7. SUMMARY AND CONCLUSIONS

The Washington Aqueduct produces drinking water for approximately one million citizens in the District of Columbia, Arlington County, VA, and the City of Falls Church, VA and its service area. Raw river water is obtained from the Great Falls Raw Water Intake or the Little Falls Pumping Station on the Potomac River. This water flows through the Dalecarlia Reservoir and is then diverted for settling to either the Dalecarlia plant or the Georgetown Reservoirs. As allowed in the Aqueduct's NPDES permit, residual solids from the Dalecarlia plant sedimentation basins are periodically discharged to the Potomac River through Outfall 002, which is located upstream of Chain Bridge. Residuals from Georgetown Reservoir Basins 1 and 2 and are periodically discharged to the Potomac River via Outfalls 003 and 004.

A water quality study was developed to be responsive to a series of specific technical issues raised by staff from U.S. EPA and the District of Columbia's Department of Health. A formal Aqueduct study plan (dated 24 June 1999) was developed and approved by U.S. EPA. This report presents the results from those studies and includes discussions of: effluent dilution and fate modeling, effluent toxicity testing and chemical characterizations, discussions of fisheries issues, and the results of a field program to evaluate the benthic macroinvertebrate community. The findings from these efforts are summarized below.

7.1 EFFLUENT FATE AND TRANSPORT MODELING

A key part of the program was to determine acute and chronic dilution factors for the Aqueduct discharges, and to examine the fate of released solids as they travel downstream. Modeling studies used the Surfacewater Modeling System (SMS), which includes the U.S. Army COE – supported models RMA2, RMA4, and SED2D. The model extended 8.0 km from Outfall 002 (upstream of Chain Bridge), downstream to below Roosevelt Island, and contained a total of 2,021 elements and 6,281 nodes.

Plume mapping studies were conducted at Outfall 002 (Dalecarlia Basin) and Outfall 003 (Georgetown Reservoir). At each outfall, a Rhodamine WT dye-tracer study was performed on the day the reservoir was being drawn down, and a turbidity study was performed the following day during a solids clean-out event.

- At Outfall 002, 22 percent of the total mass discharged passed beyond the downstream end of the model during a 24-hr run. The resulting depositional footprint estimated using

the SED2D model was 1-mm thick in the vicinity of the Outfall 002 and decreased to approximately 0.02 mm downstream in the vicinity of Roosevelt Island.

- At Outfall 003, 13 percent of the total mass discharged passed beyond the downstream end of the model during a 24-hr run. SED2D indicated that the resulting depositional footprint typically exceeded 1 mm in the first 350 m, exceeded 0.2 mm for approximately 2,500 m along the shallow near-shore region downstream, and decreased to approximately 0.05 mm in the vicinity of Roosevelt Island.

- To put the Aqueduct releases into perspective, daily Potomac River flows and total suspended solids (TSS) loads measured at Little Falls (upstream) were obtained for the 20-year period, 1980 to 1999. The median (natural) suspended load in the Potomac River for this period was 218,000 kg/day. The 25 May 2000 discharge event from Dalecarlia Basin 3 released approximately 17,800 kg of solids, a value which is exceeded on 90 percent of the days each year by the daily mass of solids in the Potomac River passing Little Falls. The 3 May 2000 discharge event from Georgetown Reservoir released an estimated 153,600 kg of solids. This solids loading from Georgetown Reservoir is exceeded on 55 to 60 percent of the days each year by the daily mass of solids passing Little Falls.

- Based on current regulatory guidance, a chronic mixing zone at Outfall 002 (at the permitted river flow of 153 cms) is limited by the 10 percent cross-section criterion at a dilution factor of 51. Using U.S. EPA's (1991) 1-hr float time approach, the acute dilution factor is calculated to be 169 in this turbulent and rapidly moving portion of the Potomac River. The complete mix dilution factor for Outfall 002 would be a factor of 1,160.

- At Outfall 003 (Georgetown Reservoir) the chronic mixing zone is limited by the 10 percent cross-section criterion resulting in a dilution factor of 4.3. The 1-hr average exposure associated with acute criterion results in a dilution factor of approximately 2.3. The complete mix dilution factor would be a factor of 136.

- At Outfall 003, acute and chronic dilution factors increase when calculated using TSS rather than a conservative dye tracer. The resulting chronic mixing zone dilution factor was 31.6 and the acute dilution factor (1-hour average exposure) was 8.1.

- Relocation of Outfall 003 to a distance 200-m offshore resulted in an acute (1-hour average exposure) dilution factor of 8.4 and a chronic (10 percent cross-section) dilution factor of 18.6 (conservative dye tracer).

7.2 TOXICITY TESTING

Acute and chronic toxicity tests were performed on effluents collected from the Dalecarlia and Georgetown facilities during normal periodic cleaning operations. As described in the Study Plan, toxicity tests were conducted on three different fractions of the Aqueduct effluent: whole effluent samples (using acute toxicity tests); supernatant from the settled whole effluent (using chronic toxicity tests); and the settled solids portion of the whole effluent (using benthic tests).

- The acute test results indicate that (with one exception) the whole effluent samples collected for the preliminary testing and for Rounds #1 through #4, were <u>not</u> acutely toxic to the test organisms. The 48- and 96-hour LC50 values were >100 percent effluent (TUa <1.0) for *D. magna*, *P. promelas* and *M. saxatilis*. One fathead minnow test showed some level of dose-related acute toxicity, which resulted in a 96-hour LC50 value of 29.3 percent effluent

- The chronic toxicity test results showed that in two of the four rounds, the effluent was not chronically toxic. In the other two rounds, the lowest 7-day chronic value (ChV) for a fish or invertebrate was 35.4 percent effluent. It is noteworthy that 7-day chronic effluent toxicity tests were conducted and reported in the Dynamac (1992) study which showed "*that the effluent released from the sampled sedimentation basins had no effect on either mortality or growth of fathead minnows.*"

- For the benthic testing, the 10-day LC50 values (based on survival) from the four rounds of testing were >100 percent sample, but the effluent concentration causing a reduction in growth (the IC25 value) ranged from 6.9 to 32.8 percent effluent.

Interpretation of these effluent toxicity test results is complicated by the fact that these tests continuously expose the test organisms in the laboratory to a series of effluent concentrations for 2 to 10 days (depending upon the test). In contrast, exposure to the Aqueduct plume is a transient phenomenon which lasts for perhaps 4-8 hours. Using the guidance presented in U.S. EPA's (1991)Technical Support Document for Water Quality-Based Toxics Control, the lowest acute value would require a dilution factor of approximately 11:1 to be non-toxic (i.e., to yield 0.3 TUa); and the lowest chronic value would require a dilution factor of approximately 9.4:1.

The benthic results would suggest that a dilution factor of 14.5 would result in no effect on organism growth. As discussed in Chapter 2, these dilution factors are easily obtained for Outfall 002, but outfall modification or relocation would be required to achieve these dilution factors for the Georgetown Reservoir discharges from Outfall 003.

7.3 EFFLUENT CHEMICAL CHARACTERIZATION

The study summarized the recent chemistry data collected and analyzed by the Aqueduct, and generated additional effluent chemistry data as part of the toxicity testing program. Overall mean total aluminum concentrations for the Dalecarlia and Georgetown basins averaged 2,273 and 1,510 mg/L, respectively, for the period 1997-2001. EA Engineering's data included both total and dissolved aluminum, and indicated that the percentage of *dissolved* aluminum is considerably less than one percent of the total aluminum value in the effluent samples. Although total aluminum concentrations are high, effluent toxicity testing does not suggest that the aluminum in the effluent samples is as bioavailable or toxic as the data used to determine EPA's aluminum criterion would suggest (which requires the use of reagent grade aluminum salts in clean laboratory water).

7.4 FISHERIES ISSUES

Life history information for each of the key species in the Study Plan was assembled and presented in the report, followed by discussions of the potential effects of Aqueduct discharges on the fish community. The report concludes that *potential* impacts to the fishery would be primarily restricted to young life stages of some of the fish species of concern. Juvenile and adult fish are mobile, and would be expected to avoid the discharges if stressed. Larvae, and particularly eggs, however, would be less able to avoid the sediment plume in the discharge areas.

Risks to young life stages of fish from the discharges are from suspended solids (either in the water column or deposited on the substrate) and elevated aluminum concentrations. Studies from this water quality program indicate that a substantial quantity of solids falls to the substrate within a reasonably small area near the discharge (primarily from Outfall 003), and there could be moderate risk to several fish species of concern from sediment discharges when young life stages are present. The primary risk is from deposition of suspended solids onto eggs and larvae (causing smothering and reduced oxygen levels), which could affect survival. However, the area potentially affected represents a small portion of the Aqueduct study area.

Management options to minimize potential impacts on fishery resources are also discussed in the report. These include:

- Eliminating discharges between 15 February and 15 June of each year to avoid spawning and nursery periods (which would require a revision to the existing river flow restriction in the NPDES permit).

- Reducing the river flow threshold (below which Aqueduct discharges cannot take place) by 20 percent

- Cleaning and discharging solids more slowly using more dilution water to reduce effluent concentrations and maximize the assimilative capacity into the River

- Negotiating an agreement with the EPA and pertinent resource agencies to allow discharges during the spring on an emergency basis

7.5 BENTHIC MACROINVERTEBRATE STUDIES

The study design used Hester-Dendy artificial substrate units to allow comparisons between upstream (reference) and downstream benthic organism communities; and to compare the post-discharge benthic data to the before discharge data. The observations and conclusions from this study are as follows:

- The substrate in the study area consists of areas of sand, mud, boulders and bedrock. Large bedrock formations were evident along the shoreline and also out in mid-river where they were above the water surface during low tide. The softer sediments are in patches between or on these rock substrate areas. Sediments are being continually redistributed following medium to high flow events which was confirmed by our observations of sediment deposition during the Hester-Dendy study.

- Based on the pre- and post-discharge collections, a very large load of sediment naturally moves through this segment of the Potomac River during times of increased flows, and deposits in the wider, slower current velocity reach of the river. This was evident at the downstream stations *as well as* the upstream reference station (UP-1). These large sediment loads, which resulted before the Georgetown basin discharge event, compromised the resulting dataset that was collected using the Hester-Dendy sampling approach. So much sediment covered some of the Hester-Dendy units that organisms

could not colonize the samplers resulting in lower than expected numbers of benthic organisms and taxa. These low numbers of organisms affect the ability to draw strong conclusions from the dataset both from upstream versus downstream and pre- versus post-discharge perspectives.

- The benthic community was very similar in the samples collected during the pre- and post-discharge surveys. Based on modeling and dye studies, the Hester-Dendy locations were expected to be in varying concentrations of the discharge plume. The only station where a difference was evident was at the first downstream station (DS1) where pre-discharge mean abundance averaged 43 compared to post-discharge abundance of 0.3 organisms. DS1 is closest to Outfall 003, which may have resulted in scouring effects on the benthos reducing abundance in the post-discharge samplers, but this conclusion is only tentative considering the pre-discharge replicate variability.

- The benthic community that was collected in the Hester-Dendy study (including replicates not covered by sediment) consisted of tolerant taxa, which is a consequence of the rigorous naturally occurring environmental conditions they are exposed to on a periodic but regular basis. It is clear that a large natural sediment load is transported through this area and the benthic community that is adapted to these conditions continues to exist. As an example, based upon a 19 year historical dataset, the upper 10^{th} percentile daily sediment load value measured at the upstream end of the study area is approximately 157 times higher than the sediment load released from a typical discharge at Outfall 003, and 1,358 times higher than the sediment load released from a typical discharge at Outfall 002.

- This tolerant community does not appear to differ based on the present study's upstream versus downstream station comparison. Based on our observations during this benthic study, interpretation of existing river and discharge sediment load data, and supporting information from past studies, intermittent Dalecarlia and Georgetown discharge events are not expected to have a substantial or cumulative impact on the tolerant benthic community present in this reach of the Potomac River. These results are generally consistent with the Dynamac (1992) study using a different sampling technique but also finding a tolerant benthic community.