Analysis of Atmospheric Deposition of Mercury to the Savannah River Watershed

EXECUTIVE SUMMARY

This document presents an estimate of mercury deposition from the atmosphere to the Savannah River watershed. This analysis was done to support the development of a Total Maximum Daily Load (TMDL) limit for the Savannah River watershed under the requirements of the Clean Water Act. The purpose of the TMDL is to restore this impaired water body to its designated use - fishable waters. Mercury has been identified as the primary contaminant contributing to the current impairment of the Savannah River watershed for which fish consumption advisories have been established. Current information indicates that the main source of mercury loading to the watershed is derived from atmospheric deposition.

This analysis estimated the level of mercury deposited from the atmosphere to the Savannah River watershed for a baseline period (1994-1996) and a future date (2010) when all currently promulgated standards under the Clean Air Act (CAA) – Section 112 for Maximum Achievable Control Technology Standards (MACTs), and Section 111 New Source Performance Standards, and Section 129 Solid Waste Combustion – will have been implemented. The analysis indicates that mercury deposition to the watershed will be reduced approximately 38%-48% by 2010 from the baseline period due to implementation of the CAA standards (and a number of facilities that are known to have closed). This result was derived with the following methodology:

1. The analysis used the results of national atmospheric mercury deposition modeling done for EPA's 1997 *Mercury Study Report to Congress* (referred to as *The Mercury Study*) to estimate the level of mercury deposited to the Savannah River watershed during the baseline period (1994-1996) from local sources (in or within 100 km of the watershed), plus national, and global sources. The analysis presumes that local sources primarily contribute to the loading by deposition of reactive gaseous mercury (RGM, divalent mercury gas), while national sources (i.e. at distance >100 km) contribute particle bound mercury, and global sources contribute gaseous elemental mercury.

2. The total RGM emitted from local sources was estimated for the baseline period from the emissions data files used to conduct *The Mercury Study* modeling. Local sources include categories such as hospital and medical waste incinerators, municipal waste incinerators, electric utility plants, a chlor-alkali chlorine production facility, and industrial and residential boilers.

3. Future RGM emissions for 2010 from local sources were estimated using projected population growth as an indicator of growth in emissions over time, along with calculated reductions in mercury emissions due to MACT and Waste Combustion controls. Then an estimate of RGM deposition to the watershed was calculated for 2010 as proportional to local emissions.

4. The sum total deposition of mercury to the watershed in 2010 was developed by combining the RGM deposition value from Step 3 with an estimate of proportional national deposition in 2010 and global source contributions. Comparison of the total value calculated in Step 1 with the total value calculated in Step 4 indicates that a 38-48% reduction of mercury deposition is probable over the approximately 15 years from the baseline to 2010, based on currently promulgated and proposed standards in the Clean Air Act (MACT and section 129.)

5. The particulars of this analysis are specific to the Savannah River watershed and the surrounding area, counties within 100 kilometers around the watershed boundary. Neither the estimated percent reductions in emissions by 2010 nor the estimated percent reduction in deposition should be applied uncritically to other geographic areas. If another region of the United States develops an analysis using similar methodology, that area must develop its own specific information on deposition of mercury, and data on the source categories present in the area, and estimates of the effects of promulgated regulations on emissions from those sources.

This document concludes with a brief summary of regulations promulgated to date on major emissions sources of mercury under the sections of the Clean Air Act which address maximum achievable control technology (MACT), new source performance standards, and solid waste combustion. In addition, Appendix II provides an informational review of a variety of regulatory and related initiatives, some of which are enacted but many are subject to change as programs continue to develop.

In addition to the regulatory MACT and waste combustion standards mentioned above, a number of voluntary programs to reduce mercury releases to the air, water, and land disposal are being developed and implemented in many states. These include:

- Recycling of mercury containing switches and other devices (e.g. from buildings and automobiles);
- Changes in industrial processes to reduce the use of mercury;
- Reduced use of mercury devices in health care, and reduction of mercury in related wastes;
- Substitution of non-mercury materials or devices for current uses, where possible; and
- Distribution of information to facilitate safe collection/recycling of stored mercury and other chemicals in laboratories, schools and colleges, and improved handling of mercury during waste collection efforts.

The effects of these and similar voluntary efforts on current or future reductions in mercury releases to the environment have not been estimated, to date. It is also uncertain whether these or related activities will be developed and fully active during the next decade in the area of Georgia and South Carolina in and near the Savannah River watershed. Therefore, these voluntary programs were not included in this document as part of developing the estimate of reduced emissions and reduced atmospheric deposition of mercury in 2010.

1.0 INTRODUCTION

The purpose of this analysis is to estimate the deposition of mercury to the Savannah River watershed, in kilograms per year (kg/yr) for:

- A Baseline period (1994-1996); and
- A future year (2010).

This information is needed for the development of a Total Maximum Daily Load (TMDL) for the Savannah River watershed under the requirements of the Clean Water Act. The purpose of the TMDL is to restore impaired water bodies to their designated uses. Mercury has been identified as the primary contaminant contributing to the current impairment (fish consumption advisories) of the watershed in question.

Mercury in the atmosphere is present primarily in four forms:

- Gaseous elemental mercury vapor (Hg^0 or zero valent mercury);
- Gaseous divalent mercury (Hg^{2+}), also called reactive gaseous mercury (RGM);
- Particulate or particle-bound mercury (both Hg^0 and Hg^{2+}, relative proportion not known, and likely varying with type of particle); and
- Organic mercury (mostly mono-methylmercury) which can be measured in rainfall, but in amounts so much below the other forms that it will not be discussed further in this document.[1]

As discussed in Volume III of the *Mercury Study Report to Congress* (EPA 1997; hereafter referred to as "*The Mercury Study*"), the deposition of mercury from the atmosphere occurs by two mechanisms:

- ***Wet deposition*** - In this mechanism, RGM dissolved in rain (or fog or snow) is deposited on to land and/or the surface of water bodies. Particle-bound mercury is also deposited by this mechanism, but is a relatively minor constituent in rain in most areas.

- ***Dry deposition*** - In this process, both gaseous and particulate forms of mercury are deposited on land, vegetation and/or the surface of water bodies by atmospheric mixing and adsorption, plus settling by gravity. Land uses and type of vegetation cover can affect the net dry deposition. Recent tests indicate that RGM represents the majority of mercury deposited by this mechanism.

[1]Note that organic forms of mercury are important in the biomagnification of mercury in fish and, ultimately, in the exposure of humans to mercury through fish consumption. However, the amount of organic mercury depositing (as such) from air is considered negligible in comparison to that formed in the aquatic ecosystem.

The distance from the emission source, the forms of the mercury in the emissions, other pollutants in the emissions and the atmosphere, and the weather patterns of precipitation are important factors in determining where mercury released to the air will be deposited. This analysis utilizes the following recently developed information about mercury species and deposition relative to source location (Dvonch et al. 1999):

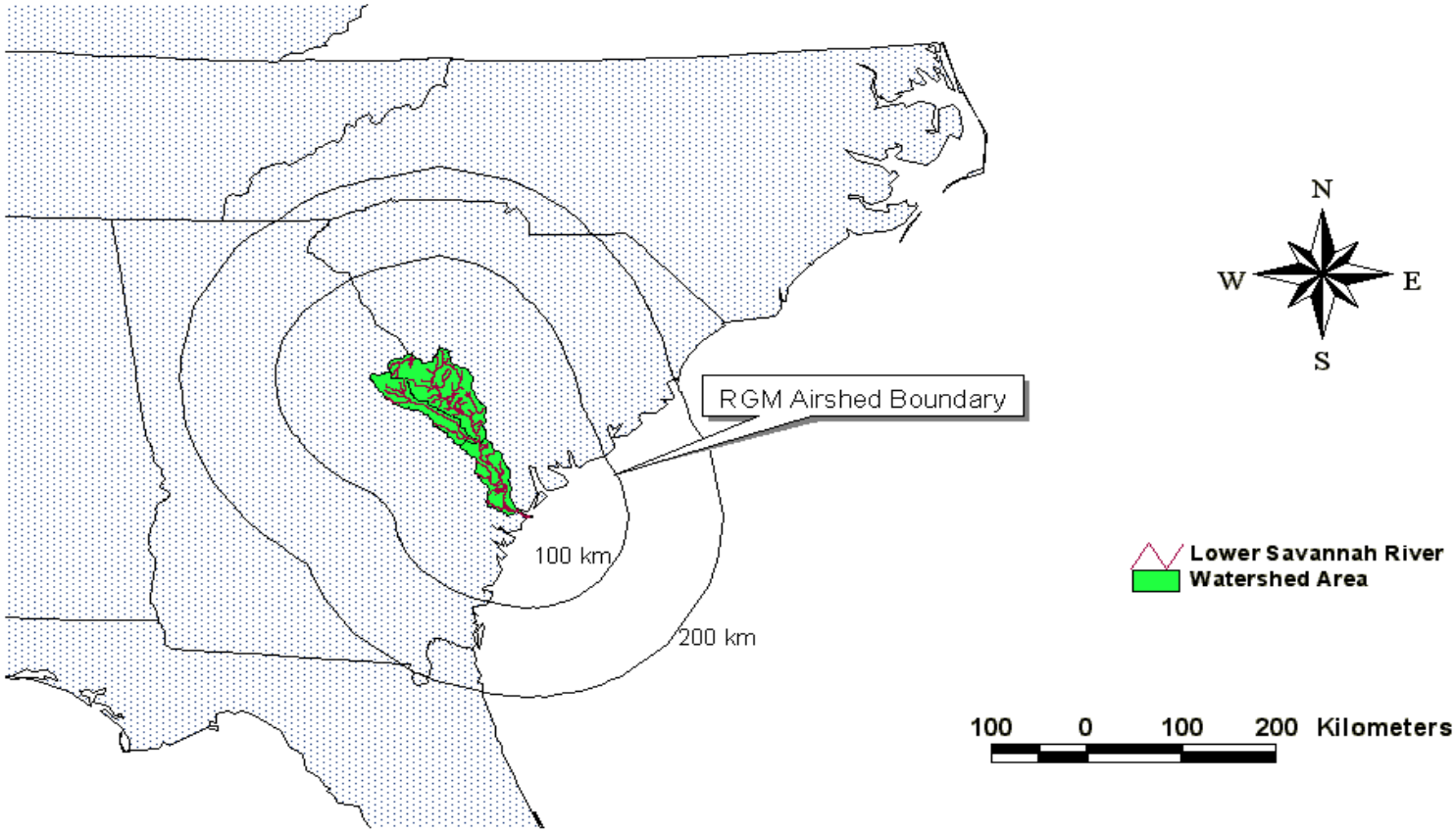
1. RGM released to the air has a relatively short residence time in the lower atmosphere (one to a few days), with the majority of the RGM in emissions being deposited within 100 km of the source.
2. Particle-bound mercury has a somewhat longer residence time in the atmosphere, but is generally deposited to the surface of the earth over longer distances (up to a few thousand km).
3. Gaseous elemental mercury has a relatively long residence time in the atmosphere (approximately one year) and is deposited over international or "global scale" distances. Chemical conversion to the divalent form is important to its deposition, and is affected by other trace elements, gases, and aerosols in the atmosphere.

Because RGM is the dominant form of mercury in both rainfall and most dry deposition processes, and because most of the RGM emitted from anthropogenic sources is deposited relatively quickly, this analysis focuses first on Clean Air Act point sources within the watershed and within a distance of 100 km around the watershed boundary, and on their emissions of RGM to the air. These sources are referred to in this document as "local sources", and the area within which they are located is referred to as the "RGM Airshed[2]." Thus, the RGM Airshed extends well beyond the borders of the Savannah River watershed. A graphical illustration of the RGM airshed is provided in Figure 1.

It should be noted that the sources evaluated in this analysis may emit all three forms of inorganic mercury. As noted above, emissions of RGM from a particular source will affect primarily the local area around the source (i.e., within 100 km), while emissions of particulate mercury from the same source are expected to be spread over a much larger area. As such, only a small proportion of the particulate emissions from local sources will be deposited within the RGM airshed. Additional studies within the U.S. have also shown that particulate mercury represents a relatively minor proportion of the mercury emitted by most sources, and contributes only a small to moderate fraction of the mercury in wet or dry deposition. Emissions of gaseous elemental mercury from local sources will also contribute little to the deposition within the RGM airshed, since they are transported long distances, and do not contribute directly to either wet or dry deposition until converted to RGM (a slow process) or adhered onto particles (which, as

[2] The term "RGM Airshed" is defined for this analysis to include an area extending 100 km from the boundary of the Savannah River watershed, including the area of the watershed (See Figure 1). For this analysis, we located sources of mercury emissions by county. In cases where the 100 km boundary included a fraction of a county, we conservatively included all sources within that county for our analysis. (Also see Section 3.3, "The Airshed" in 3.0 Discussion of Concepts and Uncertainties.)

Figure 1. Savannah River RGM Airshed



noted, tend to be spread over a much larger area than the RGM airshed).

With regard to non-local sources, they will also contribute some of the total mercury depositing to the Savannah River watershed. That is, some proportion of gaseous elemental and particulate mercury from these non-local sources will be incorporated in the wet and dry deposition to the watershed. However, complex computer air deposition modeling would be necessary to estimate the contribution from these more distant U.S. and global sources. Such modeling is beyond the scope of this first analysis in support of the TMDL.[3]

2.0 METHODOLOGY

No new air deposition modeling of mercury to the watershed was performed for this analysis. Rather, we relied on the results of a previous national modeling effort for both wet and dry deposition performed for *The Mercury Study*. The deposition of mercury within the area of the Savannah River watershed was estimated by examining the detailed deposition values that national model calculated across the U.S. The annual emissions data, which the model used to calculate deposition, were developed primarily for the time period 1994-1996 (referred to here as the baseline condition). We used this baseline emissions database and added information on required emission-controls to project the emissions inventory for a future date (2010). The year 2010 was selected as the future date because all sources subject to currently promulgated Clean Air Act (CAA) regulations for control of mercury emissions under Maximum Achievable Control Technology (MACT), and under CAA Section 129 for solid waste combustion sources, are required by the CAA to meet the new standards or close by that calendar year, or by earlier years.

Analysis of current data on water discharges and estimates of atmospheric deposition indicate that virtually all of the mercury loadings into the Savannah River watershed are caused by atmospheric deposition (both rainfall and dry deposition.) Analysis of recent research studies further shows that RGM is the dominant form of mercury in both rainfall and most dry deposition processes in the eastern United States. Therefore, EPA determined that RGM is the primary chemical form of mercury depositing to the Savannah River watershed, and that the RGM airshed (i.e., the area within the Savannah River watershed and within 100 km of the watershed boundary) is a reasonable geographic scope for an analysis of sources which contribute significantly to atmospheric deposition of mercury to that watershed.

Deposition of mercury to the Savannah River watershed was calculated based on the detailed geographic results of deposition from the national modeling in *The Mercury Study*. Numeric estimates for deposition per square meter of mercury in all forms were developed

[3]This initial attempt to characterize mercury deposition to the Savannah River Watershed is referred to as the first phase of analysis, to indicate the reliance on existing information to develop an estimate of deposition to the area. Future work, in the next few years, may utilize complex computer models in conjunction with a more refined emissions inventory for the RGM airshed and possibly including other areas in Georgia and South Carolina.

separately for wet deposition and for dry deposition. These values were then allocated to the chemical species of mercury based on the relative proportions of the species, as discussed in *The Mercury Study*, to estimate deposition to the watershed that was derived from RGM emissions during the baseline period.

The next step was to relate the baseline deposition of RGM to the baseline emissions of RGM. To estimate RGM emissions from the sources in the RGM airshed, EPA extracted data from the baseline emission inventory in conjunction with information on relative percentages of RGM in emissions as presented in *The Mercury Study*. We then used this baseline RGM emissions inventory, in conjunction with projected population growth factors and projected reductions resulting from CAA controls, to predict RGM emissions for the year 2010 within the RGM airshed. EPA then used this projected future emissions inventory for RGM to estimate the deposition of RGM in 2010 to the Savannah River watershed. This estimate was based on a simple proportion of deposition to emissions, as described below in Section 2.4. To calculate total deposition of mercury in 2010 (i.e., both wet and dry deposition of all forms of mercury) to the Savannah River watershed, EPA estimated additional deposition values for particle-bound and elemental mercury for 2010 based on the modeled deposition for the eastern U.S. in *The Mercury Study*. Deposition values of these other forms of mercury were derived using the assumption that they are directly proportional to the deposition of RGM during the baseline period. The calculation methodology is described below in Section 2.4, and the assumptions regarding proportional deposition of the forms of mercury are discussed in Section 3.4.

2.1 Baseline Deposition

The detailed deposition results calculated for *The Mercury Study* were based on the Regional Lagrangian Model of Air Pollution (RELMAP) computer modeling studies for the conterminous United States. The RELMAP study included input data on mercury emissions in various forms, meteorological data, atmospheric processes, and calculated wet and dry deposition. In this analysis, we examined in detail the RELMAP results which include the area of the Savannah River watershed. The results of the national RELMAP modeling provide annual wet and dry mercury deposition rates within each cell (of approximately 40 km x 40 km) in a grid over the entire U.S. For this Savannah River analysis, EPA determined that a greater resolution (finer grid size) was needed over the landscape of Georgia and South Carolina. This finer grid was developed by mathematical interpolation of the national RELMAP results. The deposition estimates within each of the fine grid cells that overlay the Savannah River watershed (which includes the Middle Savannah River, Brier Creek, and the Lower Savannah River) were summed to obtain estimates of the wet and dry deposition of mercury within the watershed. Within the Savannah River watershed, the average **wet** deposition of total mercury was 12.2 micrograms per square meter per year, and the average **dry** deposition of total mercury was 8.22 micrograms per square meter per year.

The watershed covers an area of approximately 9,319 square kilometers. Thus, based on the RELMAP model results, the total wet and dry deposition of mercury in the baseline period to

this watershed is approximately 190 kg per year.

We used additional analysis of the RELMAP modeling presented in *The Mercury Study* to estimate the mercury deposition to the Savannah River watershed from distant sources of particulate-bound and gaseous elemental mercury. The RELMAP national maps show a distinct pattern: the eastern half of the country receives considerably more deposition than the western half. The analysis provides ranges of deposition values as percentiles for wet and dry deposition by each form of mercury to the U.S. east of 90° W longitude. (A separate set of deposition percentiles was developed for the U.S. west of 90° W longitude.) A summary of the 50th percentile deposition values from Tables 5-5 and 5-6 in *The Mercury Study* is presented below for the eastern wet and dry mercury deposition values. The 50th percentile values are generally close (within a factor of 2) to the modeled wet deposition and dry deposition values for the Savannah River watershed provided above.

As noted above, the national RELMAP analysis included separate modeling runs for wet deposition and dry deposition for each type of mercury (gaseous elemental, divalent forms (RGM), and particulate forms) and our analysis used these percentile results of different mercury species to generate data on wet and dry deposition by mercury species in the watershed. Specifically, the "percent of sum wet" and "percent of sum dry" columns in Tables 1a and 1b were calculated by dividing the estimated deposition for each form of mercury by the sum within each table (wet or dry). For example, the "percent of sum wet deposition of mercury" for elemental mercury (Hg^O) for U.S. sources was calculated by dividing 0.181 *ug/m²/yr* by 9.927 *ug/m²/yr*, which equals approximately 2%.

Table 1a. RELMAP Wet Deposition Estimates from *The Mercury Study* (East of 90° W Longitude)

Deposition Variable	Deposition at 50th Percentile (ug/m²/yr)	% of Sum Wet Deposition of Mercury
Hg^0 (elem) from U.S. sources	0.181	2 %
Hg^{2+} (RGM) from U.S. sources	2.652	26.5 %
$Hg_{particle}$ from U.S. sources	1.956	19.5 %
Hg^0 from global sources	5.138	52 %
Sum of the Sources Above	9.927	100 %

Table 1b. RELMAP Dry Deposition Estimates from *The Mercury Study* (East of 90° W Longitude)		
Deposition Variable	Deposition at 50th Percentile ($ug/m^2/yr$)	% of Sum Dry Deposition of Mercury
Hg^{2+} (RGM) from U.S. sources	4.101	98 %
$Hg_{particle}$ from U.S. sources	0.078	2 %
Sum of the Sources Above	4.179	100 %

The discussion of RELMAP modeling in *The Mercury Study* considers the deposition which results from atmospheric gaseous elemental mercury vapor (Hg^0) in two ways: (i) as emitted from U.S. sources, and (ii) as general atmospheric "background" which this analysis refers to as "Hg^0 from global sources". Note that Table 1a, above, represents the contribution to deposition from elemental gaseous mercury, not the relative amounts of mercury which can be measured in ambient air. The RELMAP model calculated the contribution to deposition from "background" elemental mercury separately from elemental mercury emissions from U.S. sources, and considered the "background" contribution to be constantly available across the U.S., though weather patterns strongly affect its atmospheric chemistry and net deposition in different geographic regions. This analysis for the Savannah River watershed notes that elemental mercury is transported internationally, even globally, and thus considers deposition from "background" to represent the effects of global transport, thus not affected by control measures specifically within the U.S. See Sections 3.1 and 3.5 for additional discussion of elemental mercury and assumptions related to global transport and deposition within the U.S. As shown in Table 1a, approximately 52% of the total wet deposition of mercury is derived ultimately from "background" or global sources. If the total wet and dry deposition are combined, the global sources contribute about 36% of the total mercury deposition in the eastern U.S.

In this analysis, in order to estimate the separate contribution that each species and type of mercury (listed in Table 1 as "deposition variable") makes to total wet deposition and to total dry deposition, EPA utilized the analysis of the RELMAP results, using values in the 50th Percentile distribution for deposition within the eastern half of the U.S. That is, the RELMAP model generated data sets and maps of deposition across the U.S. which would be the result if each type of mercury were the sole contributor to emissions and to deposition. In *The Mercury Study* the range of RELMAP's deposition values for each type of mercury was analyzed into percentiles, and values for the 10th, 50th, and 90th percentiles were presented. (Values for the percentiles are shown in Tables 5-5 and 5-6 of Volume III of *The Mercury Study*.) This analysis for the Savannah River watershed used the values for deposition at the 50th percentile as estimators to divide total wet deposition, and total dry deposition, into their constituent source types. EPA recognizes that the deposition values for each deposition variable shown in Table 1 (e.g. wet deposition of Hg^{2+} from U.S. sources) appear to have been modeled and analyzed separately in

The Mercury Study, and that using these values in one set of calculations to allocate total mercury deposition into source types constitutes an additional step of analysis. EPA considers it valid to use these values of the 50th percentiles as estimators for relative contribution to deposition because these percentiles are based on a coordinated set of RELMAP model runs that utilized the same inputs for emissions, and the same model algorithms for atmospheric chemistry and deposition processes. Also, application of these general estimators (based on the eastern half of the U.S.) for the specific case of the Savannah River watershed is suitable because the national maps for deposition (in *The Mercury Study*) show that the geographic area of the Savannah River watershed is fairly typical of the general eastern U.S. (Also see Section 3.4 "Relating Chemical/ Physical forms of Mercury to Deposition.")

In order to calculate the deposition of mercury from various origins in relation to the total mercury deposition during the baseline period (1994-1996), we used the percentages shown in Table 1a and 1b. That is, the relative percentages are drawn from the results of the national modeling and applied to the estimated deposition values derived for the Savannah River watershed. Specifically, the estimated wet deposition for the Savannah River watershed is calculated by multiplying the "percent of total wet deposition of mercury" values from Table 1a by the average wet deposition of total mercury for the Savannah River watershed (12.2 ug/m^2/yr) according to Equation 1 : (Note that each term in Equation 1 represents annual deposition per square meter.)

$$[DEP_{Base\text{-}Wet}]_{Total} = [DEP_{Base\text{-}Wet}]_{US\text{-}elem} + [DEP_{Base\text{-}Wet}]_{RGM} + [DEP_{Base\text{-}Wet}]_{Particle} + [DEP_{Base\text{-}Wet}]_{Global} \quad \textbf{(Equation 1)}$$

Where:

$[DEP_{Base\text{-}Wet}]_{Total}$ = the total amount of wet deposition in the baseline period (this is the value derived above for average wet deposition of total mercury within the Savannah River watershed);

$[DEP_{Base\text{-}Wet}]_{US\text{-}elem}$ = the amount of wet deposition in the baseline period due to U.S. sources releasing elemental mercury;

$[DEP_{Base\text{-}Wet}]_{RGM}$ = the amount of wet deposition in the baseline period due to U.S. sources releasing RGM;

$[DEP_{Base\text{-}Wet}]_{Particle}$ = the amount of wet deposition in the baseline period due to U.S. sources of particulate mercury; and

$[DEP_{Base\text{-}Wet}]_{Global}$ = the amount of wet deposition in the baseline period due to global sources of elemental mercury.

Note that the value for $[DEP_{Base\text{-}Wet}]_{Total}$ was determined in this study by summing the total wet deposition results from the RELMAP model for grid squares which overlay the Savannah River watershed. As described above, for the baseline period the value for the average wet deposition is equal to 12.2 micrograms per square meter per year.

Substituting the percentages from Table 1a and the modeled estimate for $([DEP_{Base\text{-}Wet}]_{Total})$ gives us:

$[DEP_{Base\text{-}Wet}]_{US\text{-}elem} = (0.02)([DEP_{Base\text{-}Wet}]_{Total}) = (0.02)(12.2\ ug/m^2/yr) = 0.244\ ug/m^2/yr$

and

$[DEP_{Base\text{-}Wet}]_{RGM} = (0.265)([DEP_{Base\text{-}Wet}]_{Total}) = (0.265)(12.2\ ug/m^2/yr) = 3.23\ ug/m^2/yr$

and

$[DEP_{Base\text{-}Wet}]_{Particle} = (0.195)([DEP_{Base\text{-}Wet}]_{Total}) = (0.195)(12.2\ ug/m^2/yr) = 2.38\ ug/m^2/yr$

and

$[DEP_{Base\text{-}Wet}]_{Global} = (0.52)([DEP_{Base\text{-}Wet}]_{Total}) = (0.52)(12.2\ ug/m^2/yr) = 6.34\ ug/m^2/yr$.

The estimated dry deposition for the Savannah River watershed is calculated in an analogous fashion (Equation 2) by multiplying the "percent of total dry deposition of mercury" values from Table 1b by the average dry deposition of total mercury determined for the Savannah River watershed, that is 8.22 $ug/m^2/yr$, presented above.

(In Equation 2, note that each term represents annual deposition per square meter.)

$$[DEP_{Base\text{-}Dry}]_{Total} = [DEP_{Base\text{-}Dry}]_{RGM} + [DEP_{Base\text{-}Dry}]_{Particle} \qquad \textbf{(Equation 2)}$$

Where:

$[DEP_{Base\text{-}Dry}]_{Total}$ = the total amount of dry deposition in the baseline period; (this is the value derived above for average dry deposition of total mercury within the Savannah River watershed);

$[DEP_{Base\text{-}Dry}]_{RGM}$ = the amount of dry deposition due to RGM from U.S. sources in the baseline period; and

$[DEP_{Base\text{-}Dry}]_{Particle}$ = the amount of dry deposition due to particulates from U.S. sources in the baseline period.

Note that the value for $[DEP_{Base\text{-}Dry}]_{Total}$ is determined in this study by examining the dry deposition results from the RELMAP model for the Savannah River watershed. As described above in Section 2.1, first paragraph, this value for the average dry deposition during the baseline period is equal to 8.22 micrograms per square meter per year.

Substituting the percentages from Table 1b and the modeled estimate for $([DEP_{Base\text{-}Dry}]_{Total})$ gives us:

$$[DEP_{Base\text{-}Dry}]_{RGM} = (0.98)([DEP_{Base\text{-}Dry}]_{Total}) = (0.98)(8.22\ ug/m^2/yr) = 8.06\ ug/m^2/yr$$

and

$$[DEP_{Base\text{-}Dry}]_{Particle} = (0.02)([DEP_{Base\text{-}Dry}]_{Total}) = (0.02)(8.22\ ug/m^2/yr) = 0.164\ ug/m^2/yr\ .$$

For the first part of this analysis (calculating the ratio of RGM deposition to RGM emissions in the baseline period) we are interested in the total wet and dry deposition of RGM to the Savannah River watershed, including RGM coming from sources outside the RGM airshed. To obtain total deposition to the Savannah River watershed derived from RGM, we added wet deposition of Hg^{2+} from U.S. sources to dry deposition of Hg^{2+} from U.S. sources, as shown in Equation 3:

$$[DEP_{Base}]_{RGM} = [DEP_{Base\text{-}Wet}]_{RGM} + [DEP_{Base\text{-}Dry}]_{RGM} \quad \textbf{(Equation 3)}$$
$$= 3.23\ ug/m^2/yr + 8.06\ ug/m^2/yr$$
$$= 11.29\ ug/m^2/yr$$

The annual total deposition of RGM within the Savannah River watershed , as an average per square meter, is equal to **11.29 ug/m^2/yr** for the baseline period. The watershed covers an area of approximately 9,319 square kilometers. Thus, based on the analysis above, the total wet and dry deposition of RGM in the baseline period to this watershed area is approximately 105 kg per year.

2.2 Baseline Emissions Inventory

In this analysis, we want to develop a ratio for the baseline period which will relate the deposition of RGM into the watershed (calculated just above) to the emissions of RGM from local sources. (As we discussed above, local sources are Clean Air Act point sources located either within the Savannah River watershed or within 100 km of the watershed boundary. See Section 1.0 above.) We examined the mercury emissions data used for the RELMAP modeling in *The Mercury Study* and we summed the emissions of "total" mercury (all species and forms taken together) from all the sources in the RGM airshed. This process is discussed immediately below.

2.2.1 Calculating $[EI_{Base}]$: the emissions of "total" mercury in the baseline period.

To develop the "baseline emissions inventory," EPA examined the emissions inventory (EI) files that were used for the RELMAP modeling in order to identify stationary point sources of mercury in Georgia and South Carolina that are in the watershed or within 100 km of the

watershed boundary (i.e., within the RGM airshed). See section 3.3 for additional discussion of the airshed concept and its use in this study. We recognize that there may be additional sources of mercury emissions within the RGM airshed (i.e., mobile sources, landfills, crematories, etc.). However, emissions estimates for these categories of sources in the RGM airshed are currently unavailable. As stated in Section 1.0, in cases where the RGM airshed included a fraction of a county where the source was located, EPA conservatively included all sources in that county. The source categories located within the RGM airshed include:

- Hospital, Medical, and Infectious Waste Incinerators [36 Sources];
- Fossil Fuel Electric Utility Boilers (coal, oil, and gas) [18 Sources];
- Chlor-Alkali Plants (mercury cell) [1 Source];
- Municipal Solid Waste Combustors [3 Sources];
- Residential and Industrial Boilers [80 Counties];
- Pulp and Paper Plant Recovery Furnaces [12 Sources];
- Portland Cement Manufacturing (two burn some hazardous waste) [3 Sources];
- Sewage Sludge Incinerators [6 Sources]; and
- Hazardous Waste Incinerators [2 Sources; different from the cement manufacturing sources].

The emissions inventories available for these source categories provide only the value for the total amount of mercury released and do not specify the physical and chemical species of mercury (gaseous elemental, divalent, or particulate). This limitation on details of species of mercury emitted is characteristic of essentially all emissions inventories at state and national levels.

EPA and the States are continuing to refine mercury emissions inventories (EIs), and more recent EIs than those used in *The Mercury Study* are being developed. We recognize that these newer EIs may provide updated estimates of the current mercury emissions in the RGM airshed. However, our analysis relies on comparison to the emissions used in the RELMAP model and the deposition values that the model calculated from that inventory. Therefore, to mix data from other EIs into the basic data used by RELMAP would not be consistent. Future work for a later phase of the TMDL may include development of a more recent and refined EIs to be used in conjunction with an updated modeling analysis.

2.2.2 Calculating $[EI_{Base}]_{RGM}$: emissions of RGM in the baseline period.

To relate deposition of RGM to emissions of RGM, it was necessary to refine the emissions data of "total" mercury to focus on emissions of RGM. The national RELMAP modeling for *The Mercury Study* developed estimates of the percentage of RGM in the total mercury emitted for each source category. This analysis uses the same percent RGM estimates developed for the national RELMAP modeling, using the values in Table 4-2 in Volume III of *The Mercury Study*. The percentages of RGM in mercury emissions from each source category in the Savannah River RGM airshed are as follows:

- Hospital, Medical, and Infectious Waste Incinerators: 73%;
- Fossil Fuel Electric Utility Boilers (coal, oil, and gas): 30% ;
- Chlor-Alkali Plants (mercury cell): 30%;
- Municipal Solid Waste Combustors: 60%;
- Residential and Industrial Boilers: 30%;
- Pulp and Paper Plant Recovery Furnaces: 30%;
- Portland Cement Manufacturing: 10%;
- Portland Cement Plants that burn some hazardous waste fuel: source-specific (here, one 86% and one 94%);
- Sewage Sludge Incinerators: 60%; and
- Hazardous Waste Incinerators: source-specific (here, one 8% and one 95%).

The Mercury Study RELMAP modeling also included estimated emissions from "area sources[4]" on a per county basis, and assigned a speciated profile of 0% (zero percent) emitted as RGM. Therefore, RGM emissions from area sources were not included in this analysis.

The results of this analysis for RGM emissions in the 1994-1996 base period are summarized in Table 2. A detailed presentation by each source category is provided in Appendix I. Based on this methodology (summing the data shown in Appendix I), the total RGM emissions for the baseline period from sources within the Savannah River RGM airshed ($[EI_{Base}]_{RGM}$) was determined to be **1760 kg/yr**.

2.3 Projected Future Emissions Inventory (for 2010)

To continue this analysis, we needed to develop a ratio that will relate the future deposition of RGM into the watershed to the future emissions of RGM from local sources. First, we used available information from the baseline emissions inventories discussed above to calculate a projected inventory of emissions for the year 2010. To develop an estimate for emissions of RGM from local sources, we considered both: probable growth in their activities (thus growth in their emissions), and the reductions in emissions of mercury that will be required by regulations and standards as currently promulgated.

2.3.1 Calculating $[EI_{2010}]$ and $[EI_{2010}]_{RGM}$

To estimate the emissions inventory in the year 2010, we developed "growth factors" for each of the source categories in the RGM airshed. The growth factors use population increase

[4]Use of the term "area sources" here refers to its meaning in the Clean Air Act. An "area source" is any source of hazardous air pollutants (HAP) that is not defined as a "major source." A "major source" is one that emits or has the potential to emit 10 tons or greater per year of any single HAP or 25 tons per year or greater of HAPs in aggregate. Thus "area sources" may be a number of small sources, such as residential heating units, within a given area; or the term may refer to net diffusion into the air from land uses, such as plowed land or forestry.

Table 2. Summary of Mercury Emissions in the RGM Airshed during the Baseline Period (1994-1996)						
Source Category	**No. of Sources**	**Total Hg Emissions Baseline Period (kg/yr)**	**% of Total Hg**	**% of Total Hg that is RGM**	**Total RGM Emissions Baseline Period (kg/yr)**	**% of Total RGM**
MedWIs	**36**	**963**	**25.65**	**73**	**703**	**39.93**
Power Plants	**17**	**866**	**23.08**	**30**	**260**	**14.76**
Chlor-alkali	**1**	**597**	**15.92**	**30**	**179**	**10.18**
MuniWCs	**3**	**589**	**15.69**	**60**	**353**	**20.08**
Res/Ind Boilers	**80***	**477**	**12.70**	**30**	**143**	**8.12**
Pulp and Paper	**12**	**121**	**3.23**	**30**	**36**	**2.06**
Portland Cement	**3**	**113**	**3.01**	**10**	**70**	**3.95**
Sew Sludge Incin.	**6**	**26**	**0.69**	**60**	**16**	**0.88**
HazWIs	**2**	**1**	**0.03**	**8-95**	**<1**	**0.02**
Total	**160**	**3753**	**100.00**		**1760**	**100.00**

* This value indicates the number of counties in the study area with residential or industrial boilers. The emissions inventory for the residential/industrial boiler source category provides total mercury emissions by county. Of the 80 total counties, 51 counties are in Georgia and 29 are in South Carolina.

projections between the years 1995 and 2010 as a surrogate for growth in mercury emissions from the source categories in question (the U.S. Census Bureau only provides estimated population increases between 1995 and 2010 at the State and Regional level). We also identified the Maximum Achievable Control Technology (MACT) and Solid Waste Combustion standards applicable to these source categories for which compliance must be achieved between 1995 and 2010 and the amount by which they are expected to reduce emissions of RGM from these sources. Once EPA developed growth factors and identified expected MACT-related emission reductions, EPA estimated the projected mercury emissions in 2010 by multiplying the baseline period (1994-1996) emissions of total mercury from each source category by the growth factor, and by multiplying that value by the percent total mercury that EPA expects would still be released following implementation of the applicable MACT or waste combustion standard. To estimate the 2010 emissions of RGM ($[EI_{2010}]_{RGM}$), we then multiplied the estimated 2010 total mercury emissions for each category by the percentage of the mercury emitted that is RGM for that source category. The results of these calculations are summarized in Table 3 and presented for each point source in the tables included in Appendix I.

In the particular geographic area of Georgia and South Carolina included in our "RGM Airshed", there were nine Source Categories emitting mercury to the air. Table 2 lists these in order of their emissions of Total Mercury during the baseline period. In our calculations of the estimated reductions in future emissions, only those standards which were promulgated by November, 2000, were included. That is, this document calculates that expected reductions in emissions by 2010 will reflect full implementation of CAA regulations for only three source categories: Municipal Waste Combustors (MWI), Medical Waste Incinerators (MWI, known more formally as Hospital, Medical and Infectious Waste Incinerators), and Hazardous Waste Incinerators ("HazWI" in Table 2 and Table 3.) Section 4.0 gives additional information on the relevant sections of the Clean Air Act, and enactment dates for these standards. The Draft version of this document, released in December, 2000, did include calculations of future emissions for the chlor-alkali plant in this watershed which included an estimate of possible controls that facility might implement by 2010. That draft calculation used a percent reduction in future emissions of total mercury based on information from engineers studying this source category. However, as of February, 2001, a MACT or related standard for the source category of Chlor-alkali plants using mercury cell technology has not been formally proposed. (EPA expects to propose such a regulation in 2001, with promulgation possibly coming later.) This document in its current version used in its calculations only those reductions in emissions which are based on promulgated standards. Thus in this document, the calculations for the chlor-alkali plant assume no percent reduction in emissions of total mercury in 2010.

For all but three source categories, EPA projects that the percentage of total mercury emissions comprised by RGM will remain constant from the baseline period to 2010. For two source categories, implementation of the Clean Air Act standards is expected to result in changes to the RGM percentage. EPA expects that compliance with the CAA standards (reflecting MACT) for municipal waste combustors (MWCs) will reduce emissions of RGM by 100% (i.e., no RGM emissions after MACT compliance). For medical waste incinerators (MWIs), EPA expects the RGM percentage to be reduced from 73% to 50%. All of the RGM percentages, with

the exception of the chlor-alkali plant for 2010 (see next paragraph), are identical to those used for the RELMAP modeling done for *The Mercury Study*. (See Table 4-2 of Volume III of *The Mercury Study*). For our calculations concerning MWCs and MWIs we used the pre-MACT RGM percentages for the baseline period and post-MACT RGM percentages for 2010.

In addition, for the calculation in this document only, EPA revised the percentage RGM for the sole chlor-alkali plant in the RGM airshed to be approximately 5% for 2010, compared to 30% in the RELMAP database for the baseline period. This change in percentage RGM is based on recent emissions testing at this particular facility. Preliminary results indicated the percent RGM in the emissions ranged from 1% to 5% (with a few measurements of higher percents.) Because the testing was short term and limited by weather, and because the change in RGM percentage is significant, the value of 5% was chosen as an interim value for this calculation. The 5% value is at the upper end of the range of measurements (1%-5%) and thus results in less of a change from the 30% value used in the RELMAP database. Note that because of the preliminary nature of the tests and analyses at that facility, the use in this document of 5% RGM in emissions from this chlor-alkali plant does not constitute an official EPA position on the nature of speciated mercury emissions for this plant or for the source category of mercury-cell chlor-alkali plants.

Facilities in the baseline emissions inventory that have closed between 1995 and 2000 (based on recent information from Georgia and South Carolina agencies) were considered to have no emissions of mercury in 2010. Each facility which is still active (not closed) in the year 2000 is assumed to still be active in 2010. For purposes of estimation, we assumed that each facility would have growth in its activity the same as the average growth factor for that source category. The growth factors for each category were developed as follows:

1. For municipal waste combustors, it was presumed that most waste comes from the nearby populations (i.e., that waste is not shipped in from distant locations). Since the state is the lowest division of geographic detail provided by the U.S. Census Bureau for population increase, the projected percentage increase in state population was used as a surrogate for the increase in waste generation and the corresponding increase in RGM emissions for each of the municipal waste combustors in question. We recognize that the mercury content in the solid wastes being generated may be decreasing due to voluntary recycling and reduction efforts. However, data to support this reduction is not readily available so a conservative approach of assumed growth is included in this analysis.

2. For medical waste incinerators, it was presumed that most people visiting a medical facility come from nearby populations (this is especially true with county hospitals). Since the state is the lowest division of geographic detail for population increase, the projected percentage increase in state population was used as a surrogate for increase in medical waste generation and the corresponding

increase in RGM emissions from each of the hospital incinerators in question. As with municipal waste combustors, we recognize that the mercury content in the medical wastes being generated may be decreasing due to voluntary recycling and reduction efforts. However, data to support this reduction is not readily available so a conservative approach of assumed growth is included in this analysis. Because of new MACT requirements, most small hospital medical waste incinerators in Georgia were closed by the year 2000. The information on sources in South Carolina was updated where possible and many of the small facilities are also expected to close, but data on operating status since 1996 was not available for some of the sources. For these sources, we conservatively assumed continued operation and typical growth rates for waste incineration and emissions to 2010.

3. For electric utility power plants, it was presumed that energy usage would generally be expected to rise as population over a large area increases, since power companies commonly sell their electricity over a regional (or larger) grid. The projected percentage increase in the population of the Southeast was used as a surrogate for RGM emission increases for each of the power plants in question.

4. For portland cement manufacturing plants, it was presumed that cement production would increase proportionately with increases in population over a large area, since cement companies commonly sell their product over a regional (or larger) area. The projected percentage increase in Southeast's population was used as a surrogate for portland cement plant RGM emission increases for each of the plants in question.

5. For pulp and paper plants, it was presumed that production would increase as population over a larger area increases, since pulp and paper plants commonly sell their product to customers over a large area. The projected percentage increase in the Southeast's population was used as a surrogate for pulp and paper plant RGM emission increases at each of the facilities in question.

6. For municipal sludge incinerators, it was presumed that most municipal sludge results from the nearby populations (i.e., that sludge is not shipped in from distant locations). Since the state is the lowest division of geographic detail for population increase, the projected percentage increase in state population was used as a surrogate for the increase in sludge incineration and the associated RGM emission for each of the municipal sludge incinerators in question.

7. For the chlor-alkali plant, it was presumed that production would increase as population over a larger area increases, since the chlor-alkali plant commonly supplies its product to a paper mill which in turn sell their products to customers over a large area. As such, the projected percentage increase in the Southeast's population was used as a surrogate for chlor-alkali plant RGM emission increases

for the plant in question.

8. For residential and industrial boilers, the original emissions inventory data was supplied as county totals for mercury emissions. Since it was not known what portion of the county level aggregates is due to industrial and residential boilers, the larger projected growth factor (state versus regional) was used as a conservative estimate of growth in RGM emissions from these sources.

9. For hazardous waste incinerators, the few sources within the RGM airshed are known to be on-site units, handling wastes generated at the facility. The Hazardous and Solid Waste Amendments (HSWA) to the Resource Conservation and Recovery Act (RCRA) require facilities that handle hazardous wastes to have a "Waste Minimization Plan," which is required to be periodically updated. Because of these ongoing efforts to reduce the generation of hazardous wastes, we assumed that such efforts would offset possible growth in the mercury emissions from this activity. As such, no net growth in hazardous waste incineration RGM emissions was assumed by 2010.

Based on this methodology, EPA calculated that in the year 2010 the emissions of RGM from point sources within the RGM airshed ($[EI_{2010}]_{RGM}$) would be **665 kg/yr**. (See Table 3).

Table 3. Summary of Mercury Emissions in the RGM Airshed Projected for 2010						
Source Category	**No. of Sources Projected in 2010**	**Total Hg Emissions 2010 (kg/yr)**	**% of Total Hg**	**% of Total Hg That is RGM**	**Total RGM Emissions 2010 (kg/yr)**	**% of Total RGM**
Power Plants	17	1010.5	37.60	30	303.1	45.62
Chlor-alkali	1	698.9	26.01	5	35.0	5.26
Res/Ind Boilers	80*	565.0	21.03	30	169.5	25.51
Pulp and Paper	12	141.7	5.27	30	42.5	6.39
Portland Cement	3	118.9	4.43	10	69.8	10.51
MuniWCs	3	69.0	2.57	0	0.0	0.00
MedWIs	10	53.0	1.97	50	26.4	3.98
Sew Sludge Incin.	6	30.3	1.13	60	18.2	2.74
HazWIs	1	0.2	0.01	8-95	0.01	0.00
Total	133	2687.4	100.00		664.5	100.00

* This value indicates the number of counties in the study area with residential or industrial boilers. The emissions inventory for the residential/industrial boiler source category provides total mercury emissions by county. Of the 80 total counties, 51 Counties are in Georgia and 29 are in South Carolina.

2.4 Projected Future Deposition (for the year 2010)

One key goal in this analysis is to estimate deposition of total mercury (all forms, from all sources and areas) to the Savannah River basin for the year 2010. Our basic assumption is that, for RGM, the ratio of deposition to emissions in the future year will be essentially the same as the ratio of deposition to emissions in the baseline period. EPA believes this is a reasonable assumption because the ratio represents a general relationship resulting from basic chemistry and physics of atmospheric transport, which will remain essentially the same in future years. That is, we have no reason now to project that the atmospheric conditions in Georgia and South Carolina will be greatly different (due to events such as widespread, long-lasting forest fires or major changes in the regional atmospheric chemistry) in 2010 than during the baseline period of 1994-1996. For both time periods, the deposition under analysis is an annual sum of deposition to the Savannah River watershed, and the emissions for both time periods are from Clean Air Act point sources in the "RGM airshed" (the watershed plus the counties within 100 kilometers of the watershed). In addition, we are assuming that the year 2010 will be a year with "average" meteorology for the U.S., comparable to the RELMAP model use of "average" meteorology for the baseline period. (In the RELMAP model runs, the weather data from 1989 was used, because meteorology in that year was generally average across the country.)

2.4.1 Calculating $[DEP_{2010}]_{RGM}$: the future deposition of RGM to the watershed.

To estimate the RGM deposition in 2010 that results from anthropogenic sources within the RGM airshed, the ratio of the modeled RGM deposition in the Baseline period (1994-1996) to the RGM emissions from sources in the RGM airshed for the same period was compared to a similar ratio for 2010 by a simple proportion (**Equation 4)**:

$$\frac{[DEP_{Base}]_{RGM}}{[EI_{Base}]_{RGM}} = \frac{[DEP_{2010}]_{RGM}}{[EI_{2010}]_{RGM}} \qquad \textbf{(Equation 4)}$$

Where:

$[DEP_{Base}]_{RGM}$ = the total annual deposition of RGM to the Savannah River watershed in the baseline period (1994-1996), as calculated above in Equation 3.

$[DEP_{2010}]_{RGM}$ = the projected total annual deposition of RGM to the Savannah River watershed in 2010 (this is the value to be solved for in Equation 4.)

$[EI_{base}]_{RGM}$ = the annual emissions of RGM from local sources within the

RGM airshed, based on data gathered during the 1994-1996 base period (Table 2.)

$[EI_{2010}]_{RGM}$ = the projected emissions estimate for RGM during 2010 from a projected inventory of sources within the RGM airshed (Table 3.)

Substituting values for these parameters gives us:

$$[DEP_{2010}]_{RGM} = \frac{[DEP_{Base}]_{RGM} \times [EI_{2010}]_{RGM}}{[EI_{base}]_{RGM}}$$

$$= \frac{(11.29\ ug/m^2/yr) \times (665\ kg/yr)}{(1760\ kg/yr)} = 4.27\ ug/m^2/yr$$

As discussed in Section 2.1, the watershed covers an area of approximately 9,319 square kilometers. Thus, the projected total wet and dry deposition of RGM on the watershed in 2010 is approximately 40 kilograms per year.

2.4.2 Calculating $[DEP_{2010}]_{Total}$: future deposition of "total" mercury to the watershed.

In Section 2.4.1, we calculated an estimate of the amount of RGM deposited from the air to the Savannah River watershed in a future year, 2010. However, we know that additional sources of mercury from outside the RGM airshed will contribute to the overall depositional loading. In earlier sections, we estimated what this overall loading would be for a baseline period. However, we do not know what the loadings of these additional sources of mercury would be for the future year. Thus, to estimate the deposition of **total** mercury to the watershed for the year 2010, additional steps were needed. Specifically, we added an estimated value for annual deposition from global sources of elemental mercury as well as values for U.S. sources of both elemental and particulate mercury. The procedure we used to obtain these values is provided below.

2.4.2.1 Calculating $[DEP_{2010}]_{Global}$

Since we had no way to determine how the deposition from global background mercury would change over the approximately 15 year projection period (approximately 1995 to 2010), we presumed that the deposition from globally circulating mercury will be essentially the same during the year 2010 as for the baseline period (1994-1996). This assumption reflects the expectation that, while mercury emissions from fossil fuel combustion for energy production are likely to increase in developing countries, the industrialized nations are expected to continue adding new controls on their sources to reduce mercury emissions. Based on this assumption, EPA projected mercury deposition from global background sources in 2010 to be the same as for the baseline period (Equation 5):

$$[DEP_{2010}]_{Global} = [DEP_{Base\text{-}Wet}]_{Global} = 6.34 \text{ ug/m}^2\text{/yr} \quad \textbf{(Equation 5)}$$

2.4.2.2 Calculating $[DEP_{2010\text{-}Wet}]_{US\text{-}elem}$, $[DEP_{2010\text{-}Wet}]_{particle}$, and $[DEP_{2010\text{-}Dry}]_{particle}$

To estimate deposition resulting from U.S. elemental and particulate mercury sources for 2010, we presumed that the amounts of these species, relative to the amount of RGM deposited from U.S. sources, would not vary between the baseline period and the future year. From Tables 1a and 1b we know that the amount of RGM deposited from U.S. sources in the baseline period is the sum of wet and dry deposition from U.S. sources during that time (Equation 6):

$$[DEP_{Base\text{-}RGM}]_{US\text{-}Total} = [DEP_{Base\text{-}Wet}]_{RGM} + [DEP_{Base\text{-}Dry}]_{RGM} \quad \textbf{(Equation 6)}$$
$$= 2.652 \text{ ug/m}^2\text{/yr} + 4.101 \text{ ug/m}^2\text{/yr}$$
$$= 6.753 \text{ ug/m}^2\text{/yr}$$

Once this value is calculated, it is a straightforward exercise to estimate the amounts of U.S.-derived particulate and elemental mercury during the baseline period relative to this value. Table 4 presents these values as percentages of the baseline period RGM amount.

Table 4. Elemental and Particulate Deposition from U.S. Sources Relative to RGM Deposition from U.S. Sources
Baseline Period
East of 90° W longitude

Deposition Variable	Deposition at the 50th Percentile (ug/m²/yr)	% (Relative to Total Hg^{2+})
Wet Hg^0 from U.S. sources	0.181	3 %
Wet $Hg_{particle}$ from U.S. sources	1.956	29 %
Dry $Hg_{particle}$ from U.S. sources	0.078	1 %
Total (Wet +Dry) Hg^{2+} from U.S. sources	6.753	100 %

Using these percentages and the assumption that they do not vary between the baseline period and the future year (see Section 3.4 for a discussion of this assumption), we can calculate the amount of future year contribution from U.S. elemental and particulate sources by multiplying the percentages in Table 4 by the estimated amount of RGM deposition to the

watershed in 2010 (as estimated above in Section 2.4.1), thus:

$$[DEP_{2010\text{-}Wet}]_{US\text{-}elem} = (0.03)([DEP_{2010}]_{RGM}) = (0.03)(4.27\ ug/m^2/yr) = 0.13\ ug/m^2/yr$$

and

$$[DEP_{2010\text{-}Wet}]_{particle} = (0.29)([DEP_{2010}]_{RGM}) = (0.29)(4.27\ ug/m^2/yr) = 1.24\ ug/m^2/yr$$

and

$$[DEP_{2010\text{-}Dry}]_{particle} = (0.01)([DEP_{2010}]_{RGM}) = (0.01)(4.27\ ug/m^2/yr) = 0.04\ ug/m^2/yr\ .$$

Once these estimated values for deposition of mercury to the Savannah River watershed from U.S. sources were calculated for 2010, the total mercury deposition to the Savannah River watershed was determined by adding the projected deposition of RGM with projected deposition from U.S. and global mercury sources (Equation 7):

Projected Total Hg Deposition to Savannah River Watershed in 2010 =

$$[DEP_{2010}]_{RGM} + [DEP_{2010\text{-}Wet}]_{particle} + [DEP_{2010\text{-}Dry}]_{particle} + [DEP_{2010\text{-}Wet}]_{US\text{-}elem} + [DEP_{2010}]_{global} = \quad \textbf{(Equation 7)}$$

$$(4.27)_{RGM} + (1.24)_{[Wet]Particle} + (0.04)_{[Dry]Particle} + (0.13)_{[Wet]US\text{-}elem} + (6.34)_{Global}$$

$$= 12.0\ ug/m^2/yr\ .$$

Based on this methodology, the projected annual deposition of total mercury to the Savannah River watershed for the year 2010 is estimated to be **12.0 ug/m^2/yr**.

As discussed in Section 2.1, the watershed covers an area of approximately 9,319 square kilometers. Thus, the projected annual deposition of total mercury in 2010 to the watershed is approximately 112 kilograms per year.

2.5 Estimated Reductions in Future Deposition (2010) from the Baseline Period

Since the total deposition value is based on the relative deposition from different types of sources in the 50th percentile distribution of RELMAP modeled deposition, we conducted a sensitivity analysis to determine the variability in the projected annual deposition of total mercury to the Savannah River watershed. Specifically, we evaluated the 10th percentile and 90th percentile results from the RELMAP analysis provided in Tables 5-5 and 5-6 of Volume III of *The Mercury Study*. Table 5 provides the projected 2010 deposition estimates for the 10th, 50th and 90th percentiles. (Also see Section 3.4 for additional discussion on using these percentiles.)

As can be seen in Table 5, the estimated percent reductions for total mercury deposition for the Savannah River watershed range from **38%** to **48%** over the 15 year period. If we consider only the deposition of RGM, Table 6 shows an estimated **62%** reduction in RGM deposition over the 15 year period. The lower estimated percent reduction for total mercury deposition is primarily a result of adding the deposition from the global sources (which we assumed to remain constant from the baseline period to 2010).

Table 5. Total Mercury Deposition Estimates

	Based on 10th Percentile	Based on 50th Percentile	Based on 90th Percentile
Baseline Total Hg Deposition in the Savannah River Watershed (Fg/m^2/yr)	20.42	20.42	20.42
Projected 2010 Total Hg Deposition in the Savannah River Watershed (Fg/m^2/yr)	12.7	12.0	10.7
Percent Reduction	38%	41%	48%

Table 6. RGM Deposition Estimates

	Based on 10th Percentile	Based on 50th Percentile	Based on 90th Percentile
Baseline RGM Deposition in the Savannah River Watershed (Fg/m^2/yr)	10.7	11.3	12.7
Projected 2010 RGM Deposition in the Savannah River Watershed (Fg/m^2/yr)	4.03	4.27	4.79
Percent Reduction	62%	62%	62%

3.0 DISCUSSION OF CONCEPTS AND UNCERTAINTIES

3.1 The RELMAP National Model of Atmospheric Deposition

This analysis of past and future deposition of mercury from the atmosphere depends heavily on the RELMAP modeling; the uncertainties inherent in that modeling remain a part of this process. The national inventory of emissions developed during the early 1990s included many first-time estimates for mercury emissions to the air from many of the point sources. During the preparation of the emission inventory data sets for the RELMAP modeling, EPA updated its estimated emissions for several source categories and individual sources, although the techniques to develop quantitative emission estimates remained somewhat limited. For the model calculations, the total emissions had to be allocated between the chemical/physical species of mercury, and this was dependent on limited studies in Europe, and a very few speciated-mercury emissions tests within the U.S.. *The Mercury Study* states that:

> *A wide variety of alternate emissions speciations have been simulated for important groups of atmospheric mercury sources in order to test the sensitivity of the RELMAP results to the speciation profiles used. [Bullock et al., 1997B]. This work showed that the RELMAP modeling results are very strongly dependent on the assumed emission speciations.* [Vol.III, p.4-4]

The constraint on modeling produced by limited test data on speciated mercury emissions continues to affect current modeling efforts. Thus the RELMAP results have no more uncertainty in this area than other models available at this time. This analysis utilizes the RELMAP data and results because the RELMAP work was widely reviewed and is considered to provide a useful overall analysis, as discussed in the second paragraph below.

Other aspects of the RELMAP modeling are also considered as contributing to uncertainty, such as the meteorological data and limits of Lagrangian type of computer models. For RELMAP, the meteorological data for the year 1989 were used, since the weather that year was fairly average over most of the U.S. The RELMAP representation of the mercury deposition from "background" was also limited by the constraints of that particular Lagrangian model. Background refers to elemental mercury which is transported internationally, thus the sources for it are "global". The background concentration of mercury in the air is fairly small but the available reservoir in the atmosphere is large. The elemental mercury is removed (deposited) from the atmosphere very slowly, but over a year's time the total deposition is significant. The RELMAP approach may have somewhat overestimated the deposition derived from "global" sources of elemental mercury because the atmospheric background concentration was assumed to remain available at a consistent level, rather than declining as air masses move across the U.S. Likewise, the atmospheric concentration of elemental mercury was not related to inputs into the modeling domain from different compass directions (i.e. across different U.S. borders). Depending on the altitudes and pathways for long-distance inputs of mercury, mixing and precipitation events, and atmospheric chemistry (especially in clouds), newer models using updated atmospheric chemistry for mercury may provide a more refined estimate of deposition

due to mercury transported internationally from global sources.

Notwithstanding the uncertainties noted in the two paragraphs above, EPA has confidence in the underlying studies that EPA used for this current analysis because scientists and interested parties provided detailed and extensive review of *The Mercury Study* and the RELMAP model results and analysis (including their uncertainties) prior to their publication. The background data, including the emissions inventory and the speciation profiles for mercury emissions and the RELMAP computer modeling, have generally been accepted as reasonable and useful to the understanding of atmospheric deposition of mercury in the continental United States.

Also, comparison of the RELMAP results for wet deposition with recent field data indicates that the model's predictions were reasonably correct. In *The Mercury Study*, the RELMAP results for deposition were compared to the available data (1996-1997) for monitored wet deposition of mercury. Since the study was published in 1997, the Mercury Deposition Network (MDN) has been expanded, so that now more data from actual measurements are available. In general, any one year's particular variations in weather (especially precipitation) has considerable influence on measured wet deposition of mercury; so making close comparisons of model results to only a few years' specific data has inherent limitations. In general, the MDN data correlate reasonably well with the RELMAP modeled wet deposition values over much of the U.S. For the Savannah River watershed, the nearest MDN site with wet deposition data from weekly monitoring is in Richland County, SC, approximately 90 km to the northeast of the watershed. The monitoring data for total mercury in wet deposition at this South Carolina site were: 13.5 micrograms per square meter in 1997, 12.8 micrograms per square meter in 1998, and 8.1 micrograms per square meter in 1999 (preliminary calculation for 1999.) These measured values are similar to the modeled estimate for wet deposition to the Savannah River watershed (12.2 micrograms per square meter), derived in this exercise using RELMAP model results for the baseline period.

3.2 Other Atmospheric Computer Models or Direct Calculation

In conducting this analysis of deposition, EPA considered obtaining atmospheric models newer than RELMAP and preparing an updated emissions inventory, then using these tools to conduct specific modeling focused on the southeastern U.S., or particularly on an area of Georgia and South Carolina. Three models were considered: Industrial Source Complex Short Term, Version 3 (ISCST3) (for small areas, generally only 100 km across), and the national-scale models Regulatory Modeling System for Aerosols and Deposition (REMSAD) and Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT). However, the working versions currently available for all of these models have calculation routines for mercury chemistry and deposition that present limitations similar to those for RELMAP. The two national-scale models are undergoing updates to their mercury calculation routines; the improved versions of the models are expected to be available sometime during calendar year 2001. Because of the limitations of each of these other models available during 2000, EPA decided for this analysis to use the

published and reviewed RELMAP modeling results and associated data on emissions. In addition, this analysis for the Savannah River watershed was prepared within a short time frame which would not allow time for the detailed work needed to develop updated emissions inventories and to test and run new versions of complex computer models.

EPA recognizes that the method of calculation used here, which focuses on reactive gaseous mercury (RGM) and derives an estimated deposition in the future by comparing ratios of RGM deposition to RGM emissions from local sources (those within the RGM airshed), is not equivalent to a full, computer modeling analysis. However, this approach does provide an estimate of future deposition based on considerations of both expected growth in activity and emissions by the sources, plus estimated reductions achieved through additional controls placed on emissions through the Clean Air Act. The estimated reduction percentages for specific source categories presented in Appendix I were taken directly from the supporting information for the MACT rule-making for each of these source categories. We recognize that we have used national averages for estimated reductions to be achieved by compliance with the MACT standards; these averages are based on the full range of processes and control options within a source category, across the nation. The actual level of reductions in emissions as controls are improved will vary for each source facility depending on the level of control already in place at the time the MACT standard becomes effective. A more in-depth analysis, including a source-by-source evaluation of facilities in the RGM airshed for the Savannah River, would be needed to obtain the details of changes in processes or controls and thus reductions in mercury emitted. Because this analysis was needed in a relatively short time, we used the national averages for reductions to be achieved under the new combustion rules. Evaluating each of 80 sources as to its present processes and control equipment and calculating its particular reductions after applying new controls would require more time and engineering analyses than were available for this first-stage analysis. Such a detailed source-by-source analysis may be developed in the future for further refinements of the emissions inventory and possible additional analyses or computer modeling.

3.3 The Airshed

The term and concept of an “airshed” is less well known than “watershed”, and can be somewhat more difficult to define. Basically, an airshed is a geographic area that includes a variety of sources that emit a certain pollutant to the atmosphere, and where the area of the airshed includes all the sources whose emissions contribute to a significant loading or impact to a receptor, by way of atmospheric deposition. Typically the “receptor” can be a watershed (itself a geographic area) or the water surface of a large lake or estuary which receives wet and dry deposition of the pollutant of concern. Different types of pollutants vary considerably in characteristics such as: how long they persist in the air, how far they are transported (in typical weather patterns of a region), and the mechanisms by which they are removed from the air. For example, each chemical species of mercury in gaseous form has different patterns of transport and deposition, and various particles and aerosols with mercury adsorbed have still different patterns. A particular airshed generally surrounds the receptor (watershed or water body) that it

affects, particularly in the eastern U.S. where wind directions often come from all compass directions when considered over a full year. The shape of an airshed depends on whether there is a predominant wind direction, and also on how precipitation relates to wind direction. The size of an airshed depends on how far the specific pollutant of concern is distributed from its emission source, and upon defining some numeric level for "significant" deposition. Generally there is a gradient around each point source, where more deposition (per square meter) of the pollutant occurs fairly near the source and then declines as one moves farther away from the source. In some detailed computer models of atmospheric deposition, all the sources that can be "upwind" of the receptor (watershed) being studied are evaluated as to how far their emissions are transported. Sources situated so that only a small percentage of their emissions are likely to reach the watershed boundary are considered to be outside the airshed of that particular receptor (watershed.) Sources situated such that a significant percentage of their deposition does enter the watershed boundary are considered to be within the airshed of that particular watershed. The setting of "significant percentage" can be complex, but figures of 66% or 75% of emissions are commonly used in particular computer models to define an airshed. It must be understood that calculating or defining an airshed boundary, even with computer modeling, does not mean that there is some sudden change in the importance of sources as one crosses that boundary. Rather the airshed boundary represents an estimate of some degree of significance of contribution to deposition, as one moves along gradients away from the receptor area.

The RELMAP model and the REMSAD and HYSPLIT models, like other computer models that are useful in evaluating atmospheric deposition, do not calculate or define boundaries of specific airsheds to correspond to specific watersheds or water bodies. Generally they are used to model the atmosphere over a large geographic area, much larger than a specific airshed is likely to be, and include all the sources emitting the pollutant of concern. The model calculations incorporate all the emissions, their overall transport and atmospheric reactions, and the resultant deposition to all parts of the geographic area. (Generally the results are expressed as a numeric value for deposition within each square of a grid which is used to subdivide the geographic area.) This analysis for the Savannah River watershed is based on the RELMAP model, so defining the RGM airshed cannot be derived directly from the model. Rather the results of the model and other research results are consulted to estimate an area within which deposition of RGM can be considered significant. The RELMAP results indicate that significant deposition occurs within two grid squares (each about 40km across) around a strong point source, with some deposition continuing into one adjacent grid square (thus to a distance of 80 to 120 km.) Various research publications on mercury, that discuss mercury's chemical species, give a range of significant deposition for RGM that varies from 50 or 60 km to as much as 200 km. For this analysis, the RGM airshed for the Savannah River watershed was set at a distance of 100 km around the watershed (and also includes the watershed area itself.) EPA chose 100 km because it is near the mid range of the various distances proposed for significant deposition of RGM. EPA's goal in defining the RGM airshed in this way was used to set a reasonable boundary within which to gather detailed information on sources, and evaluate current and probable future emissions. In this study, the boundary of the airshed in practical terms includes the boundaries of all the counties that have a portion of their area within 100 km radius of the Savannah River watershed. The information provided by the RELMAP data bases on point sources includes the

name of the county in which they are located, but not detailed locations. Therefore we did not estimate whether each source was exactly within a strictly defined distance of 100km, but included all sources in the County. This analysis does not assert that only those point sources within the RGM airshed are important for the deposition of RGM. Rather we consider that some RGM, and especially particulate and elemental mercury, emitted from sources outside this particular airshed also will contribute in some measure to deposition of mercury within the Savannah River watershed. In addition, some deposition will come from mercury reaching the watershed by international transport; that is from "background" or global sources. In future years, possible additional analyses and computer modeling will probably evaluate emissions sources in a considerably larger area than just the watershed and 100 km distance around it.

Alternatively, the RGM airshed could be redefined to extend 200 km around the Savannah River watershed, a distance which reflects some research on transport of RGM. In that case, the analysis would encompass large industrial and utility sources associated with the urban areas of Columbia, South Carolina, Atlanta and Macon, Georgia, Jacksonville, Florida, plus Charlotte and several counties in southwestern North Carolina. While sources in this larger area, and indeed within the entire southeastern U.S., may contribute to mercury deposition reaching the Savannah River watershed, absent additional modeling EPA cannot estimate their importance relative to sources within the RGM airshed based on 100 km. In addition, if future analyses are pursued, EPA may develop detailed emissions data from individual sources within a study domain which would consider transport of all species of mercury, not just RGM Source-specific data may be gathered to account for process changes, installation of emissions control equipment or facility closures; such data may show even greater reductions in mercury emissions than EPA can estimate at this time. Speciation profiles for mercury in emissions are critical for modeling, but are not readily available for individual point sources. Research on speciated emissions is very limited at this time, from many source categories known to emit significant amounts of mercury. (Currently available techniques to measure mercury species quantitatively in emissions are expensive and difficult to apply.) However, the RELMAP estimates of speciated emissions by source category have been widely reviewed, and are used here to compare this analysis to that earlier, more comprehensive study and the published discussion of its results.

3.4 Relating Chemical/Physical Forms of Mercury to Deposition

The RELMAP computer modeling and subsequent analysis of its results provides information which can be used to estimate the how each of the several chemical/physical forms of mercury in emissions contribute to wet deposition and to dry deposition. In this discussion, below, "type" of mercury refers to the chemical species (elemental or divalent), "physical form" refers to its form as gas or particulate, and "source" refers to either U.S. sources or background from "global sources". (See Table 1 in section 2.1 above, for the forms and sources of mercury, in the column headed "Deposition Variable".) In the RELMAP modeling studies, separate computational runs were made for emissions of each form of mercury, and the modeled results for deposition in each grid square across the U.S. were mapped and analyzed. For each type of mercury (e.g. elemental mercury from U.S. sources) the range of values of the calculated

deposition per square meter were arranged into percentiles, analyzing wet deposition separately from dry deposition. In *The Mercury Study*, data for the 10th Percentile, the 50th Percentile, and the 90th Percentile for each type of mercury were presented for the U.S. as a whole, and also for the eastern portion of the U.S. (EPA, 1997, Vol.III, Tables 5-5 and 5-6.) This analysis for the Savannah River watershed uses the RELMAP results as general estimators of the relative impacts on deposition of the various types of mercury, and applies some additional steps of logic beyond the RELMAP analysis.

This study, as presented above in section 2.0 and 2.1, focuses on emissions and deposition of RGM, and then relates deposition from the other types of mercury to RGM. This study utilizes the RELMAP values for deposition at the 50th Percentile for each type of mercury to estimate the relative contribution of each type to total deposition. One assumption in this study is that the depositional values at the 50th Percentile of the various types of mercury can be taken as estimators of average deposition such that a sum of their values will provide an estimate of average total deposition of all forms of mercury (referred to as "total mercury".) EPA considers this to be a reasonable assumption because the 50th percentile values result from a coordinated set of computer runs of the RELMAP model that used the same emissions inventory data and meteorology, and the same algorithms for atmospheric chemistry and processes of deposition. However, using these percentile values as estimators should be considered only a first approximation, used here because there are no other published values by which to compare the relative contribution to deposition which comes from each type of mercury released into the atmosphere.

A related question is whether to use the values at the 50th percentiles to represent "average" influence of the types of mercury, rather than using some other set of percentile values. (Here, "average" is meant in the general sense, rather than as a statistical mean.) To check this approach EPA evaluated calculations using different percentiles. EPA examined the deposition values using both the 10th percentile and 90th percentile (shown in Tables 5-5 and 5-6 of Volume III of *The Mercury Study*) and found that they produce roughly similar percentage distributions among the deposition variables, with one exception. The global sources represent a slightly larger fraction of the total wet deposition at the 10th percentile, and a slightly smaller fraction of the total wet deposition at the 90th percentile.[5] With this corroboration, EPA decided that the use of the 50th percentile values provides an appropriate estimator of relative percent contribution to deposition from the various types of mercury emitted.

When estimating <u>future</u> deposition as percentage contributions coming from each type of mercury (e.g. particulate mercury from U.S. Sources), this analysis assumed the percentages would remain the same for 2010 as for the baseline period. That is, the same percentages based on RELMAP 50th percentiles were used for the baseline period and for 2010. This approach was taken because currently there are no analyses available which propose different balances of

[5] This observation is expected because in the RELMAP modeling the deposition from the global background was analyzed separately from U.S. mercury sources; its net deposition is influenced by precipitation.

mercury types in the future atmosphere, and how such a balance of mercury species would influence deposition. Also, this document develops only a first stage analysis, so estimating effects of subtle changes which might occur in the future would need more complex analysis, such as computer modeling.

A related question regarding future estimations concerns the relative amounts of the speciated forms of mercury in emissions from sources. As new controls or changes in processes are put in place and the total amount of mercury emitted is reduced, the percentage of RGM emitted may change in relation to the other chemical species or physical types of mercury emitted. Where current engineering analysis for certain source categories has estimated the numeric value of changes in speciated emissions, such information was included in our calculations of future emissions. For source categories for which no current engineering estimates have been prepared, this analysis simply assumed the same percentage of RGM in emissions for the future year as was used for the RELMAP data bases for the baseline period. This approach was taken rather than make changes without known basis.

3.5 International Transport (Global Sources) and Reductions in the U.S.

The relative contribution to deposition in the U.S. from global sources of mercury remains controversial. Mercury which is transported in the atmosphere for long distances (internationally) is essentially all in the form of elemental mercury. Elemental mercury is transported globally because it is relatively insoluble in water, it is chemically quite inert, and it does not adsorb readily to most surfaces. Its removal from the air, by deposition, depends primarily on chemical reactions in the atmosphere which convert it to the divalent form (that is, to RGM which is soluble in precipitation) or by adsorption to particles. RELMAP and similar models consider that global sources (which includes current human activities, re-evaporation of previously deposited mercury, and natural releases) provide a low level but ubiquitous "background" of elemental mercury in the air. Current information on mercury's chemical reactions in the atmosphere indicates that conversion to RGM, and thus contribution to deposition, is rather slow under most conditions. However, the RELMAP model considers that the global "background" is always present and some conversion is always occurring. Thus the model calculates over a year's time a significant contribution to deposition (about 36% of total, for the eastern U.S.) come from the global "background". Research on atmospheric chemistry and transport, and improved national-scale computer modeling, may provide improved estimates of deposition from this source type within a few years. Until that time, there will remain some uncertainty as to what deposition will remain due to mercury from international transport, even as the U.S. achieves significant reductions in deposition from domestic sources by applying emissions controls and pollution prevention.

Some research studies have proposed that deposition in some areas of the U.S. which results from international transport (global sources) is more than the RELMAP estimate of 36% of total mercury deposition. Since reductions in emissions from sources in the U.S. will do little to reduce deposition of mercury from global sources, there may be a limit on overall reductions in deposition which national and local efforts can achieve. In contrast, some recent intensive

studies in south Florida have indicated that local emissions, within 100 km of a receptor area, can account for most of the mercury deposition (70% or more) which reaches the Florida Everglades. These results suggest that reducing emissions in a local region will probably result in significant reductions in deposition, while deposition resulting from long range transport of elemental mercury has limited impact on the total loading to a watershed. [Dvonch, et al. 1999.] There are some encouraging data from recent studies in south Florida which indicate that reductions in mercury emissions to the air within the state and the U.S. do translate, after some years, into apparent responses within the aquatic ecosystem, including lower mercury levels in fish tissues. That is, reduced domestic emissions can benefit the environment in the U.S., even if global transport continues to contribute to the total deposition.

3.6 Deposition to the Watershed in Geographic Context

A comparison for the baseline period of the estimated value for RGM deposited in the Savannah River watershed (approximately 112 kg/yr) with the estimated RGM emissions from sources in the RGM airshed (approximately 1760 kg/yr) might appear to indicate a rather small amount of net deposition to the area of concern. The ratio indicates that approximately 6% of the calculated RGM emitted from the local sources in the RGM airshed deposits within the watershed area. One way to consider this ratio is to compare the area of the Savannah River watershed itself relative to the total area of the RGM airshed. As stated in Section 1.0, one of the basis tenants for our analysis is that the majority of RGM in emissions is expected to be deposited within 100 km of the source. The area of the watershed is approximately 9319 km^2, while the area of the RGM airshed (including the watershed) is approximately 96,259 km^2. Thus the watershed area is slightly less than 10% of the RGM airshed area. Wind data from the airport at Augusta, GA, show that wind directions over a full year's time come approximately evenly from all compass directions. It is likely that much of the RGM emitted from the sources that are located near the outer edge of the RGM airshed (that is, sources which lie nearly 100 km from the boundary of the watershed) will actually be deposited outside the RGM airshed. That is, winds will disperse some of the RGM from these sources in directions "away from" the watershed, out to distances up to 100 km beyond the RGM airshed. To estimate this larger area that will receive some deposition of RGM from sources that lie within the RGM airshed, a map was generated with an additional boundary "oval" at a distance of 200 km all around the Savannah River watershed. (See Figure 1.) The area within this larger "200 km oval" includes approximately 243,352 km^2. Thus the area within the watershed itself (near 9319 km^2) is approximately 4% of the entire area within the 200 km oval. Because the sources and the amount of mercury that each source emits are not evenly distributed, the deposition of RGM will not be evenly distributed over the local area. Sources which are located in the watershed itself probably have a larger percentage of their RGM emissions deposited within the watershed than is the case for sources which are within the RGM airshed but some distance from the watershed. Therefore, it appears reasonable that 6% of the RGM emitted within the RGM airshed will be deposited within the area of the Savannah River watershed.

4.0 ONGOING AND FUTURE REDUCTIONS IN EMISSIONS

As rules and standards pursuant to the Clean Air Act have been developed, proposed, and promulgated since 1990, compliance by emitting sources as well as actions taken voluntarily have already begun to reduce emissions of mercury to the air across the US. EPA expects a combination of ongoing activities will continue to reduce mercury emissions to the air over the next decade. EPA currently regulates emissions of mercury and other hazardous air pollutants under the maximum achievable control technology ("MACT") program of Section 112 of the Clean Air Act, and under a corresponding new source performance standard ("NSPS") program under Sections 111 and 129 of the Act. Section 112 authorizes EPA to address categories of major sources of hazardous air pollutants, including mercury, by issuing emissions standards that, for new sources, are at least as stringent as the emissions control achieved by the best performing similar source in the category, and, for existing sources, are at least as stringent as the average of the best performing top 12 percent (or 5 facilities whichever is greater) of similar sources. EPA may also apply these standards to smaller area sources, or choose to apply less stringent standards based on generally available control technologies ("GACT"). Sections 111 and 129 direct EPA to establish MACT-equivalent standards for each category of new and existing solid waste incineration units, regulating several specified air pollutants, including mercury. In addition, in 1996 the US eliminated the use of mercury in most batteries under the Mercury Containing and Rechargeable Battery Management Act. This action is reducing the mercury content of the waste stream which is further reducing mercury emissions from waste combustion. In addition, voluntary measures to reduce use of mercury containing products, such as the voluntary measures committed to by the American Hospital Association, also will contribute to reduced emissions from waste combustion.

Based on the EPA's National Toxics Inventory, the highest emitters of mercury to the air include coal-burning electric utilities, municipal waste combustors, medical waste incinerators, chlor-alkali plants, and hazardous waste combustors. EPA has issued a number regulations under Sections 112 and 111 and 129 to reduce mercury pollution from several of these source categories. Relevant regulations that EPA has established to date under the Clean Air Act include, among others, those listed below.

- The source category of municipal waste combustion (MWC) emitted about 20 percent of total national mercury emissions into the air in 1990. EPA issued final regulations under Sections 111 and 129 for large MWCs on October 31, 1995. Large combustors or incinerators must comply with the rule by December, 2000. These regulations reduce mercury emissions from these facilities by about 90 percent from 1990 emission levels.

- Medical waste incinerators (MWIs) emitted about 24 percent of total national mercury emissions into the air in 1990. EPA issued emission standards under Sections 111 and 129 for MWIs on August 15, 1997. When fully implemented, in 2002, EPA's final rule will reduce mercury emissions from MWIs by about 94 percent from 1990 emission levels.

- Hazardous waste combustors (HWCs) emitted about 2.5 percent of total national mercury emissions in 1990. In February 1999, EPA issued emission standards under Section 112 for these facilities, which include incinerators, cement kilns, and light weight aggregate kilns that burn hazardous waste. When fully implemented, these standards will reduce mercury emissions from HWCs by more than 50 percent from 1990 emission levels.

These promulgated regulations when fully implemented and considered together with actions discussed above that will reduce the mercury content of waste are expected to reduce national mercury emissions caused by human activities by about 50 percent from 1990 levels.

In December 2000, EPA announced that it intends to begin developing a regulation under Section 112 to limit mercury emissions from coal-fired power plants. A proposal is expected in late 2003 and a final regulation at the end of 2004. As a group, these plants are the largest source of mercury emissions in the US. It is too early to estimate the reductions in mercury emissions that may result from regulation of electric utilities. In the meantime, we expect to see reduced emissions of mercury from this sector as a number of regulations are implemented to control SO2 and NOx, since some control technologies used to limit these pollutants collaterally reduce mercury emissions as well.

EPA expects to propose in 2001 a regulation under Section 112 that will limit mercury emissions from chlor-alkali plants, chlorine production facilities which use the mercury cell technology. In addition, under the Integrated Urban Air Toxics Strategy, which was published in 1999, EPA is developing emissions standards under Section 112 for categories of smaller sources of air toxics, including mercury, that pose the greatest risk to human health in urban areas. These standards are expected to be issued by 2004.

A review of regulatory and related initiatives to reduce mercury emissions is provided in Appendix II of this document. It is possible that the cumulative effect of additional standards and voluntary actions will reduce mercury emissions from human activities in the US by more than 50 percent from 1990 levels. However, whether the overall, total percent reduction in national mercury emissions in the future will exceed 50% cannot be estimated at this time. EPA will continue to track emissions of mercury and evaluate additional approaches to reduce releases of mercury into the environment.

5.0 REFERENCES

U.S. EPA. 1997. *Mercury Study Report to Congress*. Office of Air Quality Planning and Standards and Office of Research and Development. EPA-452/R-97-005. December 1997.

Dvonch, J.T, J.R.Graney, G.J. Keeler, and R.K. Stevens. 1999. Use of Elemental Tracers to Source Apportion Mercury in South Florida Precipitation. *Environ. Sci. Technol.* 1999, *33*, 4522-4527.

[NOTE: Citations to the Federal Register, and to Internet web pages are included in Appendix II.]

Appendix I

RGM Airshed
Emissions Inventory

Hospital, Medical and Infectious Waste Incinerators

STATE/SOURCE	COUNTY	RGM AIRSHED Pre-MACT (1994/1996) Total Hg Emissions (kg/yr)	%Hg as RGM *	RGM AIRSHED Pre-MACT (1994/1996) RGM Hg Emissions (kg/yr)	GROWTH Factor to 2010	Predicted % Reduction due to MACT (Year of MACT Compliance) 1998	Predicted Total Hg Emissions in 2010 (kg/yr)	Predicted RGM Emissions in 2010 (kg/yr)*
GEORGIA								
Baldwin County Hospital	Baldwin	1.398569	73%	1.02095537	1.23	94%	Facility Closed	Facility Closed
Bulloch County Hospital	Bulloch	0.608657	73%	0.44431961	1.23	94%	Facility Closed	Facility Closed
Candler Hospital	Chatham	0.608657	73%	0.44431961	1.23	94%	Facility Closed	Facility Closed
Central State Hospital	Baldwin	12.258179	73%	8.94847067	1.23	94%	Facility Closed	Facility Closed
Effingham County Hospital	Effingham	0.699285	73%	0.51047805	1.23	94%	Facility Closed	Facility Closed
Emanuel County Hospital	Emanuel	0.286427	73%	0.20909171	1.23	94%	Facility Closed	Facility Closed
Evans Memorial Hospital	Evans	1.558712	73%	1.13785976	1.23	94%	Facility Closed	Facility Closed
Fairview Park Hospital	Laurens	2.097854	73%	1.53143342	1.23	94%	Facility Closed	Facility Closed
Georgia Regional Hospital	Richmond	2.07971	73%	1.5181883	1.23	94%	Facility Closed	Facility Closed
Humana Hospital-Augusta	Richmond	4.894992	73%	3.57334416	1.23	94%	Facility Closed	Facility Closed
Jefferson Hospital	Jefferson	1.293676	73%	0.94438348	1.23	94%	Facility Closed	Facility Closed
McDuffie County Hospital	McDuffie	3.496423	73%	2.55238879	1.23	94%	Facility Closed	Facility Closed
Medical College of Georgia	Richmond	12.687215	73%	9.26166695	1.23	94%	Facility Closed	Facility Closed
Memorial Hospital	Chatham	5.034849	73%	3.67543977	1.23	94%	Facility Closed	Facility Closed
Oconee Regional Medical Center	Baldwin	5.069813	73%	3.70096349	1.23	94%	Facility Closed	Facility Closed
Saint Josephs Hospital	Richmond	12.053876	73%	8.79932948	1.23	94%	Facility Closed	Facility Closed
Saint Josephs Hospital	Chatham	4.194708	73%	3.06213684	1.23	94%	Facility Closed	Facility Closed
Saint Marys Hospital	Clarke	6.766837	73%	4.93979101	1.23	94%	Facility Closed	Facility Closed
University Hospital	Richmond	44.950595	73%	32.81393435	1.23	94%	Facility Closed	Facility Closed
Wayne Memorial Hospital	Wayne	4.3006	73%	3.139438	1.23	94%	Facility Closed	Facility Closed
Corps of Engineers	Liberty	2.097854	73%	1.53143342	1.23	94%	Facility Closed	Facility Closed
U.S. Army Hospital, Ft. Gordon	Richmond	1.736463	73%	1.26761799	1.23	94%	Facility Closed	Facility Closed
U.S. Army Hospital, Ft. Stewart	Liberty	2.900073	73%	2.11705329	1.23	94%	Facility Closed	Facility Closed
VA Hospital, Dublin	Laurens	19.573255	73%	14.28847615	1.23	94%	Facility Closed	Facility Closed
	Georgia Totals	152.647279		111.4325137			0	0
SOUTH CAROLINA								
Aiken Regional Medical Center	Aiken	2.900073	73%	2.11705329	1.14	94%	0.198364993	0.099182497
Chamber Med. Tech. SC (SDS)	Hampton	717.76807	73%	523.9706911	1.14	94%	49.09533599	24.54766799
Collecton Regional Hospital	Colleton	0.608657	73%	0.44431961	1.14	94%	Facility Closed	Facility Closed
Fairfield Memorial Hospital	Fairfield	0.699285	73%	0.51047805	1.14	94%	Facility Closed	Facility Closed
VA Hospital, Columbia	Richland	6.992846	73%	5.10477758	1.14	94%	0.478310666	0.239155333
Anderson Memorial Hospital	Anrderson	25.150928	73%	18.36017744	1.14	94%	1.720323475	0.860161738
Roper Hospital	Charleston	36.287	73%	26.48951	1.14	94%	Facility Closed	Facility Closed
Kershaw County Memorial Hospital	Kershaw	4.195708	73%	3.06286684	1.14	94%	0.286986427	0.143493214
Charleston Naval Hospital	Charleston	6.713132	73%	4.90058636	1.14	94%	0.459178229	0.229589114
HCA Trident Regional Hospital	Charleston	2.900073	73%	2.11705329	1.14	94%	0.198364993	0.099182497
Self Memorial Hospital	Greenwood	5.5942	73%	4.083766	1.14	94%	0.38264328	0.19132164
Shaw Airforce Base	Sumter	0.286427	73%	0.20909171	1.14	94%	0.019591607	0.009795803
	South Carolina Totals	810.096399		591.3703713			52.83909966	26.41954983
	GRAND TOTALS	***962.743678***		***702.8028849***			***52.83909966***	***26.41954983***

*The percent RGM is presumed to drop to 50% of the total released, after implementation of the MACT (See Table 4-2 in Volume III of *The Mercury Study*)

Fossil Fuel Electric Utility Boilers (Power Plants)

STATE/SOURCE	FUEL TYPE	COUNTY	RGM AIRSHED Pre-MACT (1994/1996) Total Hg Emissions (kg/yr)	%Hg as RGM**	RGM AIRSHED Pre-MACT (1994/1996) RGM Hg Emissions (kg/yr)	GROWTH Factor to 2010	Predicted % Reduction due to MACT	Predicted Total Hg Emissions in 2010 (kg/yr)	Predicted RGM Emissions in 2010 (kg/yr)
GEORGIA									
SAVANNAH ELEC & PWR WENTWORTH STM	BIT COAL	Chatham	20.79	30%	6.237	1.17	No MACT	24.3243	7.29729
SAVANNAH ELEC & PWR MCINTOSH	BIT COAL	Jasper	23	30%	6.9	1.17	No MACT	26.91	8.073
GA POWER CO BRANCH STM ELEC GEN STA	BIT COAL	Putnam	240.76	30%	72.228	1.17	No MACT	281.6892	84.50676
MCMANUS (KRAFT)	OIL FIRED	Glynn	0.1377	30%	0.04131	1.17	No MACT	0.161109	0.0483327
RIVERSIDE	GAS FIRED	Chatham	0.0141	30%	0.00423	1.17	No MACT	0.016497	0.0049491
WILSON	BIT COAL	Burke	9	30%	2.7	1.17	No MACT	10.53	3.159
SOUTH CAROLINA									
Westinghouse SAVANNAH RIVER PLANT*	COAL	Aiken	99.79	30%	29.937	1.14	No MACT	113.7606	34.12818
SCE&G:URQUHART	BIT COAL	Aiken	34.1349	30%	10.24047	1.17	No MACT	39.937833	11.9813499
SCE&G:CANADYS	BIT COAL	Colleton	51.02	30%	15.306	1.17	No MACT	59.6934	17.90802
SCE&G:MCMEEKIN	BIT COAL	Lexington	57.0205	30%	17.10615	1.17	No MACT	66.713985	20.0141955
SCE&G:WATEREE	BIT COAL	Richland	101.14	30%	30.342	1.17	No MACT	118.3338	35.50014
JEFFERIES	OIL FIRED	Berkley	0.1373	30%	0.04119	1.17	No MACT	0.160641	0.0481923
JEFFERIES	BIT COAL	Berkley	31.217	30%	9.3651	1.17	No MACT	36.52389	10.957167
SANTEE COOPER	BIT COAL	Berkley	99.7903	30%	29.93709	1.17	No MACT	116.754651	35.0263953
SCEN&G	BIT COAL	Berkley	63.5029	30%	19.05087	1.17	No MACT	74.298393	22.2895179
HAGOOD	GAS FIRED	Charleston	0.14	30%	0.042	1.17	No MACT	0.1638	0.04914
HAGOOD	OIL FIRED	Charleston	0.0041	30%	0.00123	1.17	No MACT	0.004797	0.0014391
LEE	BIT COAL	Anderson	34.5978	30%	10.37934	1.17	No MACT	40.479426	12.1438278
	Grand Total		*866.1966*		259.85898			1010.456322	303.1368966

* This source is exclusively for the U.S. Deparment of Energy Savannah River Site

** Tests of coal fired utility boilers have shown variability in the percentage of total mercury emissions that is RGM. An estimate of 30% RGM was presented in Table 4-2 of Volume III of the Mercury Study Report to Congress

MISCELLANEOUS SOURCES

STATE/SOURCE	FACILITY TYPE	COUNTY	RGM AIRSHED Pre-MACT (1994/1996) Total Hg Emissions (kg/yr)	%Hg as RGM	RGM AIRSHED Pre-MACT (1994/1996) RGM Hg Emissions (kg/yr)	GROWTH Factor to 2010	Predicted % Reduction due to MACT ** see notes **	Predicted Total Hg Emissions in 2010 (kg/yr)	Predicted RGM Emissions in 2010 (kg/yr)
GEORGIA									
OLIN	CHLOR-ALKALI	RICHMOND	597.381151	30%	179.2143453	1.17	No MACT **	698.9359467	34.94679733
SAVANNAH ENERGY	MSW COMBUSTOR	CHATTHAM	207.564	60%	124.5384	1.23	90% *	25.530372	0 *
WPCP #1	Sewage Sludge Incinerator	CHATHAM	4.32056	60%	2.592336	1.23	No MACT	5.3142888	3.18857328
WPCP #2	Sewage Sludge Incinerator	CHATHAM	4.32056	60%	2.592336	1.23	No MACT	5.3142888	3.18857328
FEDERAL PAPER BOARD COMPANY 1	Pulp and Paper Recovery Furnace	RICHMOND	4.9673	30%	1.49019	1.17	No MACT	5.811741	1.7435223
FEDERAL PAPER BOARD COMPANY 2	Pulp and Paper Recovery Furnace	RICHMOND	1.43643	30%	0.430929	1.17	No MACT	1.6806231	0.50418693
GEORGIA PACIFIC 1	Pulp and Paper Recovery Furnace	GLYNN	14.902142	30%	4.4706426	1.17	No MACT	17.43550614	5.230651842
GEORGIA PACIFIC 2	Pulp and Paper Recovery Furnace	GLYNN	11.487068	30%	3.4461204	1.17	No MACT	13.43986956	4.031960868
ITT-RAYONIER 1	Pulp and Paper Recovery Furnace	WAYNE	15.212604	30%	4.5637812	1.17	No MACT	17.79874668	5.339624004
ITT-RAYONIER 2	Pulp and Paper Recovery Furnace	WAYNE	10.245223	30%	3.0735669	1.17	No MACT	11.98691091	3.596073273
STONE SAVANNAH RIVER	Pulp and Paper Recovery Furnace	CHATHAM	11.060668	30%	3.3182004	1.17	No MACT	12.94098156	3.882294468
UNION CAMP 1	Pulp and Paper Recovery Furnace	CHATHAM	18.627676	30%	5.5883028	1.17	No MACT	21.79438092	6.538314276
UNION CAMP 2	Pulp and Paper Recovery Furnace	CHATHAM	10.524638	30%	3.1573914	1.17	No MACT	12.31382646	3.694147938
INTERSTATE PAPER	Pulp and Paper Recovery Furnace	LIBERTY	4.4470643	30%	1.33411929	1.17	No MACT	5.203065231	1.560919569
G.D. SEARLE AND CO.	HW Incinerator	RICHMOND	0.8903	8%	0.0667725	1	80%	0.17806	0.0133545
SOUTH CAROLINA									
FOSTER WHEELER	MSW COMBUSTOR	CHARLESTON	290.299	60%	174.1794	1.14	90% *	33.094086	0 *
CHAMBER MEDICAL TECH OF SC.	MSW COMBUSTOR	HAMPTON	91.172	60%	54.7032	1.14	90% *	10.393608	0 *
CHARLESTON/PLUM ISLAND	Sewage Sludge Incinerator	CHARLESTON	4.32056	60%	2.592336	1.14	No MACT	4.9254384	2.95526304
NORTH CHARLESTON SEWAGE DISTRICT	Sewage Sludge Incinerator	CHARLESTON	4.32056	60%	2.592336	1.14	No MACT	4.9254384	2.95526304
COLUMBIA/METROPLANT INC. 1	Sewage Sludge Incinerator	RICHLAND	4.32056	60%	2.592336	1.14	No MACT	4.9254384	2.95526304
COLUMBIA/METROPLANT INC. 2	Sewage Sludge Incinerator	RICHLAND	4.32056	60%	2.592336	1.14	No MACT	4.9254384	2.95526304
WESTVACO 1	Pulp and Paper Recovery Furnace	CHARLESTON	7.264794	30%	2.1794382	1.17	No MACT	8.49980898	2.549942694
WESTVACO 2	Pulp and Paper Recovery Furnace	CHARLESTON	10.897192	30%	3.2691576	1.17	No MACT	12.74971464	3.824914392
BLUE CIRCLE	Portland Cement	DORCHESTER	37.679918	10%	3.7679918	1.17	No MACT	44.08550406	4.408550406
GIANT CEMENT HOLDING INC	Portland Cement (also burns HW)	DORCHESTER	13.16005	94%	12.370447	1.17	15%	13.08766973	12.30240954
HOLNAM INC	Portland Cement (also burns HW)	ORANGEBURG	62.10079	86%	53.4066794	1.17	15%	61.75923566	53.11294266
US DOE Savanah River Site	HW Incinerator	AIKEN	0.22489	95%	0.2136455	1	80%	0.044978	Facility Closed
	Grand Total		*1447.468258*		*654.3367373*			*1059.094966*	*165.4788057*

*After implementation of the MACT, municipal solid waste combutors are presumed to release no RGM (see Table 4-2 in Volume III of *The Mercury Study*)

** Based on recent emissions testing done to characterize mercury emissions from chlor-alkali facilities, the projected 2010 % RGM for the Olin facility was changed from 30% to 5%.

RESIDENTIAL/INDUSTRIAL BOILERS

STATE/SOURCE	FACILITY TYPE	RGM AIRSHED Pre-MACT (1994/1996) Total Hg Emissions (kg/yr)	%Hg as RGM	RGM AIRSHED Pre-MACT (1994/1996) RGM Hg Emissions (kg/yr)	GROWTH Factor to 2010	Predicted % Reduction due to MACT	Predicted Total Hg Emissions in 2010 (kg/yr)	Predicted RGM Emissions in 2010 (kg/yr)
GEORGIA COUNTY								
Appling	Res/Ind Boilers	1.22	30%	0.366	1.23	No MACT	1.5006	0.45018
Baldwin	Res/Ind Boilers	3.05	30%	0.915	1.23	No MACT	3.7515	1.12545
Brantley	Res/Ind Boilers	0.856	30%	0.2568	1.23	No MACT	1.05288	0.315864
Bryan	Res/Ind Boilers	1.19	30%	0.357	1.23	No MACT	1.4637	0.43911
Bulloch	Res/Ind Boilers	3.33	30%	0.999	1.23	No MACT	4.0959	1.22877
Burke	Res/Ind Boilers	1.59	30%	0.477	1.23	No MACT	1.9557	0.58671
Candler	Res/Ind Boilers	0.598	30%	0.1794	1.23	No MACT	0.73554	0.220662
Chatham	Res/Ind Boilers	16	30%	4.8	1.23	No MACT	19.68	5.904
Clarke	Res/Ind Boilers	6.77	30%	2.031	1.23	No MACT	8.3271	2.49813
Columbia	Res/Ind Boilers	5.1	30%	1.53	1.23	No MACT	6.273	1.8819
Effingham	Res/Ind Boilers	1.98	30%	0.594	1.23	No MACT	2.4354	0.73062
Elbert	Res/Ind Boilers	1.46	30%	0.438	1.23	No MACT	1.7958	0.53874
Emanuel	Res/Ind Boilers	1.59	30%	0.477	1.23	No MACT	1.9557	0.58671
Evans	Res/Ind Boilers	0.674	30%	0.2022	1.23	No MACT	0.82902	0.248706
Glascock	Res/Ind Boilers	0.182	30%	0.0546	1.23	No MACT	0.22386	0.067158
Glynn	Res/Ind Boilers	4.83	30%	1.449	1.23	No MACT	5.9409	1.78227
Greene	Res/Ind Boilers	0.911	30%	0.2733	1.23	No MACT	1.12053	0.336159
Hancock	Res/Ind Boilers	0.688	30%	0.2064	1.23	No MACT	0.84624	0.253872
Hart	Res/Ind Boilers	1.52	30%	0.456	1.23	No MACT	1.8696	0.56088
Jackson	Res/Ind Boilers	2.32	30%	0.696	1.23	No MACT	2.8536	0.85608
Jasper	Res/Ind Boilers	0.653	30%	0.1959	1.23	No MACT	0.80319	0.240957
Jefferson	Res/Ind Boilers	1.34	30%	0.402	1.23	No MACT	1.6482	0.49446
Jenkins	Res/Ind Boilers	0.637	30%	0.1911	1.23	No MACT	0.78351	0.235053
Johnson	Res/Ind Boilers	0.643	30%	0.1929	1.23	No MACT	0.79089	0.237267
Jones	Res/Ind Boilers	1.6	30%	0.48	1.23	No MACT	1.968	0.5904
Laurens	Res/Ind Boilers	3.09	30%	0.927	1.23	No MACT	3.8007	1.14021
Liberty	Res/Ind Boilers	4.07	30%	1.221	1.23	No MACT	5.0061	1.50183
Lincoln	Res/Ind Boilers	0.575	30%	0.1725	1.23	No MACT	0.70725	0.212175
Long	Res/Ind Boilers	0.479	30%	0.1437	1.23	No MACT	0.58917	0.176751
Madison	Res/Ind Boilers	1.63	30%	0.489	1.23	No MACT	2.0049	0.60147
McDuffie	Res/Ind Boilers	1.55	30%	0.465	1.23	No MACT	1.9065	0.57195
McIntosh	Res/Ind Boilers	0.667	30%	0.2001	1.23	No MACT	0.82041	0.246123
Montgomery	Res/Ind Boilers	0.553	30%	0.1659	1.23	No MACT	0.68019	0.204057
Morgan	Res/Ind Boilers	0.995	30%	0.2985	1.23	No MACT	1.22385	0.367155
Newton	Res/Ind Boilers	3.23	30%	0.969	1.23	No MACT	3.9729	1.19187
Oconee	Res/Ind Boilers	1.36	30%	0.408	1.23	No MACT	1.6728	0.50184
Oglethorpe	Res/Ind Boilers	7.54	30%	2.262	1.23	No MACT	9.2742	2.78226
Putman	Res/Ind Boilers	1.09	30%	0.327	1.23	No MACT	1.3407	0.40221
Richmond	Res/Ind Boilers	14.7	30%	4.41	1.23	No MACT	18.081	5.4243
Screven	Res/Ind Boilers	1.07	30%	0.321	1.23	No MACT	1.3161	0.39483
Taliaferro	Res/Ind Boilers	0.148	30%	0.0444	1.23	No MACT	0.18204	0.054612
Tattnall	Res/Ind Boilers	1.37	30%	0.411	1.23	No MACT	1.6851	0.50553
Toombs	Res/Ind Boilers	1.86	30%	0.558	1.23	No MACT	2.2878	0.68634
Treutlen	Res/Ind Boilers	0.463	30%	0.1389	1.23	No MACT	0.56949	0.170847
Twiggs	Res/Ind Boilers	0.757	30%	0.2271	1.23	No MACT	0.93111	0.279333
Walton	Res/Ind Boilers	2.98	30%	0.894	1.23	No MACT	3.6654	1.09962
Warren	Res/Ind Boilers	0.469	30%	0.1407	1.23	No MACT	0.57687	0.173061
Washington	Res/Ind Boilers	1.48	30%	0.444	1.23	No MACT	1.8204	0.54612
Wayne	Res/Ind Boilers	1.73	30%	0.519	1.23	No MACT	2.1279	0.63837
Wilkes	Res/Ind Boilers	0.819	30%	0.2457	1.23	No MACT	1.00737	0.302211
Wilkinson	Res/Ind Boilers	7.9	30%	2.37	1.23	No MACT	9.717	2.9151

SOUTH CAROLINA								
Abbeville	Res/Ind Boilers	3.67	30%	1.101	1.17	No MACT	4.2939	1.28817
Aiken	Res/Ind Boilers	18.6	30%	5.58	1.17	No MACT	21.762	6.5286
Allendale	Res/Ind Boilers	1.8	30%	0.54	1.17	No MACT	2.106	0.6318
Anderson	Res/Ind Boilers	22.3	30%	6.69	1.17	No MACT	26.091	7.8273
Bamberg	Res/Ind Boilers	3.6	30%	1.08	1.17	No MACT	4.212	1.2636
Barnwell	Res/Ind Boilers	3.12	30%	0.936	1.17	No MACT	3.6504	1.09512
Beaufort	Res/Ind Boilers	13.3	30%	3.99	1.17	No MACT	15.561	4.6683
Berkeley	Res/Ind Boilers	19.8	30%	5.94	1.17	No MACT	23.166	6.9498
Calhoun	Res/Ind Boilers	1.96	30%	0.588	1.17	No MACT	2.2932	0.68796
Charleston	Res/Ind Boilers	45.3	30%	13.59	1.17	No MACT	53.001	15.9003
Clarendon	Res/Ind Boilers	4.37	30%	1.311	1.17	No MACT	5.1129	1.53387
Colleton	Res/Ind Boilers	5.28	30%	1.584	1.17	No MACT	6.1776	1.85328
Dorchester	Res/Ind Boilers	12.8	30%	3.84	1.17	No MACT	14.976	4.4928
Edgefield	Res/Ind Boilers	2.82	30%	0.846	1.17	No MACT	3.2994	0.98982
Fairfield	Res/Ind Boilers	3.42	30%	1.026	1.17	No MACT	4.0014	1.20042
Greenville	Res/Ind Boilers	49.2	30%	14.76	1.17	No MACT	57.564	17.2692
Greenwood	Res/Ind Boilers	9.15	30%	2.745	1.17	No MACT	10.7055	3.21165
Hampton	Res/Ind Boilers	2.79	30%	0.837	1.17	No MACT	3.2643	0.97929
Jasper	Res/Ind Boilers	2.38	30%	0.714	1.17	No MACT	2.7846	0.83538
Kershaw	Res/Ind Boilers	6.7	30%	2.01	1.17	No MACT	7.839	2.3517
Laurens	Res/Ind Boilers	8.92	30%	2.676	1.17	No MACT	10.4364	3.13092
Lexington	Res/Ind Boilers	25.7	30%	7.71	1.17	No MACT	30.069	9.0207
McCormick	Res/Ind Boilers	1.36	30%	0.408	1.17	No MACT	1.5912	0.47736
Newberry	Res/Ind Boilers	5.1	30%	1.53	1.17	No MACT	5.967	1.7901
Orangeburg	Res/Ind Boilers	13	30%	3.9	1.17	No MACT	15.21	4.563
Richland	Res/Ind Boilers	43.9	30%	13.17	1.17	No MACT	51.363	15.4089
Saluda	Res/Ind Boilers	2.51	30%	0.753	1.17	No MACT	2.9367	0.88101
Sumter	Res/Ind Boilers	15.8	30%	4.74	1.17	No MACT	18.486	5.5458
Union	Res/Ind Boilers	4.66	30%	1.398	1.17	No MACT	5.4522	1.63566
	Grand Total	*476.617*		*142.9851*			*565.04031*	*169.512093*

Appendix II

Emissions Reductions Programs and Initiatives

Appendix II
Emissions Reductions Programs and Initiatives

Air Standards and Programs Impacting
Hazardous Air Pollutant Emissions/Deposition to Watersheds

This Appendix summarizes the hazardous air pollutant (HAP) related standards and programs (including time-frames) that will impact emissions and ultimately air deposition into watersheds. The descriptive text and Table II.1. are based on EPA's document, the *Air-Water Interface Work Plan*, which can be accessed on the World Wide Web at http://www.epa.gov/ttn/oarpg/t3/reports/combined.pdf. Additional information on these programs can be found in EPA's *Deposition of Air Pollutants to the Great Waters, Third Report to Congress* (EPA-453/R-00-005, June 2000) which can be accessed on the World Wide Web at http://www.epa.gov/oar/oaqps/gr8water. This Appendix is only a summary of many diverse and dynamic activities, and should be viewed as informational, subject to change as programs and activities continue to develop.

1. ***National Technology-Based Standards*** - Under Section 112 (d) of the Clean Air Act as amended in 1990 (CAA), EPA is required to regulate stationary sources of 188 listed hazardous air pollutants (HAPs). On July 16, 1992, EPA published a list of 174 industry groups (known as source categories) that emit one or more of these air toxics. For listed categories of "major" sources (those that emit, or have the potential to emit, 10 tons/year or more of a HAP or 25 tons/year or more of a combination of HAPs), the CAA requires EPA to develop standards that require the application of air pollution reduction measures known as maximum achievable control technology, or MACT standards. During the process of developing standards for "major sources," EPA also determined that for some source categories MACT standards would be needed for both major and area sources. Otherwise, area sources are to be regulated under less stringent generally available control technology, or GACT standards. Area sources are defined as stationary sources which emit, or have the potential to emit less than10 tons per year of one HAP or 25 tons per year of multiple HAPs. Thus far, EPA has developed 46 stationary source standards, addressing 82 different types of sources.

The CAA provided a 10-year schedule in which to promulgate these MACT standards with a certain percentage of these standards being promulgated within 2, 4, 7 and 10-years. Some of the 10-year standards such as those for refractory manufacturing (many sources emit POM), and commercial industrial boilers (sources emit mercury, cadmium, lead) are still under development. EPA intends to address all the originally listed source

categories by May 15, 2002.

2. ***Solid Waste Combustion Standards*** - Section 129 of the CAA directs EPA to establish new source performance standards, or NSPS, and emission guidelines under section 111 of the Act to limit emissions of dioxins and furans, cadmium, lead, mercury, and NOX, as well as particulate matter, opacity, sulfur dioxide, carbon monoxide, and hydrogen chloride from solid waste incineration units burning nonhazardous solid waste. These standards are essentially equivalent to MACT standards and apply to all subject solid waste incineration units without regard to "major" or "area" status. EPA has issued final standards and guidelines for large municipal waste combustors (MWCs), small MWCs, hospital/medical/infectious waste incinerators (HMIWIs) and commercial and industrial solid waste incinerators (CISWI). MWCs and HMIWIs account for 30 percent of the national mercury emissions to the air. By the time these rules for MWCs and HMIWIs are fully implemented, they will reduce mercury emissions from these sources by about 90 percent from baseline levels, and will reduce dioxin/furan emissions from these sources by more than 95 percent from baseline levels.

3. ***Residual Risk Standards*** - The residual risk standards program, required under sections 112(f) and 129(h)(3) of the CAA is designed to assess the risk from source categories after MACT standards and NSPS for solid waste incinerators are implemented. It is in the residual risk phase of the air toxics program that EPA determines the adequacy of the MACT standards already in place. Within 8 years of the promulgation of the MACT standard, EPA is required to assess whether further standards are needed to provide an ample margin of safety to protect public health, or to prevent (after considering costs, energy, safety and other factors) an adverse environmental effect. If EPA concludes that existing technology-based standards are not sufficient to meet these risk-based goals, EPA is required to promulgate additional regulations.

   In analyzing residual risk, EPA will conduct risk assessments consistent with the Agency's human health and ecosystem risk assessment technical guidance and policies. The EPA will use a tiered approach, usually first conducting a screening level assessment for a source category, and move to a refined assessment only where the risks identified in the screening assessment appear unacceptable. Depending on the characteristics of the hazardous air pollutants, these assessments will address single or multiple pathways of exposure (e.g., inhalation, consumption of contaminated fish) as well as human and ecological endpoints (e.g., terrestrial wildlife, fish-eating wildlife).

4. ***Area Source Standards*** - Under the urban air toxics program required under Section 112 (k) of the CAA, EPA must list at least 30 "area source" HAPs and then ensure that 90 percent of the area source emissions of the area source HAPs are regulated. The 30 HAPs were listed in the Integrated Urban Air Toxics Strategy (Strategy) published in the Federal Register on July 19, 1999. In order to begin meeting the 90 percent goal in the Strategy, EPA identified 13 new categories of smaller commercial and industrial operations or so-called "area" sources for regulation. Examples of area sources are dry cleaners, gasoline service stations, and public owned treatment works.

The EPA plans to finalize regulations for the recently listed 13 new area source categories by 2004. In addition, the EPA has completed or nearly completed regulations on an additional 16 area source categories. By 2003, EPA will have listed enough additional source categories for regulation in order to meet the requirement to regulate 90 percent of the area source emissions from all area source HAPs.

5. ***Seven Specific Pollutants*** - Section 112(c)(6) of the CAA lists seven specific pollutants (alkylated lead compounds, POM, hexachlorobenzene, mercury, PCBs, dioxins and furans) for special attention by EPA. The Act requires that EPA assure that stationary sources accounting for 90 percent of the emissions of these air toxics are subject to regulation. EPA published a list of source categories for regulation in the Federal Register in April 1998. Most of these source categories are already being regulated under the MACT program described in #1 above. An example of an area source category being regulated under this requirement is mercury cell chlor alkali plants (which emit mercury) and are a part of the chlorine manufacturing source category. EPA plans to complete these standards by 2003.

6. ***Utility Determination and Actions*** - As reported in the Mercury Report to Congress in 1997, utility plants (primarily coal-fired plants) emitted approximately 52 tons per year of mercury nationwide in 1994, which is almost 1/3 of the human made mercury emissions in the United States. EPA continues to gather data on the mercury emissions from coal-fired electric utility power generation plants to evaluate the need for regulation of toxic air pollutants from these sources. The EPA, in conjunction with the U.S. Department of Energy and other parties, is collecting information to assess the effectiveness and costs of various mercury pollution control technologies and pollution prevention options. Through an agreement with EPA, the National Academy of Sciences (NAS) recently completed a review of the available data on the health impacts associated with exposure to mercury. On December 14, 2000, EPA announced that it will regulate emissions of mercury and other air toxics from coal- and oil-fired electric utility steam generating units. EPA will propose regulations by December 15, 2003 and issue final regulations by December 15, 2004.

7. ***Mobile Source Standards*** - While the toxic reductions from EPA's mobile source emission standards have been large, prior to 1990 EPA had no specific directions from Congress for a planned program to control air toxic emissions from mobile sources. However, in 1990 Congress amended the CAA adding a formal requirement to consider motor vehicle air toxics controls. Section 202(l) requires the Agency to complete a study of motor vehicle-related air toxics, and promulgate requirements for the control of air toxics from motor vehicles. The EPA completed the required study in 1993, and has recently updated the emissions and analyses. EPA proposed a rule to address the requirements of section 202(l) in July 2000. EPA expects to issue a final rule by Spring 2001. In addition, EPA has discretionary authority under CAA section 213(a)(4) to regulate HAP emissions from non-road mobile sources, which the Agency has not yet exercised.

Table II.1.: Office of Air Standard Setting Timeline for Standards Related to Toxics

National Technology-Based Standards		
Standards required by the Act in 1992 and 1994 (2&4-year)	Promulgate the 2&4 year air toxics standards.	Done
Standards required by the Act in 1997 (7-year)	Promulgate remaining 7-year air toxics standards.	Done
Standards required by the Act in 2000 (10-year)	Develop 10-year air toxics standards.	May 2002
Combustion standards	Promulgate remaining combustion standards.	November 2002
Residual Risk (RR) Program		
Residual risk	Propose any additional standards needed for coke ovens.	2001
	Propose any necessary residual risk standards for 2- and 4-year technology based standards.	2002-2004
Area Source Category Listing and Standards		
Update area source category list	Complete the area source list.	December 2003
Develop area source standards	Promulgate 13 area source standards.	2004
	Promulgate additional area source standards.	2006
	Promulgate last group of area source standards.	2009
Seven Specific Pollutants - Source Category List and Standards		
Standards for seven specific pollutants	Promulgate any standards necessary to meet requirement that sources accounting for 90% of emissions are subject to regulation for seven specific pollutants (to the extent not already achieved through the 2,4,7 and 10-year MACT standards).	2003

Utilities Determination and Actions		
Information collection	Collect information from the utility industry, conduct analysis of potential control technologies.	Completed December 2000
Regulatory Decision/Action	Make regulatory determination for air toxics emissions (including mercury) from electric utilities.	Positive determination made December 2000
	Develop regulation (if positive determination is made) for utilities.	2001-2004
Office of Transportation and Air Quality(OTAQ) -Related Activities		
Section 202(l) rule	Proposal identifies mobile source air toxics and considers control options, particularly for gasoline benzene.	Proposal completed July 2000. Final expected Spring 2001
Assessment activities	Final diesel health assessment document.	Expected Spring 2001
	Propose re-assessment of mobile source HAP controls.	2003/2004

Table II.2. Status of Clean Air Act Standards Related to Control of Mercury By Source Category

Source Category	Status	Federal Register Citation
Electric Utility Boilers: coal combustion, oil, and natural gas http://www.epa.gov/ttn/uatw/combust/utiltox/utoxpg.html	Positive determination Dec. 14, 2000	12/20/2000, 65 FR 79825 - Regulatory Finding on the Emissions of Hazardous Air Pollutants from Electric Utility Steam Generating Units
Municipal waste combustion (small) http://www.epa.gov/ttn/uatw/129/mwc/rimwc2.html	Final rules complete 12/06/00 65 FR 76349 12/06/00 65 FR 76377	Subpart AAAA of 40 CFR Part 60 - New Source Performance Standards for Small Municipal Waste Combustion Units Subpart BBBB of 40 CFR Part 60 - Emission Guidelines for Small Municipal Waste Combustion Units
Municipal waste combustion (large) http://www.epa.gov/ttn/uatw/129/mwc/rimwc.html	Final rule and guidelines complete Rule comply date 12/2000 12/19/1995 60 FR 65387	40 CFR Part 62[AD-FRL-6603-5]RIN 2060-ZA03 Page 33461-33469 Federal Plan Requirements for Large Municipal Waste Combustors Constructed On or Before September 20, 1994
Medical waste incineration http://www.epa.gov/ttn/uatw/129/hmiwi/rihmiwi.html#RULE	Final rule and guidelines completed 8/1997 Rule comply date 09/2002 09/15/1997 62FR48348	40 CFR Part 62Federal Plan Requirements for Hospital/Medical/Infectious Waste Incinerators Constructed On or Before June 20, 1996; Final Rule[[Page 49868]]
Chlor-alkali production	Proposed rule expected 2001 Estimated promulgation 2002	

Source Category	Status	Federal Register Citation
Hazardous waste combustors http://www.epa.gov/hwcmact/	Final rule promulgated 09/1999 09/30/1999 64 FR 52827	40 CFR Parts 60, 63, 261, and 270[FRL-6720-9]RIN 2050-AE01 NESHAPS: Final Standards for Hazardous Air Pollutants for Hazardous Waste Combustors. Final rule; technical correction.
Portland cement, excluding hazardous waste fired http://www.epa.gov/ttn/uatw/pcem/pcempg.html	Final rule promulgated 06/1999 Rule comply date 06/2002 06/14/1999 64 FR 31898	40 CFR Part 63 National Emission Standards for Hazardous Air Pollutants for Source Categories; Portland Cement Manufacturing Industry; Final Rule[[Page 31898]]
Commercial/Industrial boilers: coal and oil http://www.epa.gov/ttn/uatw/combust/boiler/boilerpg.html	Proposed rule 01/2001 Estimated promulgation 2002	
Pulp and paper manufacturing cluster http://www.epa.gov/ttn/uatw/pulp/pulppg.html	Proposed rule 04/15/1998 63 FR 18755 Final rule promulgated	12/22/00 65 FR 80755 Final Rule Amendments Amendments to add alternatives to the testing and monitoring of boilers and open biological treatment units used for air pollution control in the MACT I rule. 01/12/01 66 FR 3180 Final Rule Final rule for MACT II covers chemical recovery combustion sources 01/22/01 66 FR 6922 Final Rule Amendments Includes amendments to Appendix C that adds "multiple zone" compliance procedures for biological treatment systems used by MACT I standards.

Source Category	Status	Federal Register Citation
Commercial and Industrial Solid Waste Incinerators http://www.epa.gov/ttn/uatw/129/ciwi/ciwipg.html	Rule Promulgation 12/2000 12/01/2000 65 FR 75337	
Petroleum Refineries http://www.epa.gov/ttn/uatw/petuuu/petuuupg.html	Proposed rules 09/11/1998 63 FR 48890	
Miscellaneous metal surface coating http://www.epa.gov/ttn/uatw/mcoil/mcoilpg.html	Proposed rules 07/18/2000 65 FR 44615	