APPENDIX A

SUMMARY OF STAR GRANTS PROGRAM AWARDS
Mercury: Transport and Fate through a Watershed

Appendix A contains a summary of grants awarded as part of ORD's Science to Achieve Results (STAR) Grants Program on mercury transport and fate through a watershed. In 1998, ORD issued a Request for Applications (RFA) inviting interested parties to submit research ideas that advance the fundamental understanding of chemical and physical transformations and movement of mercury in the environment (EPA 1998e). The awards summarized below were made in September 1999 and generally have a lifetime of three years. Specifically, the grants focus on the aquatic and terrestrial transport, transformation, and fate of mercury. The total funding for the research program over its three-year life is approximately $6.2 M. Each summary includes a description of the research being conducted, the institution conducting the research, and the principal investigator(s) leading the efforts. The summaries were prepared by the Principal Investigators as part of their proposal submissions. Additional information on the STAR Grants Program can be obtained by contacting EPA's National Center for Environmental Research (NCER) at http://www.es.epa.gov/ncerqa/.

Title: Methylmercury Sources to Lakes and Forested Watersheds: Has Enhanced Methylation Increased Mercury in Fish Relative to Atmosphere Deposition?

Institution: University of Minnesota/Minnesota Pollution Control Agency

Principal Investigator: Edward B. Swain

Summary:

The study will investigate enhanced methylmercury loads that results in elevated mercury concentrations in fish. The objectives of the study are to: (1) establish the relative importance of atmospheric, in-lake, and wetland sources of methylmercury to a lake in a forested watershed containing three types of wetlands; (2) determine the net retention and source strength of different wetland types; (3) conduct mesocosm (wetland and lake) and whole wetland experiments to elucidate methylation enhancing processes; and (4) add a hydrologically-based wetland GIS module to the Mercury Cycling Model (MCM) to apply finding to a larger set of lakes where GIS and mercury data have been collected.

The research will be conducted by the University of Minnesota and the Minnesota Pollution Control Agency and will focus on the sediments and fish in lakes within the State of Minnesota. Researchers hope to apply the study's findings to other regions of the country. The study will use a three-tiered approach involving microspace experiments, lake/wetland studies, and evaluation of the new understanding through modeling. Through this study, researchers will improve the understanding of the sources of methylmercury in fish and explain the observed differences in fish mercury levels in Minnesota and elsewhere.

Title: Response to Methylmercury Production and Accumulation to Changes in Hg Loading: A Whole-ecosystem Mercury Loading Study

Institution: The Academy of Natural Sciences Estuaries Research Center, The University of Maryland, Chesapeake Biological Laboratory, Canada Department of Fisheries and Oceans, Freshwater Institute.

Principal Investigator: Cynthia C. Gilmore

Summary:

The study attempts to understand the mercury cycle by studying methylmercury production as part of a whole-ecosystem mercury loading experiment. Researchers will attempt to answer the question of "How much does methylmercury in an ecosystem change in response to a change in mercury loading?" The study will measure the net accumulation of methylmercury, instantaneous methylmercury production and degradation rates, and the key biogeochemical parameters in each of these locations that affect mercury bioavailability and methylation.

The research will be conducted by several institutions (see above). United States and Canadian scientists will conduct the research at the Experimental Lakes Area (ELA) in northwestern Ontario. In addition, an experiment will also be conducted in the Florida Everglades for comparison of mercury loading. Researchers will use two approaches to study mercury loadings: (1) the stable mercury isotopes and (2) the manipulation of a whole watershed with mercury. The results will allow researchers to predict changes in methylmercury from changes in mercury loading over the range of mercury loadings that would result from regulatory action. The resulting data will also provide insights on regional and landscape variations that affect methylmercury production and accumulation in fish.

Title: Photo Induced Reduction of Mercury in Lakes, Wetlands, and Soils

Institution: University of Michigan, Oak Ridge National Laboratory

Principal Investigator: Jerome O. Nriagu

Summary:

The study will evaluate photosynthesis induced formation of mercury in a watershed. A comparison between the similarities and differences in pathways and rates of mercury formation in different segments of a watershed will be conducted. The study will measure the diurnal and seasonal variations in cross-gradient generation of mercury and total release of mercury from surface waters.

The experiments will be conducted in both laboratory and field conditions. The field study will take place at Saginaw Bay and Lake Huron. Researchers hope that the data will help explain the process of natural mercury release into the environment and the role of this process in reducing the amount of mercury loading in the Great Lakes.

Title: Chemical and Biological Control of Mercury Cycling in Upland, Wetland and Lake Ecosystems in the Northeastern U.S.

Institutions: Syracuse University, Cornell University, Smith College, Tetra Tech, Inc.

Principal Investigator: Charles T. Driscoll

Summary:

The study will attempt to clarify the chemical and biological processes that regulate mercury transport, fate, and bioavailability in the northeastern United States. The study will also attempt to develop and apply a simulation model to explain these processes. The research objectives are to: (1) quantify patterns of transport and transformations of mercury species in an upland northern hardwood forest through adjacent wetlands; (2) evaluate the processes and mechanisms controlling methylmercury concentrations and transport in pore-water and surface water in wetlands; (3) evaluate historical patterns of mercury dynamics in soft-water lakes; and (4) develop and apply a lake/watershed mercury cycling model to a lake/watershed ecosystem.

The project will examine the: (1) transport of mercury and interactions with organic matter and metals in upland soil, wetlands and surface waters; (2) rates and controls of methylation and demethylation of mercury in organic matter-rich wetland environments; and (3) factors which influence historical changes in the deposition of mercury to lake sediments. Field watershed measurements and controlled experiments will be employed to quantify mercury behavior in a typical glaciated landscape in the Adirondack Region of New York.

The result of this study will provide information to the EPA and agencies in the northeast concerned with the consequences of elevated atmospheric mercury deposition. The study will develop and calibrate a comprehensive watershed mercury cycling model to be used in assessing regional effects of atmospheric mercury deposition on watershed and lake ecosystems.

Title: Processes Controlling the Chemical/Isotopic Speciation and Distribution of Mercury from Contaminated Mine Sites

Institution: Stanford University, University of Nevada-Reno, U.S. Geological Survey

Principal Investigator: Gordon E. Brown, Jr.

Summary:

Researchers will attempt to understand the physical and chemical processes that control the speciation and distribution of mercury in mine wastes and its release from mine sites. The study will attempt to (1) determine the chemical and isotopic speciation of mercury in natural samples; (2) test the transport of mercury on colloidal particles in laboratory column experiments; (3) examine the sorption processes of mercury on mineral particles common in sediments downstream from mine sites, as well as the effects of common aqueous ligand sulfate and chloride on Hg sorption processes; and (4) monitor the atmospheric emissions of mercury from selected mine waste sites representing different weathering and climatic regimes. The objective is to correlate emission levels with the chemical speciation of mercury in the mine wastes. Researchers will conduct the experiments at selected mining waste sites in the western United States.

The chemical and isotopic forms of mercury associated with mining wastes will be determined using spectroscopic and isotopic methods. Laboratory column experiments will be conducted to examine the transport of mercury by colloids. Sorption experiments will be conducted to examine the sorption of mercury on mineral particles. To measure atmospheric emissions of mercury, micrometeorological and flux chamber methods will be used. The result of the study will allow researchers to better understand the process involved in speciation and distribution of mercury in mining waste. It will also allow scientists to better characterize the risk associated with mercury in mine wastes for local and regional ecosystems.

Title: Microbiological and Physicochemical Aspects of Mercury Cycling in the Coastal/ Estuaries Waters of Long Island Sound and Its River-Seawater Mixing Zones.

Institution: Department of Marine Sciences, University of Connecticut

Principal Investigator: William F. Fitzgerald

Summary:

This research is designed to better understand how mercury cycling in natural water plays a key role in controlling the overall aquatic biogeochemistry of mercury and the bioavailability of mercury species. The study is a three-year comprehensive examination of the physicochemical and microbiological marine program to investigate reactions and processes controlling mercury emissions, cycling, and bioavailability in Long Island Sound and its watershed/coastal water interface. The objective of the study is to understand the aquatic biogeochemistry of mercury and interactions between the terrestrial watersheds and near shore marine waters.

The program will take place at the estuaries and coastal waters in Long Island Sound. Scientists will use previous mercury mass balance studies and are proposing an experimental and theoretical design that will allow the results to be applicable to other regions. The experimental aspect of the study will be conducted largely in the field but also will involve laboratory experiments. The project increase**s** the understanding of the role and environmental impact of in-situ mercury production and emissions on the aquatic and atmospheric mercury cycle. Researchers also hope to evaluate the importance of the in-situ biological synthesis of methylmercury on the behavior and fate of this toxic species in Long Island Sound and other areas.

Title: Understanding the Role of Sulfur in the Production and Fate of Methylmercury in Watersheds

Institution: Chesapeake Biological Laboratory, University of Maryland, Academy of Natural Sciences Estuaries Research Center

Principal Investigator: Dr. Robert P. Mason and Dr. Cynthia Gilmore

Summary:

Researchers will investigate the influence of sulfide and other parameters, and the relative importance of microbial community structure and activity to net methylmercury production in natural sediments and soils. The objective of this project is to understand the role of sulfur in mercury methylation and methylmercury fate and transport in watersheds. The hypothesis is that the decreased methylation of mercury in high sulfide environments results from changes in mercury availability to the methylating organisms while low production in sulfate-limited systems is driven by limitation of microbial activity.

Laboratory and field experiments will be conducted. Bioavailability of mercury to methylating organisms will be determined using bacterial cultures and natural sediments and soils, combining laboratory, field and mesocosm experiments. Engineered microorganisms will also be used to test the hypothesis about factors controlling mercury uptake by methylating bacteria. The study results will provide information needed to understand the factors controlling the formation, degradation, fate and transport of methylmercury in watersheds. In addition, the results will provide new information regarding the relationship between atmospheric deposition of mercury to watersheds and mercury bioaccumulation in piscivorous fish.

Title: The Redox Cycle of Mercury In Natural Waters

Institution: Department of Geosciences, Princeton University

Principal Investigator: Francois M. M. Morel

Summary:

The study will provide a better understanding of the parameters that control the flux of elemental mercury from natural waters to the atmosphere. Researchers will conduct a series of iterative laboratory and field experiments focused on the principal chemical and biological redox mechanisms that transform mercury between its divalent and elemental forms. Researchers will model simple systems and build up to more complex models of natural waters. Lab experiments will create the mechanisms and the rates of the processes of interest and will provide methods and probes for the field experiments.

The field experiments will cover a number of sites and will attempt to establish the actual occurrences of the mechanisms in nature and provide kinetic data. The result of the project will allow for better understanding of how parameters affect the rate of mercury loss from bodies of water to the atmosphere. It will also help answer the question of why bodies of water with similar inputs of mercury end up having different mercury loadings.

Title: Watershed Influences on Transport, Fate and Bioavailability of Mercury in Lake Superior

Institution: Bureau of Integrated Science Services, Wisconsin Department of Natural Resources, University of Wisconsin-Madison, and Lake Superior State University

Principal Investigator: James P. Hurley

Summary:

This study will assess the importance of watersheds in controlling sources, transport, fate and bioavailability of mercury in a northern temperate lake system. The specific objectives of the study are to: (1) determine the speciation and bioavailability of mercury transported to Lake Superior by representative tributaries/watersheds; (2) determine the importance of watershed-specific characteristics (soil type, land use, surficial deposits) that control physical/chemical forms of mercury transported downstream; (3) identify key mechanisms controlling mercury bioavailability and speciation in near-shore zones relative to open lake regions; and, (4) provide process-level information to complement concurrent development of mercury fate and transport models of the Lake Superior ecosystem. The approach uses a combination of field and laboratory studies with modeling to assess the importance of watershed processes in controlling mercury fate and transport in Lake Superior. Anticipated results will provide information on the links between atmospheric mercury deposition and accumulation of mercury in biota within the Lake Superior Basin.