Starnes and Gasper 1996). Demand for sand and gravel for construction continues to increase in the U.S. Construction sand and gravel output increased 5.4% in 2000 and was projected to increase by an additional 2.6% in 2001, and domestic sales of industrial sand and gravel increased 2% in 2000 (USGS 2001). Approximately 10-20% of the sand and gravel mined in the U.S. in 1974 was dredged from streams (Newport and Moyer 1974). North Carolina was ranked seventh in total production (method of removal not specified) of industrial sand and gravel in 1998, producing 10,900,000 metric tons valued at $58,000,000 (USGS 1999). In 1999, the total number of permitted mines in North Carolina was 854. Six-hundred-and-two (70%) of the permits were for mining sand and gravel, and 53 (8.8% of the 70%) were instream mines. There were another nine new permits issued for instream mines in 2000 (totaling 62 permitted instream mines), and six additional permits have been applied for as of July 2001. Nine permitted instream mining operations are in the Mountain region and 53 are located in the Piedmont. Mining permits are typically effective for 10 years, at which time the applicant has the option to apply for a renewal permit. Mining operations that affect less than 1 acre of upland area (instream area is not taken into account) are not regulated; therefore, the number of actual instream mining operations is underestimated.

Draglines and hydraulic dredges are the two main types of equipment permitted to mine sand and gravel from North Carolina streams. Mining operations typically remove sand and gravel from a section of river extending to 2,500 linear feet. Processing usually includes grading and screening the sand and gravel in wash water and stockpiling the aggregate along the riverbank for subsequent transport. Wash water is discharged into settling pits before being released back into the river. After removal of alluvial materials, the river bottom may be as much as 8 feet deeper than adjacent upstream and downstream areas. Many of the streams with permitted mines contain federal or state endangered, threatened, special concern, significantly rare, or other sensitive aquatic species.

C. Impacts on Aquatic and Riparian Environments

Stream Geomorphology
Removal of alluvial materials by instream sand and gravel mining disrupts the balance between sediment supply and transport capacity, typically inducing incision upstream and downstream of the extraction site (Kondolf 1997). The alteration of geomorphic structure may occur due to increased velocity and decreased sediment load associated with mined areas. Excavation in the active channel lowers the streambed, creating a nick point that steepens channel slope and increases velocity (Kondolf 1997). The nick point migrates upstream due to increased water speed, i.e., headcutting. The deposition of sediments at the mine site creates a sediment-deficient flow leaving the site, this in turn results in the water picking up more sediment from the stream reach below the mine site; ultimately resulting in bed degradation downstream. Both processes can move long distances (as much as 7 river miles) and headcutting can additionally move into tributaries (Kondolf 1997). Channel incision can also cause lateral instability by increasing stream bank heights, resulting in bank failure and additional transport of sediments downstream.

Aquatic and Riparian Habitat
Effects directly related to extraction and to changes in geomorphology include increased sedimentation, turbidity, and bankfull widths (Rosgen 1996), higher stream temperatures, reduced dissolved oxygen, lowered water table, decreased wetted periods in riparian wetlands, and degraded riparian habitat (see reviews by Nelson 1993; NMFS 1996; Meador and Layher 1998; Bork 1999; Roell 1999; and original research by Kanehl and Lyons 1992; Brown et al. 1998; and references therein). Channel geomorphology changes, such as a wider and shallower streambed (Kanehl and Lyons 1992; Brown et al. 1998) may consequently result in increased stream temperature (Kondolf 1997). Although studies have shown differing results, chemical changes such as reduced dissolved oxygen and changes in pH levels have been reported downstream of instream mining areas (Nelson 1993; Meador and Layher 1998). Loss of riparian habitat may result from direct removal of vegetation along the stream bank to facilitate the use of a dragline or through the process of lowering the water table, bank undercutting, and channel incision (Kondolf 1997; Brown et al. 1998). The physical composition and stability of substrates are altered as a result of instream mining, and most of these physical effects may exacerbate sediment entrainment in the channel. Furthermore, the process of instream mining and gravel washing produces fine sediments under all flow conditions, resulting in a deposition of fine sediment in riffles as well as other habitats at low discharge (Nelson 1993). Excess sediment is considered the greatest pollutant in U.S. waters and constitutes one of the major environmental factors in the degradation of stream fisheries (Waters 1995). Much of the excess sediment is a result of poor watershed and riparian land use. However, instream mining may contribute additional sediment to downstream reaches due to the disruption of substrate stability. Once sediment enters the stream, it is best to let natural geomorphological and hydrological processes reach a dynamic equilibrium, rather than further exacerbating the situation by additional disturbance.

Aquatic Organisms
The distribution of stream biota is strongly related to physical habitat (Brown et al. 1998); therefore, fundamental changes in the total biotic community are to be expected when the physical structure of the stream is altered. Suspended sediments can limit primary production by reducing light penetration (Nelson 1993; Waters 1995), which, in turn, will affect the aquatic food chain and limit production at higher trophic levels. Both fish and aquatic invertebrate abundance may be significantly diminished by direct damage, removal of the substrate, degradation of habitat, riparian habitat removal, reduction in spawning success, reduction in food availability, and clogging and damage of gills (see reviews by Nelson 1993; NMFS 1996; Meador and Layher 1998; Bork 1999; Roell 1999; and original research by Kanehl and Lyons 1992; Brown et al. 1998; Lake and Hinch 1999; and references therein). Brown et al. (1998) found significant reductions in invertebrate densities and biomass and significantly lower biomass of most fishes as a result of instream gravel mining in Ozark streams. In addition, Hartfield (1993) found severe effects on the mussel fauna in Mississippi streams due to headcutting that resulted from instream mining. Increases in suspended sediment can disrupt respiration and modify behavior in aquatic invertebrates and fishes, reduce fish tolerance to disease and toxicants, increase physiological stress in fish, and smother fish eggs (Waters 1995).

In addition to the effects of mining activities at the site of extraction, physical and biotic effects can extend far upstream and downstream (Brown et al. 1998). All of these adverse impacts can result in shifts in species composition, decrease in species diversity and abundance, and a loss of sensitive species and ecosystem integrity. The effects of sand and gravel extraction on stream ecosystem recovery time can be extensive. Kanehl and Lyons (1992) found conditions in some stream reaches in Wisconsin to remain in early stages of recovery 20 years after mining had stopped, and other reaches were in worse condition after 10 years. Further, total restoration of severely affected streams has been considered to be improbable (Brown et al. 1998).

D. Needed Actions

Minimization or mitigation of the effects of instream mining is problematic, if not unlikely, because physical structure is the very foundation upon which stream communities are assembled (Brown et al. 1998). Gravel replenishment has been used as a technique to mitigate the reduction of sediment load below dams (Kondolf 1997), but has not been considered to be a viable option for instream mining sites because of the difficulty in distributing the aggregate naturally and completely throughout the basin prior to the next high water event (Brown et al. 1998). Even when results have been successful below dams, effects are short termed and require continual replenishment efforts (Kondolf 1997). In addition, strategies to minimize impacts are often not effective. The State of California permits extraction of a specified depth below the channel bed or only down to the thalweg. However, a limit in actual elevation was not stated, and therefore, the extraction limits have migrated vertically downward as the channel incises (Kondolf 1997). Another approach that has been examined is to estimate the annual bedload to determine the "safe sustainable yield". However, there are complications with this approach as well, due to the variability in bedload transport from year to year. Alternatively, if extraction rates were instead based on the amount of new deposition per year, the channel may remain negatively affected because mining at the replenishment rate is expected to produce sediment-deficient flow conditions downstream, since the upstream area is the sediment source for downstream reaches (Kondolf 1997).

Implementation of rock gabions may halt headcutting (Kanehl and Lyons 1992), however this and other types of "hard" engineering can impede fish movement (Waters 1995) and ultimately do more harm than good. Measures such as installing rock vanes and rootwads and revegetating stream banks may be used to enhance habitat and stabilize stream banks once mining has completely ceased, and may provide a level of restoration. However, even with mitigative practices, instream excavation causes extreme damage (Waters 1995).

Recommended Guidelines
In circumstances that may warrant instream mining for construction or industrial purposes on a case-by-case basis, we offer the following recommendations.

- Waters containing state or federally endangered, threatened, special concern, or significantly rare aquatic species, or waters designated by the North Carolina Division of Water Quality (NCDWQ) as Outstanding Resource Waters, Trout Waters, High Quality Waters, Swamp Waters, or Nutrient Sensitive Waters, or North Carolina Wildlife Resources Commission designated spawning and primary nursery areas or anadromous fish waters should be avoided.
- Examine alternatives to instream mining and demonstrate that it is the only practicable means of obtaining the materials.
- An integrated environmental assessment, management, and monitoring program should be part of any instream gravel or sand extraction operation. Individual extraction operations should be evaluated from a perspective that includes their potential secondary and cumulative impacts.
- Prior to sand and gravel removal, a thorough review should be undertaken of potentially toxic sediment contaminants where extraction operations are proposed or where bed sediments may be disturbed (upstream and downstream) by the operation.
- Evaluate physical, chemical, and biological effects of instream mining on a river basin scale, so that the cumulative effects of extraction on the aquatic and riparian resources can be recognized.
- Develop a sediment budget based on present and historical conditions. Evaluate limiting instream mining to 50% of the replenishment rate as a safe yield to minimize effects (Kondolf 1997).
- Establish long-term monitoring programs funded by permitting fees. Monitoring should include extraction rates, volume of aggregate removal, and measures of stream morphology, riparian vegetation, bottom composition, bank erosion, and downstream turbidity rates.
- Reduce the period of time that a permit is valid to 3 years.
- Implement a time of year restriction on in-water activities and processing activities (that involve a discharge of wash water) during the generalized fish spawning season (for warmwater streams—15 March through 30 July, for streams supporting anadromous fishes—15 February through 30 June, and for trout streams 15 October through 15 April).
- Evaluate minimization and control measures such as bank stabilization, revegetation of buffer strips, influences of connected floodplain pits, devices to control headcutting, and wash water recycling. Restoration efforts should concentrate on techniques that will optimize fish production, promote aquatic diversity, and restore biotic integrity.
- We encourage the development of legislation that minimizes the environmental impacts from instream mining. It is incongruous that any private citizen, commercial entity, or government agency is required to implement well-established and necessary measures (best management practices) to reduce turbidity, erosion, and siltation in land disturbing activities; but, commercial instream mining has minimal restrictions on instream turbidity, downstream siltation, or habitat degradation impacts. [Mining operations are required to obtain a National Pollutant Discharge Elimination System (NPDES) wastewater discharge permit for discharges from settling ponds.]

E. Position

Due to the numerous credible studies demonstrating environmental degradation that results from instream mining, it is quite probable that the existing operations in North Carolina streams and rivers have adversely affected fisheries and aquatic communities in those systems, and particularly those species that are already rare or endangered, due to the elimination of suitable habitats and reduction in quantity and quality of food resources.

It is therefore the position of the North Carolina Chapter of the American Fisheries Society:

1. that the continued degradation of North Carolina streams due to instream mining and the cumulative impacts of the many mining operations and other stressors on these systems is likely impacting the state's aquatic resources.

2. to support state and federal regulations to prohibit commercial instream sand and gravel mining in North Carolina streams containing state or federally endangered, threatened, special concern, or significantly rare species or waters designated by the North Carolina Division of Water Quality as Outstanding Resource Waters, Trout Waters, High Quality Waters, Swamp Waters, or Nutrient Sensitive Waters, or North Carolina Wildlife Resources Commission designated spawning and primary nursery areas or anadromous fish waters. If these conditions do not exist, we recommend that the guidelines listed above for instream mining operations are followed.

3. to encourage energy conservation and resource recycling (i.e. recycling concrete rubble to produce aggregate) to minimize the need for sand and gravel mining, with the ultimate goal of conserving our natural resources.

4. to encourage assessment of non-point sources of sedimentation and advocate erosion control at the local level.

Literature cited:

Bork, K. 1999. Floodplain and instream mining: a TU primer. Trout Unlimited, Arlington, Virginia.

Brown, A.V., M.M. Lyttle, and K.B. Brown. 1998. Impacts of gravel mining on gravel bed streams. Transactions of the American Fisheries Society 127:979–994.

EPA (U.S. Environmental Protection Agency). 1995. Sector notebook project: profile of the non-fuel, non-metal mining industry. EPA, Office of Compliance, Washington, D.C.

Hartfield, P. 1993. Headcuts and their effect on freshwater mussels. Pages 131–141 *in* K.S. Cummings, A.C. Buchanan, and L.M. Kock, eds. Conservation and management of freshwater mussels. Proceedings of an Upper Mississippi River Conservation Committee (UMRCC) symposium, 12–14 October 1992, St. Louis, Missouri, UMRCC, Rock Island, Illinois.

Kanehl, P., and J. Lyons. 1992. Impacts of in-stream sand and gravel mining on stream habitat and fish communities, including a survey on the Big Rib River, Marathon County, Wisconsin. Wisconsin Department of Natural Resources Research Report 155, Madison.

Kondolf, G.M. 1997. Hungry water: effects of dams and gravel mining on river channels. Environmental Management 21:533–551.

Lake, R.G., and S.G. Hinch. 1999. Acute effects of suspended sediment angularity on juvenile coho salmon. Canadian Journal of Fisheries and Aquatic Sciences 56:862–867.

Meador, M.R., and A.O. Layher. 1998. Instream sand and gravel mining: environmental issues and regulatory process in the United States. Fisheries 23(11):6–13.

NCDWQ (North Carolina Division of Water Quality). A guide to surface freshwater classifications in North Carolina. http://h2o.enr.state.nc.us/csu/swcfaq.html

Nelson, K.L. 1993. Instream sand and gravel mining. Pages 189–196 *in* C.F. Bryan and D.A. Rutherford, eds. Impacts on warmwater streams: guidelines for evaluation. Southern Division, American Fisheries Society, Little Rock, Arkansas.

Newport, B.D., and J.E. Moyer. 1974. State-of-the-art: sand and gravel industry. U.S. Environmental Protection Agency, EPA-660/2-74-066, Washington, D.C.

NMFS (National Marine Fisheries Service) 1996. NMFS National Gravel Extraction Policy. NMFS Southwest Region, Habitat Conservation Division, Long Beach, California.

Roell, M.J. 1999. Sand and gravel mining in Missouri stream systems: aquatic resource effects and management alternatives. Executive Summary. Missouri Department of Conservation, Columbia.

Rosgen, D. 1996. Applied river morphology. Wildland Hydrology, Pagosa Springs, Colorado.

Starnes, L.B., and D.C. Gasper. 1996. Effects of surface mining on aquatic resources in North America. Fisheries 21(5):24–26.

USGS (U.S. Geological Survey). 2001. Mineral Commodity Summaries. USGS, Geologic Division, Reston, Virginia.

USGS (U.S. Geological Survey). 1999. Minerals yearbook. USGS, Geologic Division, Reston, Virginia.

Waters, T. F. 1995. Sediment in streams: sources, biological effects, and control. American Fisheries Society Monograph 7, Bethesda, Maryland.

Glossary

Alluvial – Related to material deposited by running water.

Channel – A natural or artificial waterway that periodically or continuously contains moving water, has a definite bed, and has banks that serve to confine water at low to moderate stream flows.

Channel Incision – A result of down-cutting into the substrate.

Dragline – Equipment used to excavate and remove bottom materials from a water body. The materials are removed with a bucket that is pulled toward the piece of equipment with cables.

Geomorphology – Study of the origin of landforms, the processes that form them, and their material composition.

Headcutting – Erosion of the channel upstream of dredging.

Hydraulic Dredge – Equipment used to excavate and remove bottom materials from a water body using suction.

Nick Point – Where the channel dips into the head of the mine pit.

Thalweg – Deepest point in a channel cross section.

Watershed – Region or area drained by surface and groundwater flow in rivers, streams, or other surface channels.