WASHINGTON AQUEDUCT SEDIMENT DISCHARGES

REPORT OF PANEL RECOMMENDATIONS

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Washington Aqueduct Sediment Discharges
Fisheries Panel Summary of Recommendations, March 1999

A panel of fisheries biologists from the District of Columbia, State of Maryland, Interstate Commission on the Potomac River Basin, National Marine Fisheries Service, and U.S. Fish and Wildlife Service was convened to provide recommendations on minimizing impacts to migratory fish from sediment discharges at the Washington Aqueduct. The fisheries panel provides these recommendations to the administrators at the Washington Aqueduct in an effort to advance the anadromous (and resident) fish restoration efforts in the Potomac River. By minimizing the adverse effects to water quality from sediment discharges at the Dalecarlia and Georgetown settling basins, fisheries resource managers have a better chance at achieving fish and habitat restoration goals for the Potomac River.

1. The goal is to eliminate sediment discharges to the Potomac River. If sediment discharges are absolutely necessary, the panel recommends eliminating the flocculent/sediment discharges from February 15 to June 15, to avoid the early and late spawning activities of migratory fish.

2. Mix the flocculent/sediments with raw river water in the settling basins to produce an effluent, that when discharged to the river, reduces the adverse impacts of concentrated sediments on migratory fish.

3. Slow the rate of flocculent/sediment discharge to the river to a minimum of 72 hours per basin. We recommend that the ratio of discharge to river flow be less than 0.1%. This will also reduce the adverse impacts to migratory fish from concentrated sediments entering the river.

4. Monitor water quality daily at the discharge sites to identify a time when water quality conditions are least sensitive to sediment discharges in the river. The water quality monitoring parameters include: pH, temperature, alkalinity, and conductivity.

5. Remove rocks from the Dalecarlia outfall to ensure controlled and measurable sediment discharge rates, and establish outfall maintenance and discharge monitoring plans to promote safe operation and predictable discharge rates.

6. Create a panel of stakeholders to assist the Washington Aqueduct with issues relating to the Potomac River ecosystem. Theses entities could include citizen coalition, local, state, interstate, and federal representatives.

Introduction

National Pollution Discharge Elimination System

The Washington Aqueduct Division (Aqueduct) of the Baltimore District, U.S. Army Corps of Engineers (USACOE) operates under National Pollution Discharge Elimination System (NPDES) permit number DC 0000019. The existing permit was issued by the U.S. Environmental Protection Agency (EPA) in 1989. A new permit application has been received and is under review by EPA. The permit that was issued in 1989 has been administratively extended, which means it remains in effect pending issuance of a new permit. A new permit is expected to be issued in 2001, and it is anticipated that it will contain provisions factoring in the results of new data. NPDES permits are issued by EPA to ensure compliance with the provisions of the Clean Water Act. The existing permit contains effluent discharge limitations, which are intended to reduce the impact of the release of sediments into the Potomac River. The permit contains language, which specifies the conditions under which discharge of sediment may take place. According to the permit, sediment should be discharged: 1) when there is an increase in the flow of the receiving waters equal to or greater than 3.5 billion gallons per day (bgd) or 2) when the turbidity of the receiving waters is equal to or greater than 100 NTU. The permit further specifies that a gauge reading of 3.47 feet or above shall indicate flow greater than 3.5 bgd.

Description of the Problem

As a result of the NPDES conditions, the Aqueduct discharges from the settling basins to the Potomac River primarily during the spring months, and has limited opportunities for discharging sediment at other times of the year. This narrow window of opportunity requires the Aqueduct to discharge average amounts of 10.5 million pounds of treated sediment each spring (USACOE, 1998). Consequently, the Aqueduct is discharging sediments primarily during the period when anadromous and resident fish migrate and spawn within the Potomac River, and when they are most vulnerable to water quality impacts caused by flocculent/sediment discharges.

Investigation of the Problem

Concerns about the effect of the Aqueduct's sediment discharges on water quality, fish, and other aquatic life have been debated since the issuance of the NPDES permit in the late 1980s. In 1993, a study was funded by the USACOE to investigate the potential hazards associated with the sediment discharges. The conclusion from the study's final report stated that there were no adverse effects on the test animals from any aspect of the sediment discharges from Dalecarlia and Georgetown settling basins (Dynamac Corp.,1993). However, these results have been questioned by the scientific community because of the study design and concerns about data analysis. For example, the number of sampling sites and replicates were limited, and the test animals were not include species of ecologically relevant, or sensitive life stages, such as eggs and juveniles. Furthermore, a follow-up with a more rigorous study design is needed.

In 1995, engineers at the Aqueduct investigated options to eliminate sediment discharges to the Potomac River (USACOE, 1995). However, no alternatives to river disposal of sediment from the Dalecarlia and Georgetown settling basins have been agreed to by local residents and USACOE.

In 1998, when no solution to the sediment discharges was pending, the EPA requested that the U.S. Fish and Wildlife Service chair a panel of fisheries biologists from the District of Columbia, State of Maryland, Interstate Commission on the Potomac River Basin, and National Marine Fisheries Service to develop measures that would minimize the impacts of the sediment discharges to spawning anadromous and resident fish, and which could be implemented in the short term without changing the physical operations at the facility. In developing these measures, the panel focused on two key aspects of the discharges: 1) the amount and timing of the sediment/flocculent discharges and 2) the toxicity of the discharged sediment. This report covers a review of the scientific literature and the recommendations of this panel.

Sediment/Flocculent Source

Sediments that accumulate in the Dalecarlia and Georgetown setting basins, and are then discharge to the Potomac River, are originally contained in the raw water withdrawn from the Potomac River by the Aqueduct. The rate that sediments accumulate in the basins is dependent on the flow levels in the river; that is, the general relationship between sediment and flow is linear, such that with increasing flow, the amount of sediment generally increases.

After raw water is withdrawn from the river, aluminum sulfate (alum), a settling agent, is added to remove the suspended solids in the raw water. When the alum mixes with water, aluminum hydroxide is created. The aluminum hydroxide binds with the suspended solids and precipitates out of solution as a visible flocculent. The flocculent and sediment accumulates at an average rate of 117,600 lb/day during the spring, based on average annual river flows from 100 to 220 million gallons per day (USACOE, 1998). When river flows exceed the regulated flow-by or turbidity levels, the flocculent and sediment is discharged from the settling basins to the river during cleaning of the basins to restore their settling capacity.

Water Quality

Sediment Deposition

The adverse impacts from sediment deposition on aquatic fauna and flora is well documented in scientific literature. Plants, plankton, benthic invertebrates, and fish all depend on good water quality for ecosystem health. Both natural and artificial discharges of large quantities of sediment can cause mortality to sensitive life stages of aquatic species. Biodiversity is jeopardized when species dependent on water clarity or an oxygenated gravel-bottom perish or are replaced with species tolerant of degraded habitat.

Submerged aquatic vegetation (SAV), an important component of fish habitat used by migratory and resident fish and invertebrates in the Potomac River, is widely regarded as a primary indicator of water quality (CBP, 1995). SAV enhances water quality (Rybicki and Hammerschlag, 1991) and provides habitat for migratory and resident fish and macroinvertebrate species, as nursery, refuge (Maldeis, 1979; Killgore et al., 1989), and forage (Monk, 1988).

Habitat requirements for SAV, which include a light attenuation coefficient of less than 2 per meter of depth (for tidal fresh water), chlorophyll (a) < 15 &g l^{-1}, and total suspended solids <15 mg l^{-1} (Funderburk et al., 1991), are adversely effected by excessive sediment turbidity and deposition (Valdes-Murtha and Price, 1998). In a re-analysis of the data from the Dynamac Report (1993), EPA calculated post-discharge suspended sediment at the discharge points of 192.4 mg/l (EPA 1996a, 1996b). Although the post discharge suspended sediment levels are temporary, the discharges may be affecting SAV establishment in areas proximal to and downstream of the sediment discharge points. The suspended sediment levels may exceed the SAV requirement for greater periods of time. SAV data from areas downstream of the Aqueduct's outfalls areas indicate sparse coverage in 1996 and 1997 (Jon Siemien, personal communication). During a recent site visit to the Dalecarlia and Georgetown sediment outfalls, the lack of SAV was verified on September 28, 1998, with only two plants observed at five snorkeling locations downstream of the outfalls (David Sutherland, personal observation).

Plankton are rarely studied in relation to sediment or suspended solids, and there are no standard methods and few sampling procedures to measure the possible affects on these species. Plankton are widely distributed, and the sampling variability within a site may be larger than the variability between sites, masking any possible effects of sediment discharges (Morton, 1977). The limited studies have shown reductions in carbon assimilation (Sherk et al., 1974) and feeding (Sullivan and Handcock, 1973) due to high turbidity and low light penetration, as well as short term reduction in primary productivity (Chesapeake Biological Laboratory, 1970). Suspended sediments can also trap plankton as they flocculate to the bottom, causing additional light attenuation (Ingle, 1952; Kaplan et al., 1974). For zooplankton, downstream of a sediment disposal site was most toxic, while the disposal site was least toxic (DeCoursey and Vernberg, 1975).

Benthic invertebrates provide a crucial link in the detritus-based food chain, because they consume organic matter and other material bound in the sediments (Morton, 1977). At a similar facility more than 10 miles upstream of the Aqueduct, Butler (1995) found that the Washington Sanitary Sewer Commission's (WSSC) facility significantly impacted the benthic communities for more than _ mile downstream of WSSC, under high and low flow conditions. The reported causes included elevated levels of aluminum, manganese, and turbidity. Sedimentation can cause anoxic conditions that are deadly for small, sessile, and slow moving benthic organisms (Nicol, 1967; Rose, 1973; Sailia et al., 1972). During a site visit on September 28, 1998 to the Potomac River by two of the panelists, only about 10 large fresh water mussels were observed in the sediment at five sites (D. Sutherland, Personal Observation). Even larger mollusks, similar to those found in the Potomac River, can experience high mortality when buried by mud and sediment (Morton, 1977).
Many anadromous and resident fish species that spawn near the Aqueduct have life stages influenced by sediment deposition. The anadromous species include shortnose sturgeon, *Acipenser brevirostrum*; striped bass, *Morone saxatilis*; American shad, *Alosa sapidissima*; hickory shad, *Alosa mediocris*; blueback herring, *Alosa aestivalis*, alewife, *Alosa pseudoharengus*; white perch, *Morone Americana*; and yellow perch, *Perca flavescens.* The resident species include: largemouth bass, *Micropterus salmoides*, smallmouth bass, *Micropterus dolomieu*, and walleye, *Stizostedion vitreum*. The egg, larval, and juvenile stages of these species are more sensitive than adults to high levels of suspended sediments and high sediment deposition rates (Sherk et al., 1974). For example, sediment

deposition can fill the interstitial spaces in gravel-bottomed spawning areas, and decreased dissolved oxygen concentrations below levels that are required by early life stages for survival. Sediment concentrations of 1000 mg/l reduced the hatching success of striped bass and yellow perch eggs (Schubel et al., 1974). In laboratory experiments, striped bass larvae consumed 40% less prey in suspended solids above 200 mg/l (Breitburg, 1988), and juvenile stages that rely on visual cues for plankton feeding may have reduced feeding ability in turbid water (Kortschal et al., 1991).

Both adult and juvenile stages of pelagic and filter feeding fish species tend to be less tolerant of high levels of suspended sediments and high sediment deposition rates than bottom-dwelling species. Some of these species are sensitive to gill epithelium and lamella damage from sediment deposition (Chesapeake Biological Laboratory, 1970). Fine sediments coat the gill epithelium, cutting off respiratory exchange, and large sediment blocks water exchange between the first and second lamella. Sherk et al. (1974), in laboratory studies, revealed that controlled exposure to natural Patuxent River sediments reduced striped bass and white perch oxygen consumption.

The adverse effects of sediment discharges on aquatic life can be difficult to quantitatively link to sediment transport and deposition patterns. Because sediment moving through a river channel can be suspended in the water column or settled out as bed load, sediment transport past a given point in a channel is difficult to accurately determine (Glymph, 1975). Suspended or depositional sediments can vary spatially and temporally over short distances as conditions in a river change (Mosley, 1981; Bescheta, 1983). In general, alteration of sediment transport patterns increase with increasing flow, such as during storm events. However, a similar flow rate can effect transport depending on whether the stage of the river is rising or falling (Bescheta, 1979).

A commonly used method of measuring suspended sediment is a sediment rating table, which statistically relates sediment concentrations to river flow rates that are applied to a flow duration cure for the relevant time of the year. Satterlund and Adams (1992) conclude, because of the environmentally-induces variability of sediment transport patterns monitoring programs that track sediment discharges will be difficult and costly at best and regulatory programs based on detecting moderate changes are likely to be unrealistic.

Toxicity

Toxicity of in water is difficult to predict because of complex speciation and the resulting variation in toxicological response. Toxicity of aluminum sulphate, alum, appears to be dependent on pH levels, and with other compounds, concentrations of alum may have an effect at many levels. Each mg/L of alum reacts with 0.5 mg/L of total alkalinity and reduces pH (Boyd, 1979). A toxicity study at 10 water treatment plants found algae growth was limited by alum sludge (George et al., 1995). In the algae assay, 48% of the samples inhibited growth in pH level between 5 and 9 and monomeric aluminum (mAl) concentrations between < 0.04 and 11.8 mg/L. When mAl was < 0.04 mg/L, there was an inhibitory effect 33% of the time. Hall and Hall (1989) also examined the effects of alum on daphnia and fathead minnows. They observed that mortality was the greatest when aqueous aluminum levels were the highest.

Studies with juvenile striped bass indicate that this species is extremely sensitive to several forms of aqueous aluminum (Driscoll et al., 1980; Palawski et al., 1985; Skogheim and Rosseland, 1986; Rosseland et al., 1992). An *in situ* study with larval striped bass found 90 to 99% mortality in river water with 480 to 4100 &g/L Al and pH levels between 6.0 and 6.8 (Hall et al., 1985). Klauda et al (1989) reported that 15 &g/L of monomeric aluminum (mAl) was the critical environmental value to protect larval river herring at pH levels below 6.2. A later study supported the theory that mAl, the inorganic fraction, was potentially the most toxic to early life stages of migratory fish (Hall et al., 1993).

Studies are now showing that variability of physical environmental conditions may play a role in aluminum toxicity. Polymers created from aluminum and water collect on gills and limit respiration (Oughton, 1992). Chemical changes through the polymerization process occur when waters with different pH, temperature, and ionic strength are mixed, or when waste water is discharged into a river system (Witters et al., 1996). Driscoll and Schecher (1988) determined that in a multiple step chemical process, monomeric Al ions transform to a Al polymer ring of six aluminum hydroxide octahedra, $Al_6(OH)_{12}^{6+}$ molecules, as well as to other polymer species. The ability for Al polymerization to occur in natural water, as a function of increasing pH, was described by Driscoll and Schecher in 1988. In the laboratory, Witters et al. (1996) found that when pH was increased from 4.6 to 6.4, polymerization was increased because of the high molecular weight of the total aluminum (Al).

Future Studies

Future studies that investigate the effects of sediment toxicity to the Potomac River ecosystem need to link fish population dynamics to habitat condition, then to contaminate stress. The Dynamac Report (1993) is an example of the difficulties in designing a study in riverine habitat. A fish species' response to environmental stress depends on how the habitat alteration effects its vital rates (Hayes et al., 1995). Assessment approaches to evaluate the effects of contaminant related stress can include three methods: 1) individual bioindicators, 2) integrated multivariate approach, and 3) population-level indicator (Adams and Ryan, 1994). Each method provides a different type of information and none of the individual tests completely evaluate fish health in a stressed environment.

Discussion/Recommendations

There are several compelling reasons minimize the ecological impact of the Washington Aqueduct's discharge. Although their have been improvements in water quality in the Potomac River, the EPA Index of Watershed Integrity states that the middle Potomac River is still vulnerable to pollutant loading. Furthermore, the Potomac River is one of 14 rivers in the nation to have the designation as an American Heritage River. The designation as a Heritage River targets the watershed for environmental, economic, and social restoration projects. Additionally, the Clean Water Action Plan, an extension of the Clean Water Act, calls for federal agencies to adopt, on a voluntary basis, water pollution controls already implemented by states and private industry, including controls on discharge and run-off of toxins and sediment.

American and hickory shad, river herring, American eel, striped bass, and yellow and white perch spawn, grow, and forage in the Potomac River. All of these species formally contributed to productive commercial and recreational fisheries in the Potomac River and Chesapeake Bay. However, the population levels and commercial catches for most of these species are in decline (PRFC 1998). Because spawning habitat lost through water quality degradation has been identified as a key contributing factor to the low fish populations levels, alteration of the Aqueduct's sediment discharge practices will be consistent with the Chesapeake Bay Program's fisheries restoration efforts. An example of these restoration efforts is the recent opening of the Little Falls Dam, just upstream of the Aqueduct's Dalecarlia discharge point. This project has retored passage of anadromous and resident fish to miles of historical spawning and nursery habitat upstream from the dam to Great Falls. Consequently, alteration of the Aqueduct's discharge practices will reduce both physical and chemo-sensory disruptions from sediment/flocculent discharges that inhibit the ability of fish to reach the Little Falls area during spring migrations.

Alterations of the Aqueduct's discharge practices will also assist the EPA and USACOE with compliance under the Endangered Species Act. Recently, the National Marine Fisheries Service (NMFS) has received new information indicating that the shortnose sturgeon, an endangered species under NMFS jurisdiction, is present in the lower and middle Potomac River. This information is based on recent captures of the species by commercial fishing operations in the river. No information exists on the origin or ecology of the shortnose sturgeon in the Potomac River. However, the Baltimore District Corps of Engineers Navigation Section is currently sponsoring a field study on the species in the Potomac River as part of a Section 7 consultation process between Corps and NMFS on the proposed maintenance dredging of the Potomac River Federal Navigation Project. This study should provide information on sturgeon ecology in the river. At this time, it is suspected that the Little Falls area, including that portion in the vicinity of the Dalecarlia facility sediment discharge point, is potentially spawning habitat for shortnose sturgeon. Additionally, shortnose sturgeon may overwinter in deep riverine areas near the Georgetown discharge point. Consequently, NMFS will be recommending that EPA initiate Section 7 consultation on the Aqueduct discharges.

The fisheries panel provides these recommendations to the administrators at the Washington Aqueduct in an effort to advance the anadromous (and resident) fish restoration efforts in the Potomac River. By minimizing the adverse effects to water quality from flocculent/sediment discharges from the Dalecarlia and Georgetown settling basins, fisheries resource managers have a better chance to achieve fish and habitat restoration goals for the Potomac River. From panel discussions, the spring spawning season is the most critical time of the year, and needs to be protected from February 15 to June 15. This time of year restriction will protect the adult migration of early and late spawners and the early development of their young. To minimize the effect of flocculent/sediment discharges on aquatic environment, a homogeneous solution of sediment and raw river water should be discharged. The discharge operations should last no less than three days (72 hrs) per basin, and the ratio of the discharges to river flow should be less than 0.1%. Depending on pH of the river water, the Aqueduct may have to avoid discharges during acid rain conditions that would cause dangerous toxic affects referenced earlier in the report. In a letter (January 10, 1998) Thomas Jacobus, Chief of Plant Operations, Washington Aqueduct, said to achieve protection during the spawning process, the Aqueduct would need to discharge sediment at times when the flow levels were below the legal requirement of the NPDES permit. Mr. Jacobus also mentioned that the discharges at Dalecarlia could be mixed with raw water to achieve a more homogenous water sediment solution before discharge. However, the settling basins at Georgetown are too large to permit adequate mixing of sediments with raw water, and discharges of a more homogenous water-sediment solution may be less feasible at the Georgetown than at Dalecarlia. The panel acknowledges Mr. Jacobus's willingness to work towards environmentally sound practices at the Washington Aqueduct.

While flexibility is required in the NPDES permit to protect the spawning season, the panel realizes that other adverse conditions may be created by discharges at low flow. Therefore, measures recommended by the panel that modify the Aqueduct's sediment discharge practices should be monitored to determine their effect on the river ecosystem (Minns et al., 1995). Since the discharges may occur during low flows, water quality parameters of the receiving water, including pH, temperature, conductivity, and turbidity should be monitored daily. The data generated from monitoring could them be used to make adjustments in the timing of sediment discharges. Subsequently, discharges could be avoided during periods when the water quality of the river may be susceptible to adverse chance (e.g., during a low pH event), and timed to occur during periods when the receiving waters had the greatest buffering capacity. The flow rate target should be above the 10 year daily average.

During the September 1998 site visit to the Aqueduct, it was observed that large rocks are likely blocking discharges and increase the difficulty in predicting discharge rates. Plans for outfall maintenance and discharge monitoring would promote safe operation and predicable discharge rates. In conclusion, the panel makes these specific recommendations:

1. The goal is to eliminate sediment discharges to the Potomac River. If sediment discharges are absolutely necessary, the panel recommends eliminating the flocculent/sediment discharges from February 15 to June 15, to avoid the early and late spawning activities of migratory fish.

2. Mix the flocculent/sediments with raw river water in the settling basins to produce an effluent, that when discharged to the river, reduces the adverse impacts of concentrated sediments on migratory fish.

3. Slow the rate of flocculent/sediment discharge to the river to a minimum of 72 hours per basin. We recommend that the ratio of discharge to river flow be less the 0.1%. This will also reduce the adverse impacts to migratory fish from concentrated sediments entering the river.

4. Monitor water quality daily at the discharge sites to identify a time when water quality conditions are least sensitive to sediment discharges in the river. The water quality monitoring parameters include: pH, temperature, alkalinity, and conductivity.

5. Remove rocks from the Dalecarlia outfall to ensure measurable sediment discharge rates, and establish outfall maintenance and discharge monitoring plans to promote safe operation and predictable discharge rates.

6. Create a panel of stakeholders to assist the Washington Aqueduct with issues relating to the Potomac River ecosystem. Theses entities could include citizen coalition, local, state, interstate, and federal representatives.

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