REGIONAL WASTEWATER FLOW FORECAST MODEL (RWFFM) UPDATE FOR THE BLUE PLAINS SERVICE AREA

FINAL REPORT

August 14, 2001

Prepared under
Metropolitan Washington Council of Governments
Contract 99-037: The Potomac Interceptor Conditions
Survey, Modeling and Meter Study, Task 8

Metcalf & Eddy

Metcalf & Eddy

Transmittal

TO: Ms. Andrea Putscher
Metropolitan Washington Council of Governments
Department of Environmental Programs
777 North Capitol Street, N.E., Suite 300
Washington, D.C. 20002-4239

FROM: Jane McDonough

DATE: November 1, 2004

RE: PI Modeling Study, Task 8

PROJECT NUMBER: 036911241

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√ ATTACHED | UNDER SEPARATE COVER VIA

SHOP DRAWINGS | DOCUMENTS | TRACINGS

PRINTS | SPECIFICATIONS | CATALOGS

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QUANTITY	DESCRIPTION
1	Reproducible copy of the Regional Wastewater Flow Forecast Model Report, dated August 14, 2001. M&E Task 8, PI Modeling Contract

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REMARKS:

Andrea – I sent all the files in a zip file via email. Please let me know if you did not receive them. Thanks!

Jane

14504 Greenview Drive, Suite 400 Laurel, MD 20708
Voice: 301-362-5289 Fax: 301-317-9431

Metcalf & Eddy

August 14, 2001

Mr. T.J. Murphy
Metropolitan Washington Council of Governments
Department of Environmental Programs
777 North Capitol Street, N.E., Suite 300
Washington, D.C. 20002-4239

Subject: Final Regional Wastewater Flow Forecast Model (RWFFM) Update for the Blue Plains Service Area

Dear Mr. Murphy:

M&E is submitting fifteen (15) copies of the Final Technical Memorandum for the Regional Wastewater Flow Forecast Model (RWFFM) Update for the Blue Plains Service Area for distribution to the Blue Plains Technical Committee (BPTC). The comments that COG submitted on July 20, 2001 have been incorporated into this final technical memorandum.

Thank you.

Sincerely,

Jane McDonough, P.E.
Project Manager

cc: T. Spano, MWCOG
J. Doane, M&E

Enclosures

TABLE OF CONTENTS

FINAL TECHNICAL MEMORANDUM
RWFFM UPDATE

TABLE OF CONTENTS

LIST OF TABLES

1.0 PROJECT OVERVIEW

Metcalf & Eddy (M&E) has been retained by the Metropolitan Washington Council of Governments (MWCOG) to update the base wastewater flows and input parameters for the Regional Wastewater Flow Forecast Model (RWFFM) for the Blue Plains Service Area (BPSA). The RWFFM update started in late 2000 and was completed in 2001. This work was performed as a modification to the Potomac Interceptor Conditions Survey, Modeling, and Metering Services Project (MWCOG Contract 09-037).

MWCOG's RWFFM is a planning tool for the wastewater jurisdictions in the metropolitan Washington, DC area. The computer model was originally developed in 1992 and 1993 by O'Brien and Gere Engineers, Inc. as the Blue Plains Flow Projection Model (BPFPM) to project wastewater flows for the BPSA. Since that time, the RWFFM was created by MWCOG using the BPFPM methodology. The BPFPM and the RWFFM used calculated base flows corresponding to the year 1990 as the basis for projecting future wastewater flows. However, there is a need to periodically update the model's base flows, unit flow factors (UFFs) and other important input parameters to reflect changes in flows and changes in planning parameters for all the contributing jurisdictions.

M&E has evaluated the jurisdictions' wastewater flow records and has recommended new calculated base year flows for the model to reflect year 2000 contributions from the District of Columbia Water and Sewer Authority (DCWASA), Fairfax County, the Loudoun County Sanitation Authority (LCSA), the Washington Suburban Sanitary Commission (WSSC), the Town of Vienna, and Washington Dulles International Airport (Dulles) flows. In addition, M&E met with each of the major contributing jurisdictions and discussed internal planning parameters to be integrated into the revised RWFFM. The updated RWFFM will provide more accurate flow projections for the BPSA that will be used in ongoing discussions to address future capacity issues.

MWCOG developed a seven-task work plan for this model update, as provided in Appendix A. M&E was retained to conduct two of these tasks (Task 4 and 5). Task 4 of MWCOG's work plan includes analysis and selection of the new base year flow, and Task 5 includes analysis and selection of model inputs. M&E's methodology and results for these two tasks are described in Sections 2.0 and 3.1, and M&E's recommendations are discussed in Section 3.2. The RWFFM input parameters selected by the Blue Plains Technical Committee (BPTC) are discussed in Section 3.3.

The model utilizes a base year flow and adds incremental wastewater flows to develop future flow projections over time. The future incremental wastewater flows are based on the population projections compiled and released by MWCOG's Cooperative Forecasting Program. The RWFFM is based on the following formulas:

Future Flow = Base Year Flow + Incremental Flow

Incremental Flow = Incremental Sanitary Flow + Incremental I/I

Incremental Sanitary Flow = Unit Flow Factors x Incremental Demographic Projections

Incremental I/I = Percent x Incremental Sanitary Flow

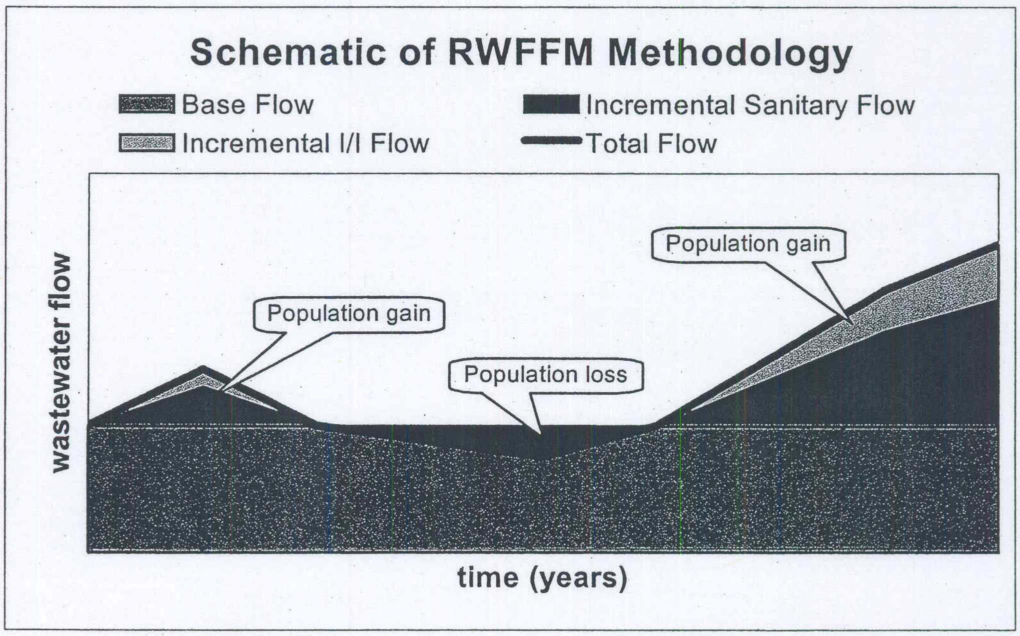
can be customized for diff. jurisdictions or all jurisdictions can share the same flow.

I/I rate – can be customized or all juris. can share the same rate

for each projected year demographics – base year demographics

ex. incremental households in 2010 = total hh in 2010 – total hh in 2000

The following schematic describes the model methodology.



During the course of this project, MWCOG staff converted the RWFFM to a Microsoft Access database format. The model computes wastewater flow projections in five-year increments from

1990 to 2025. Based on M&E's recommendations and the review/approval by jurisdictional staff, MWCOG updated the BPSA portion of the model to use base year 2000 flows and updated flow factors and I/I rates.

2.0 TASK 4 BASE YEAR FLOW UPDATE

One of M&E's tasks was to calculate base year flow equations corresponding to January 2000. In the original BPFPM, a hydrologic analysis was performed consisting of a time series correlation of hydrologic variables (rainfall, temperature, and groundwater level) with monthly wastewater flows. Regression equations were developed and then used to calculate 1990 base flows for DCWASA, Fairfax County, WSSC, LCSA, Town of Vienna, and Dulles. The base flows for DCWASA, Fairfax County, WSSC, and LCSA were then allocated among each jurisdictions' subsewersheds on a percentage basis derived from the historical contributions of those subsewersheds to the total jurisdictional flow.

M&E evaluated the methodology used for the original model (BPFPM) and updated the regression equations with current data to derive a base year flow reflective of year 2000 conditions. This update will provide a more current baseline for the RWFFM. Historical wastewater flows in the BPSA and the historical hydrologic data provided by MWCOG (see Table 1) were analyzed to calculate an updated base flow for each jurisdiction.

The monthly wastewater flows provided for the study were those reported for billing purposes by each of the jurisdictions contributing flow to the Blue Plains Wastewater Treatment Plant (WWTP). The hydrologic variables included in the regression analysis include the monthly records for rainfall and temperature recorded at Ronald Reagan Washington National Airport (DCA) by the National Weather Service, and groundwater depth recorded at the long term observation well at Fairland, Maryland (Montgomery County) by the US Geological Survey.

Table 1 – Data Used for Year 2000 Base Flows	
Data Type	**Data Period**
DCA Precipitation (in)	January 1932 – December 2000
Fairland Well Depth (ft)	March 1955 – December 2000
DCA Temperature (°F)	January 1940 – December 2000
DCWASA Wastewater Flow	January 1986 – December 2000
WSSC Wastewater Flow	January 1977 – December 2000
Fairfax County Wastewater Flow	January 1977 – December 2000
LCSA Wastewater Flow	January 1994 – December 2000
Vienna Wastewater Flow	January 1977 – December 2000
Dulles Airport Wastewater Flow	January 1983 – December 2000

The regression analysis relates wastewater flow data to hydrologic parameters in order to differentiate between short-term hydrologic impacts (i.e., rain and groundwater level fluctuations) and long-term trends in wastewater flows caused by demographic changes. To differentiate between the long-term and short-term trends in wastewater flow, the monthly wastewater flows were analyzed as a time series against the associated hydrologic parameters using a multiple linear regression technique. The regression technique used was a least squares method, which calculates an equation line that best fit the data where the dependent y-value (flow) is a function of multiple independent x-values (rainfall, temperature, groundwater level, and year). The trend line is straight only if all variables except one are held constant. M&E recalculated the original multiple linear regression for each of the contributing wastewater jurisdictions using the current data set provided by MWCOG. Based on the multiple linear regression, a flow equation was developed for each of the jurisdictions as shown in Table 2. The R^2 values, also provided in Table 2, indicate the coefficient of determination for the regression analysis. R^2 is a statistical indicator of the correlation between estimated and actual y-values for the entire data set (as provided in Table 1). R^2 values range from 0 to 1.0, with higher values indicating a stronger regression relationship.

Table 2 – Regression Equations and R^2 Values		
Jurisdiction	**Flow Equations Developed from Multiple Linear Regression**	**R^2**
Fairfax	Q = -1135.699 + 0.165 x Rn – 0.002 x Temp – 0.628 x Frld Well + 0.585 x Yr	0.90
WSSC	Q = -1059.34 + 0.755 x Rn + 0.085 x Temp – 6.508 x Frld Well + 0.635 x Yr	0.78
LCSA	Q = -1141.7 + 0.05 x Rn – 0.011 x Temp – 0.154 x Frld Well + 0.576 x Yr	0.93
DCWASA	Q = -1026.56 + 4.001 x Rn + 0.233 x Temp – 2.687 x Frld Well + 0.598 x Yr	0.52
Vienna	Q = -22.149 + 0.00764 x Rn + 0.00125 x Temp – 0.06228 x Frld Well + 0.01197 x Yr	0.36
Dulles	Q = -43.415 + 0.01735 x Rn – 0.00049 x Temp – 0.00682 x Frld Well + 0.02211 x Yr	0.54

Q = flow (mgd) Rn = rainfall (inches) Temp = temperature (°F) Frld Well = groundwater depth (feet) Yr = year

The median values for each hydrologic variable were calculated from the available data, and are shown in Table 3. These median values were used in the flow equations (Table 2) to calculate trend lines representative of average hydrologic conditions.

Table 3 – Hydrologic Data Used for Year 2000 Base Flows		
Hydrologic Parameter	**Available Data Period**	**Median Value**
DCA Precipitation (in)	Jan. 1932 – Dec. 2000	2.91
Fairland Well Depth (ft)	March 1955 – Dec. 2000	12.70
DCA Temperature (°F)	Jan. 1940 – Dec. 2000	57.95

The year 2000 base flow developed for each jurisdiction was the value generated by the trend line for January 2000, as shown in Table 4. The graphs generated from each analysis, showing historical metered data, fitted equation and trend line are provided in Figures 1 through 6 in Appendix B.

The model calculates incremental flow changes on a subsewershed basis for DCWASA, WSSC, Fairfax County and LCSA, after MWCOG's demographic data have been organized according to subsewershed. Therefore, the base year flows for these jurisdictions were apportioned among the individual subsewersheds. M&E used the 12-month rolling annual average (RAA) data provided in the October 2000 DCWASA monthly billing report, information provided by representatives of the jurisdictions, and the MWCOG geographic information system (GIS) subsewershed layer to determine the percent of total flow that each subsewershed contributes for

Fairfax County, WSSC and LCSA. DCWASA's subsewershed flow percentages were derived based on the year 2000 demographic data.

Table 4 – Summary of M&E - Recommended 2000 Base Year Flows *	
Jurisdiction	**Flow (mgd)**
Fairfax County	26.69
WSSC	135.13
LCSA	7.85
DCWASA	160.46
Vienna	1.09
Dulles	0.74

* Flows correspond to January 2000.

Table 5 provides an estimate of the Fairfax County flow contribution per subsewershed. The year 2000 base flow of 26.69 mgd (see Table 4) was apportioned to the subsewersheds based on discussions with Fairfax County and from reviewing their reports and data.

Table 5 – Fairfax County Base Year Flow Apportioned by Subsewershed		
Fairfax County Subsewersheds	**Flow %**	**Flow (mgd)**
A-1 Horsepen Creek	9.70	2.589
A-2 Horsepen Creek, E Branch	2.91	0.777
A-3 Horsepen Creek, F Branch	1.48	0.395
B-1 Sugarland Run	1.10	0.294
B-2 Sugarland Run	4.39	1.171
B-3 Sugarland Run	0.41	0.109
B-5 Sugarland Run	8.15	2.175
C-1 Nichols Run	0.02	0.005
C-2 Pond Branch	0.00	0.000
D-1 Difficult Run	4.59	1.225
D-2 Colvin Run	8.12	2.167
D-3 Difficult Run	17.93	4.786
E-1 Scotts Run	12.52	3.342
E-2 Bullneck Run	0.06	0.016
F Dead Run	4.10	1.094
G-1 Pimmit	15.03	4.011
G-2 Little Pimmit Run	1.37	0.366
G-3 Turkey Run	2.05	0.547
G-4 Strohman Run	0.23	0.061
Arlington County Contributions	5.85	1.561
TOTAL	100	26.69

Based on discussions with representatives from WSSC and from reviewing previous reports and data, M&E apportioned WSSC's base year flow of 135.13 mgd (see Table 4) as shown in Table 6. In order to further apportion the Anacostia base flow into the five individual Anacostia subsewersheds used in the MWCOG demographic forecasts, M&E evaluated the year 2000 demographic data and UFFs for households and employment to derive a percentage of flow from each of the Anacostia subsewersheds.

Table 6 – WSSC Base Year Flow Apportioned by Subsewershed

WSSC Subsewersheds	Flow %	Flow (mgd)
Anacostia East –1 (MC)	4.90	6.621
Anacostia East –2 (PGC)	12.57	16.986
Anacostia West –1 (PGC)	5.49	7.419
Anacostia West –2 (MC)	12.02	16.242
Anacostia South (PGC)	7.87	10.635
Cabin John	6.65	8.986
Rockville – Cabin John	1.63	2.203
Dulles	0.30	0.405
Little Falls	2.78	3.757
Muddy Branch	2.49	3.364
Rock Creek	19.54	26.405
Rockville – Rock Creek	1.29	1.743
Rock Run	0.62	0.838
Watts Branch	1.7	2.297
Rockville – Watts Branch	1.59	2.149
Oxon	6.35	8.581
Seneca	12.21	16.499
TOTAL	100	135.13

MC = Montgomery County PGC = Prince George's County

Table 7 provides an estimate for the LCSA flow contribution per subsewershed. The subsewershed flow allocation for year 2000 base flow of 7.85 mgd (see Table 4) was developed based on LCSA 12-month RAA flows in the October 2000 DCWASA monthly billing report and the MWCOG GIS subsewershed layer.

Table 7 – LCSA Base Year Flow Apportioned by Subsewershed		
LCSA Subsewersheds	**Flow %**	**Flow (mgd)**
Middle Broad Run	0.73	0.057
Boise Cascade	5.00	0.393
Cabin Branch	16.29	1.279
Country Side No. 1	1.09	0.086
Country Side No. 2	3.03	0.238
Great Falls Forest	2.01	0.158
Hughes Branch	2.79	0.219
Indian Creek	6.15	0.483
PIP	11.85	0.930
Russell Branch/Beaverdam Run	24.06	1.889
Seneca	3.45	0.271
Triple 7	9.74	0.765
Elklick Run	3.88	0.305
Lower Foley Branch	0.00	0.000
Stallion Branch	0.00	0.000
Upper Foley Branch	0.00	0.000
Upper Broad Run	0.00	0.000
Horsepen Run	0.44	0.035
West Sterling	1.58	0.124
Muddy Branch	7.91	0.621
TOTAL	100	7.85

Based on discussions with DCWASA, M&E determined the base flow apportionment per subsewershed for DCWASA's base year flow of 160.46 mgd (see Table 4) from MWCOG's year 2000 demographic data, as provided in Table 8. Both the household and the employment demographic data was used to derive the percentage of flow for each subsewershed.

Table 8 – DCWASA Base Year Flow Apportioned by Subsewershed		
DC Subsewersheds	**Flow %**	**Flow (mgd)**
Anacostia Main Interceptor	10.23	16.415
East Side Interceptor	6.06	9.724
Falls Branch/Upper Potomac Interceptor	9.27	14.876
Northeast Boundary	9.47	15.196
Oxon Run	6.61	10.606
Piney Branch	25.69	41.222
Rock Creek Main Interceptor	8.21	13.174
Tiber Creek/B Street-New Jersey	24.45	39.233
TOTAL	100	160.46

Future changes in flow projections in each subsewershed will be added to the base year flows in 5-year increments. These projections are based on a number of factors and are described in more detail in the following section.

3.0 TASK 5 ANALYSIS AND SELECTION OF MODEL INPUTS

MWCOG requested M&E to determine the current flow projection practices and values used by the jurisdictions contributing flow to Blue Plains WWTP. As part of this task, M&E conducted informational interviews with WSSC (in conjunction with representatives from Montgomery County and Prince George's County), Fairfax County, LCSA, and DCWASA to obtain internal planning information from each of the jurisdictions. The information obtained was used to develop updated factors for the flow projections calculated by the revised RWFFM. M&E met with representatives from Fairfax County Department of Public Works and Environmental Services (DPWES), DCWASA, WSSC and LCSA in January 2001.

During the interviews, M&E collected the following information from the four major jurisdictions (Fairfax County, DCWASA, WSSC, LCSA):

- Unit Flow Factors (UFFs) - the gallons per day (gpd) of wastewater flow per unit (different UFFs are used for household and employment).
- Infiltration/Inflow (I/I) Rate - an allowance for the nonsanitary flow component in the conveyance system.
- Nonsewered Service Conversion (NSSC) Rate - an allowance for the conversion of existing nonsewered units to sewered units.
- System Information - planned modifications during the study period to the wastewater infrastructure within each of the jurisdictions.
- Flow Projections - the internal flow projections performed by each jurisdiction.

The flow projections are primarily driven by the demographic data for the BPSA. The MWCOG Cooperative Forecasting Program generates projections based on Transportation Analysis Zones, which are then aggregated on a subsewershed basis. MWCOG's Department of Environmental

Programs has extracted the data from the BPSA using GIS. The demographic data are organized into 5-year increments and divided into major categories. The household category denotes the number of physical households in the subsewershed. Total population denotes the number of residents in the households and group quarters (such as colleges, nursing homes, barracks, etc.). Total employment represents the sum of all employees (industry, retail, office and other) within a subsewershed. The industry, retail, office, and other categories represent the number of employees within each subsewershed in that particular type of employment. Table 9 provides an example of the 2025 demographic data that are developed as part of the MWCOG Cooperative Forecasting Program, Round 6.2.

Table 9 – MWCOG Demographic Data Example	
Jurisdiction	Montgomery County
Sewershed Name	Blue Plains
Subsewershed Name	Muddy Branch
Households 2025	28,838
Total Population 2025	73,095
Employment 2025	64,432
Industry 2025	7,464
Retail 2025	8,822
Office 2025	40,212
Other 2025	7,934

The base year 2000 flows described in Section 2.0 will be added to the incremental flows calculated by the model to project future flows. Incremental flow projections will be performed for each subsewershed for DCWASA, WSSC, Fairfax County, LCSA, the Town of Vienna and Dulles.

There are two major components of the future incremental flow projections – the change in sanitary flows due to the changes in demographics compared to the base year, and the change in I/I. The model will calculate incremental sanitary flows using the change in population forecasted for each jurisdiction or subsewershed as provided by MWCOG Cooperative Forecast.

This change in population will be multiplied by a sanitary wastewater UFF which estimates the amount of sanitary flow generated by each household or employee (for residential and nonresidential customers). M&E obtained the current UFFs developed by and used for planning purposes from each of the major jurisdictions, as discussed in more detail later in this section.

The change in I/I will be calculated in the model as a percentage of the incremental sanitary flows described above. Estimated rates of I/I were obtained from each jurisdiction as part of this task and are discussed later in this section. The model will only increase I/I flows if the sanitary flow projections are increasing, therefore I/I flows will remain constant if sanitary flows are projected to remain constant or decrease.

In addition, the model currently makes an allowance for new connections to the jurisdictions' wastewater collection systems, such that future customers who are currently nonsewered can be accounted for as they become connected to the wastewater collection system. M&E obtained information from the jurisdictions regarding their future plans for converting nonsewered areas to the collection system, as described in more detail below. This adjustment is not required in the majority of subsewersheds since the collection systems in many of the subsewersheds are substantially complete, and other areas are not planned for sewer service within the 25 year planning period that this model is intended to serve. M&E has made recommendations to omit this inconsequential component of the model based on information collected from the jurisdictions regarding their current and future flows. Staff from the jurisdictions have approved this recommendation.

System information and flow projections were also obtained from the jurisdictions during the interviews for informational purposes. These data are not incorporated into the RWFFM, however the system information and flow projections are documented in this report.

3.1 Flow Projection Information Collected from User Jurisdictions

The planning information M&E collected as part of Task 5 from each of the jurisdictions is described in the following sections.

Table 10 – Fairfax County UFFs	
Category	**Factor**
Single Family	179 gpd/unit
Townhouse	145 gpd/unit
Apartment	186 gpd/unit
Nonresidential	0.08 gpd/square foot

In order to apply the nonresidential UFF developed by the Fairfax County DPWES to the MWCOG demographic data, M&E researched additional data compiled by Fairfax County. The Fairfax County Department of Systems Management for Human Services, Economic and Demographic Research Team publishes data for nonresidential gross floor area by sewershed. This information is attached in Appendix C-1. By comparing the floor area to the MWCOG demographic data, and assuming that 96% of the nonresidential properties are sewered (based on comparison of actual nonresidential square footage with square footage for nonresidential connections), M&E developed the following factors to estimate an average relationship of floor area to the number of employees per type of employment for the subsewersheds within the BPSA. In addition, by applying the 0.08 gpd/square foot (see Table 10), a wastewater UFF for each employment category (nonresidential) was developed (see Table 11).

Table 11 – Fairfax County UFFs for Employment		
Employment Category	**Factor (square feet/employee)**	**UFF (gpd/employee)**
Retail	410	33
Office	263	21
Industrial	621	50
Other	450	36

Infiltration/Inflow Rates

Fairfax County estimates I/I as a percentage of total sewer flow. The I/I percentage is derived by comparing metered wastewater flow data with the sanitary component of the flow, which is estimated from metered water consumption data. Due to differences in the age, location and condition of Fairfax County's sewer system, the I/I rates vary according to region. The older

3.1.1 Fairfax County

There are 19 subsewersheds included in the BPSA in Fairfax County. Additionally, subcontracted flows from the Town of Herndon and Arlington County, known as Sale of Service (SOS) are included in Fairfax County's capacity allocation at the Blue Plains WWTP. Arlington County has contracted with Fairfax County for 1.8 mgd of wastewater conveyance via the Pimmit Run subsewershed. The Town of Herndon has contracted with Fairfax County for up to 3 mgd of flow. Fairfax County flows are conveyed to the Blue Plains WWTP through the Potomac Interceptor (PI) and the Pimmit Run Interceptor via the Upper Potomac Interceptor Relief Sewer (UPIRS) in the District of Columbia.

Unit Flow Factors

Fairfax County DPWES uses UFFs to develop flow forecasts, which are used to perform treatment plant and conveyance capacity evaluations. Fairfax County DPWES develops residential and nonresidential UFFs based on analysis of historical water usage records. The UFFs are based on system-wide averages and are therefore not subsewershed specific. Water consumption records for the winter quarter of 1998 through 2000 were used to determine average wastewater flows for single family homes (SF) and townhouses (TH). Winter quarter water records were used to develop UFFs to better reflect the actual sewer flow since they do not include water consumption associated with car washing, watering the lawn or other activities that may increase water usage without contributing to wastewater flows. The winter quarter is defined by Fairfax County as any three-month sequence that includes the month of February. Fairfax County determined that the years 1998 through 2000 provided a fairly consistent three-year average for flows. The multi-family (apartment) residential UFFs and the nonresidential (employment) UFFs were derived similarly using water records. However, annual averages were used as opposed to the winter quarter averages based on the assumption that the same amount of water is used for apartments and nonresidential units regardless of the time of year. Fairfax County has noted a trend of increased water consumption for the apartment category (perhaps as the result of increased occupancies) over the past several evaluation periods. Fairfax County DPWES has developed a nonresidential UFF in terms of square footage of floor area based on their review of water consumption data. The Fairfax County UFFs discussed above are summarized in Table 10.

Pimmit Run subsewershed has a significantly higher I/I rate than the remaining BPSA subsewersheds within Fairfax County. Fairfax County's current I/I estimates (three-year average, developed using 1998-2000 data) are summarized in Table 12.

Table 12 – Fairfax County I/I (% of Total Flow)	
PI	20.6 %
Pimmit Run	39.3 %
BPSA within Fairfax County	25.5 %

Nonsewered Areas

Fairfax County's nonsewered areas within the BPSA are primarily located in the Nichols Run, Pond Branch, and the Bull Neck Run subsewersheds. Based on zoning criteria, these three subsewersheds will remain nonsewered, so future demographic growth in these areas will not be included in the model flow projections. Approximately 80% of the remaining subsewersheds within the Fairfax County BPSA are sewered, and all future demographic growth within these subsewersheds is expected to occur in sewered areas. The nonsewered properties in the remaining subsewersheds are expected to remain nonsewered since septic lots are not required to convert to the sewer system unless they are not operating properly and are deemed non-repairable. Based on discussions with Fairfax County, it is assumed that the overall rate of conversion from septic properties to the sewered system is insignificant for the purpose of this planning model. Therefore, a nonsewered service conversion rate is not needed in the model for Fairfax County BPSA flows.

System Information

Fairfax County has the ability to pump flows from the BPSA to the County's Noman Cole Pollution Control Plant (NCPCP) via the Difficult Run Pump Station, which has a rated capacity of 10 mgd. Fairfax County does not currently use the Difficult Run Pump Station to pump to the NCPCP (although it has been used in the past), but plans to begin using it once the Fairfax County allocated capacity for the Blue Plains WWTP is reached in the future. The current capacity of NCPCP is 54 mgd, however a planned future expansion will result in a plant capacity of 67 mgd. Fairfax County also has plans to purchase up to 5 mgd capacity from LCSA at their new Broad Run Water Reclamation Facility (WRF) which is scheduled to be on-line by 2008.

Flow Projections

Fairfax County's flow projection for Blue Plains for 2025 is 40.23 mgd, which includes 35.37 mgd of Fairfax County flow and a total of 4.86 mgd from SOS flows. For the year 2025, the projected SOS flows consist of 1.80 mgd from Arlington, 3.02 mgd from the Town of Herndon and 0.04 mgd from Fairfax County Water Authority (FCWA).

3.1.2 Washington Suburban Sanitary Commission

WSSC is responsible for wastewater conveyance and treatment for flows from Montgomery and Prince George's Counties, and portions of the City of Rockville. The City of Rockville has an agreement with WSSC to purchase capacity at Blue Plains WWTP. The Rockville flows that are sent to the Blue Plains WWTP are conveyed through the WSSC conveyance system with portions of the flow directed through the Cabin John, Rock Creek and Watts Branch subsewersheds.

Unit Flow Factors

WSSC develops base sanitary UFFs for residential and nonresidential flows. The base sanitary UFF per type of residential unit is based on average winter quarter daily average consumption (DAC) data for water accounts. The average winter quarter usually consists of the January through March time period. Similar to Fairfax County, WSSC uses winter quarter water data in order to exclude water usage attributed to car washing, lawn watering, and other activities which do not contribute to wastewater flow. Submeters and accounts billed as "water only" were not included in the UFF calculations. Residential UFFs are developed for the following dwelling types: detached single family dwelling units, individual townhouse, single family composite, garden apartments and high-rise apartments. WSSC also developed overall composites for single family, multi-family and household categories.

WSSC develops non-residential UFFs by dividing the total DAC (as of March 1999) for employment centers by the employment population forecast for 1999. The forecasts of employment populations are developed on a County-wide basis by the Maryland-National Capital Park and Planning Commission (M-NCPPC). Different UFFs per employee are developed for Montgomery County and Prince George's County, in addition to a WSSC areawide UFF. WSSC does not develop employment UFFs by employment category (i.e. retail, office, industry, other). WSSC's UFFs are summarized in Table 13.

Table 13 – WSSC UFFs	
Category	**Factor**
Detached Single Family Dwelling	210 gpd/unit
Townhouse – Individual	126 gpd/unit
Single Family Composite	*177 gpd/unit*
Garden Apartment	127 gpd/unit
High Rise Apartment	117 gpd/unit
Multiple Family Composite	*123 gpd/unit*
Household Composite	*160 gpd/unit*
Montgomery County Employment	20 gpd/employee
Prince George's County Employment	40 gpd/employee
Bi-County (WSSC-wide) Employment	28 gpd/employee

Infiltration/Inflow Rates

WSSC estimates I/I rates for the entire WSSC service area to be approximately 44% of sanitary flow, which is equivalent to approximately 30% of the total flow. This I/I rate was determined from extensive data analysis comparing water consumption and wastewater flow data from 1977 through 1998. WSSC normalizes wastewater flows to reflect flows that occur in a year of average rainfall. WSSC concluded that normalized wastewater flows have increased at a rate of 1.21 mgd per year and average daily consumption (ADC) of water has increased at a rate of 0.843 mgd /year. The ratio of the rate of increase in normalized flow to the rate of increase in ADC for the data period yields an I/I factor of 1.44. Total wastewater flow projections including I/I are derived by applying a multiplier of 1.44 to the base sanitary flow projections.

Nonsewered Areas

Within each WSSC subsewershed there are "sewered envelopes", which represent areas that are substantially sewered. There are portions of the Seneca, Upper Rock Creek, and Northwest Branch that are currently nonsewered, and will remain nonsewered. Based on discussions with WSSC, it is assumed that the conversion rate from septic systems to sewered service is negligible within the BPSA. In addition, the majority of new development will occur in the sewered envelopes. As for the Seneca subsewershed, large portions are currently served by septic and will continue to be nonsewered in the future.

System Information

M&E gathered information regarding system information from discussions with representatives from WSSC, Montgomery County and Prince George's County. The Seneca WWTP expansion is planned to be on-line by 2005. The Seneca subsewershed flows which are currently pumped to the Potomac Interceptor via the Muddy Branch subsewershed for treatment at Blue Plains WWTP will be treated at the Seneca WWTP when the capacity is available. Since the Seneca flows will be removed from the BPSA by 2005, these flows are not included in the RWFFM projections for the BPSA. However, they are computed separately by the model.

Other potential system changes which are currently in the planning stages include diverting peak flows from Rock Creek to the Potomac Interceptor and redirecting flows from Anacostia Pump Station to Blue Plains WWTP (Project 89). These flows are included in the RWFFM projections since the flows will remain in the BPSA, and the RWFFM does not evaluate transmission capacity.

Flow Projections

WSSC's most recent flow projections were completed in November 1994, which projected a flow of 172.37 mgd in year 2020. This 1994 projection was based on Round 5.0 demographic data with UFFs and I/I rates derived from the 1994 Strategic Sewer Study.

3.1.3 Loudoun County Sanitation Authority

There are 20 subsewersheds within the BPSA in Loudoun County. LCSA wastewater flow treated at Blue Plains WWTP is conveyed via the Potomac Interceptor.

Unit Flow Factors

For wastewater treatment plant capacity projections, LCSA uses UFFs based on equivalent metered units (EMU), (where one EMU is defined as one 5/8-inch connection, either residential or commercial. LCSA currently uses 225–250 gpd/EMU for WWTP flow capacity projections.

These UFFs differ from the other jurisdictions in that they include I/I. The UFFs are developed by comparing metered flows sent to Blue Plains WWTP with the number of connections served. LCSA's EMU summary table is provided in Appendix C-2. Single family houses and townhouses are equivalent to one EMU. An apartment EMU is equivalent to 62% of the number of units. LCSA uses the same flow factor per EMU for commercial connections, therefore the flows depend upon the connection size. Commercial connections range from 5/8-inch to 6-inch in size, and the associated EMU flow factors range from 225–12,500, as shown in Table 14. A summary of LCSA UFFs per connection is presented in Table 14.

Table 14 – LCSA UFFs Per EMU Connection

Connection Size	Connection Type	UFF (gpd/connection)
5/8-inch	Residential or Commercial	225 – 250
¾-inch	Commercial	338 – 375
1-inch	Commercial	765 – 850
1 ½-inch	Commercial	1,575 – 1,750
2-inch	Commercial	2,025 – 2,250
3-inch	Commercial	3,375 – 3,750
4-inch	Commercial	5,625 – 6,250
6-inch	Commercial	11,250 – 12,500
Apartment Units	Apartment	140 – 155

Infiltration/Inflow Rates

As discussed previously, the LCSA flow factors were developed by comparing metered flows sent to the Blue Plains WWTP with the number of connections served. Therefore, I/I is included in the UFF, and LCSA does not account for I/I separately.

Nonsewered Areas

Based on discussions with representatives from LCSA, it can be assumed that 100% of the eastern portion of the LCSA service area is sewered. The currently nonsewered subsewersheds are Lower Foley, Upper Foley, Stallion Branch, Upper Broad Run and portions of Elklick Run. All significant future growth in Lower Foley, Upper Foley, Stallion Branch, Upper Broad Run and Elklick Run will be sewered. Flows from the Elklick Run, Lower Foley, Upper Foley and Stallion Branch subsewersheds will be pumped to the Potomac Interceptor. It is assumed that Elklick Run, Lower Foley, Stallion Branch and Upper Broad Run will be fully sewered by 2025 and Upper Foley subsewershed will be fully sewered in 2050.

System Information

The Broad Run WRF is expected to be on-line by 2008, and will treat all LCSA flows generated greater than the 13.8 mgd annual average and the 31.9 mgd annual peak treatment capacity available to LCSA at the Blue Plains WWTP. The Broad Run WRF will have an initial capacity of 12 mgd, but LCSA plans to increase its capacity to 30 mgd within the first 10 years of operation.

Flow Projections

In 1998, the LCSA Financial Department performed flow projections through 2008 based on MWCOG Cooperative Forecast, Round 6.1. A chart illustrating these projections is attached in Appendix C-2.

3.1.4 DC Water and Sewer Authority

DCWASA has not performed recent flow projection studies, so they did not provide model input parameters such as UFFs and I/I rates for the RWFFM. Therefore, M&E recommends using UFFs and I/I rates for DCWASA similar to those developed by the other jurisdictions in the BPSA. DCWASA is planning to undertake a rigorous base flow reduction plan within the next few years, so the DCWASA RWFFM inputs may need to be revised in the future.

System Information

DCWASA is in the process of developing a long term control plan (LTCP) for addressing combined sewer overflow (CSO) reductions by maintaining the flows in the conveyance system. This CSO LTCP will change the quantity of flow conveyed to and treated at the Blue Plains WWTP. This impact will be more clearly defined after submittal of the LTCP.

3.2 M&E Recommendations for Updates to the RWFFM Input Parameters

Based upon the planning information collected from each of the main jurisdictions contributing flow to the Blue Plains WWTP, M&E has compiled the following recommendations for the input parameters (UFFs, I/I, NSSC rates) to the updated RWFFM.

3.2.1 Unit Flow Factors

M&E's recommended unit flow factors are provided in Table 15. In most cases, the UFFs are similar to or the same as those used by the jurisdictions for their internal planning purposes. As discussed previously, the RWFFM relies on MWCOG population demographics as the base for the incremental sanitary flows used to project future wastewater flows. The Cooperative Forecast demographic data are compiled per subsewershed and divided into household (residential) demographics and employment (non-residential) demographics for four categories of employment – retail, office, industrial, and other. Since these demographics provide the basis for the sanitary portion of the future flow projections, the model's unit flow factors need to be provided in these same categories.

Table 15 – M&E - Recommended UFFs for the RWFFM

Category	Fairfax County	WSSC MC	WSSC PGC	LCSA	DCWASA	Dulles	Vienna
Household (gpd/unit)	-	160	160	174	174	NA	174
Single Family	179	-	-	-	-	-	-
Townhouse	145	-	-	-	-	-	-
Apartment	186	-	-	-	-	-	-
Employment (gpd /employee)	-	20	40	21	40	48	
Retail	33	-	-	-	-	-	33
Office	21	-	-	-	-	-	21
Industrial	50	-	-	-	-	-	50
Other	36	-	-	-	-	-	36

MC = Montgomery County PGC = Prince George's County

Fairfax County: Fairfax County provides household demographic data to MWCOG in different categories, including single family, townhouse and apartment households. Therefore, M&E recommends using the individual household UFF for each category that Fairfax County has developed. Using the County's 0.08 gpd/square foot for non-residential flows, M&E developed the UFF per employee for the employment categories shown in Table 15 (the recommended values presented in Table 15 are the same values in Table 10 and 11).

WSSC: The MWCOG residential population data are available by household, and are not broken into the single family and multifamily categories that WSSC uses to express UFFs. Therefore, one composite household UFF should be used in the RWFFM for projecting future residential sanitary flows. M&E reviewed County-wide (Montgomery and Prince George's) population projections for single family and multifamily households obtained from the M-NCPPC. When the demographic data from two counties are combined, the ratio of single family and multifamily households over the years 2000, 2005, 2010, 2015, 2020 and 2025 are consistently projected to be approximately 68% and 32% of the total, respectively. Using this information and the WSSC single family (177 gpd/unit) and multifamily (123 gpd/unit) composite average unit flow factors (see Section 3.1.2), M&E calculated a weighted average residential UFF of 160 gpd/unit. For employment wastewater flow projections, M&E recommends using the County-specific non-residential UFF developed by WSSC, since MWCOG non-residential demographic data are provided by subsewershed according to County. The non-residential UFFs developed by WSSC do not differentiate between types of employment, so they should be applied uniformly over the different categories.

LCSA: LCSA uses flow factors that include both sanitary and I/I components of wastewater flow in order to plan for treatment capacity. The recommended UFFs shown in Table 15 for LCSA were developed by separating the sanitary and I/I components of the LCSA flow factors. The residential UFF used by LCSA is 225 to 250 gpd/EMU. Therefore, M&E used the more conservative flow in the range (250 gpd/EMU) and an I/I rate of 30.5% of total flow (see Section 3.2.2 for I/I discussion) to estimate the portion of the LCSA UFF that represents sanitary flow. This calculation resulted in a UFF of 174 gpd/unit for households. Since the demographic data provided to MWCOG for the Cooperative Forecast is not divided by types of household, M&E recommends using only one UFF for all households.

LCSA's non-residential UFFs range from 338 to 12,500 gpd/connection based on the size of the commercial connection, and include sanitary as well as I/I components. M&E analyzed MWCOG employment population data for year 2000 and LCSA's commercial connections, and estimated the average number of employees per commercial connection to be approximately 73. Calculation of a weighted average of the above EMU's per connection size results in 6.2 EMU per average connection. Based on the more conservative LCSA UFF (250 gpd/EMU), the employment based UFF is estimated to be 21 gpd/employee.

Other Jurisdictions: UFFs for DCWASA, Dulles and the Town of Vienna have not been developed, so it is recommended that UFFs similar to the other jurisdictions be used. M&E recommends using the most conservative of the UFFs developed by the other jurisdictions for DCWASA, which is 174 gpd/unit for households and 40 gpd/employee for all employment categories. M&E recommends using a higher employment UFF for Dulles in order to account for flows contributed by the passengers traveling through the airport. The demographic data for Dulles only includes employees at the airport. For the Town of Vienna, M&E recommends using similar UFFs as the Fairfax County UFFs, since Vienna is located within Fairfax County and it is assumed that the two jurisdictions have similar water usage patterns. However, since the Town of Vienna has a separate capacity allocation for flows sent to and treated at the Blue Plains WWTP, Vienna flow projections are conducted separately from Fairfax County.

The National Park Service (NPS) and Department of the Navy also have contracts with DCWASA to convey flows through the Potomac Interceptor for treatment at the Blue Plains WWTP. The flows generated from these two entities are expected to remain constant at an average flow of 0.007 mgd and 0.032 mgd, respectively. Therefore model input parameters are not required for NPS and Navy flows since flow projections are not needed.

3.2.2 Infiltration and Inflow Rates

M&E recommends using a uniform 44% (of sanitary flow) I/I rate in the model based upon the review and comparison of the WSSC and Fairfax County I/I rates. WSSC uses an estimated I/I rate of approximately 44% of sanitary flow, which is equivalent to approximately 30.5% of the total flow. Fairfax County uses different I/I rates for different areas, which range from 20.6% -

39.3% of the total wastewater flow. Since these rates are comparable to the 44% of sanitary flow used by WSSC, M&E recommends using a uniform 44% I/I rate in the model for all jurisdictions.

3.2.3 Nonsewered Service Conversion Rates

WSSC and Fairfax County assume that the majority of their subsewersheds are completely sewered and those that are not currently sewered will not become sewered by 2025. DCWASA also assumes their subsewersheds are completely sewered. Although there will be a conversion from septic areas to the public sewer system for portions of the Occoquan watershed in Loudoun County, these flows are low and are therefore negligible in terms of the entire BPSA flow. Therefore, a conversion rate does not need to be incorporated into the revised RWFFM.

3.3 RWFFM Input Parameters Selected by BPTC

M&E presented recommendations to the BPTC and other technical jurisdictional staff on March 23, 2001. The presentation included:

- Recommendations for the year 2000 base flows per jurisdiction based on multiple linear regressions,
- The apportionment of the base flows per subsewershed,
- The information gathered from the jurisdictions during the interviews,
- The methodology used to develop planning parameters by each of the jurisdictions,
- The results of the analysis,
- The recommended revisions to the model input parameters (see Table 15).

At the conclusion of the presentation, the committee directed MWCOG staff to use the recommended values to update the model input parameters and perform preliminary flow projections for the BPSA. Attendees also asked that a separate model run be computed using a uniform household flow factor of 170 gpd/unit, since several meeting attendees felt that the actual variation in flow factors among the jurisdictions were less pronounced than the numerical comparison might suggest.

3.3.1 Results of Preliminary Model Runs

MWCOG staff ran the model using four sets of flow factors as part of the preliminary analysis. The first model run used M&E's recommended values (see Table 15). The second, third, and fourth model runs used household flow factors of 160 gpd/unit, 170 gpd/unit, and 180 gpd/unit, respectively, applied uniformly to all jurisdictions. For all model runs, the employment flow factors used were the M&E recommended values (see Table 15).

The results of the four model runs are listed in Appendix D. Adjustments were made to the projections to account for the Fairfax County and Loudoun County capacity limitations at Blue Plains WWTP. LCSA intends to treat the excess flow at the Broad Run WRF (scheduled to be on-line in 2008) and Fairfax County intends to treat the excess flow at Broad Run WRF or at the Noman M. Cole, Jr. WWTP. Therefore these flows are listed in Appendix D.

The RWFFM methodology is constructed so that the base year flow reflects all existing flow characteristics (wastewater production rates and I/I rates), whereas the flow factors and I/I rates used by the model are applied only to the incremental (future) flows. Thus, the model is relatively insensitive to differing flow factors since the incremental flows are generally less than the base flows (except in areas such as Loudoun County experiencing rapid population growth). The flow projections for Blue Plains (including the Fairfax County & LCSA flow diversions) show that the results for all four model runs lie within about 1% of each other. For those model runs using a uniform household flow factor, increasing the flow factor by 10 gpd/household (e.g., from 160 gpd to 170 gpd) yields a projected increase in wastewater flows of less than 3 mgd for the Blue Plains service area in the year 2025.

3.3.2 Additional Flow Factor Review

Some committee members expressed concern that the flow factors under consideration for the model may not be reflective of actual wastewater production rates. For example, since DCWASA had not calculated flow factors for the District of Columbia, it was difficult to determine whether the DC flow factors were in fact similar to those of other jurisdictions as assumed for M&E's recommendations. In response to these concerns, DCWASA estimated household water consumption rates at approximately 203 gpd/household (based on 1998 data). Assuming that 90% of water usage leads to wastewater production, the associated wastewater unit flow factor would be 183 gpd/household, which is close to the range of flow factors under consideration for the RWFFM.

MWCOG staff also performed a hypothetical model run in which the District flow factor was increased by 100 gpd/household; the resulting increase in total flow was less than 6.5 mgd in the year 2025. Since the DCWASA's projected total flow in that year is on the order of 180 mgd, the net flow increase would be less than 4%.

DCWASA intends to further refine its estimates of water consumption rates and wastewater production rates as it develops its internal planning capabilities.

3.3.3 Consensus RWFFM Input Parameters

Analysis of the various model runs utilizing a range of flow factors indicated that there were no significant differences among the overall flow projections. Therefore, the BPTC agreed to utilize a household flow factor of 170 gpd/household for all jurisdictions and the employee flow factors recommended by M&E for initial planning purposes. The selected flow factors are listed below in Table 16.

Table 16 – Flow Factors Selected by the BPTC

Category	Fairfax County	WSSC MC	WSSC PGC	LCSA	DCWASA	Dulles	Vienna
Household (gpd/unit)	170	170	170	170	170	NA	170
Employment (gpd /employee)	-	20	40	21	40	48	-
Retail	33	-	-	-	-	-	33
Office	21	-	-	-	-	-	21
Industrial	50	-	-	-	-	-	50
Other	36	-	-	-	-	-	36

The committee also agreed to utilize the proposed incremental I/I rate of 44% of incremental sanitary flow, and agreed that the nonsewered service conversion rate was not necessary for the model for regional-scale projections.

3.3.4 Recognition of Future Flow Analysis

Although the BPTC selected flow factors for use in the BPSA portion of the RWFFM, it is recognized that the UFFs, I/I rates, and even the base flow can be changed in the future pending additional information from ongoing technical studies. These input parameters could also be adjusted to meet different modeling needs. For instance, the RWFFM currently projects average flows, but adjustments could be made to predict the impacts of wet weather events.

MWCOG staff have been directed by the Blue Plains Regional Committee to undertake a comprehensive Blue Plains Long-Term Planning project during Fiscal Year 2002 (July 2001-June 2002), which will allow consideration of other analyses to meet the needs of the Blue Plains user jurisdictions. MWCOG will provide the RWFFM results to M&E for incorporation into the Potomac Interceptor hydraulic model. The RWFFM projections for the year 2025 will be used for the base flows in the Potomac Interceptor hydraulic model.

4.0 REFERENCES

Fairfax County Department of Systems Management for Human Services, Economic and Demographic Research Team, *Demographic Reports 1999, County of Fairfax, Virginia*, 1999.

Fairfax County Public Works and Environmental Services, *Long-Range Financial Plan Report*, May 23, 2000.

Fairfax County Public Works and Environmental Services, *Email from Ed Jones to Jane McDonough (M&E) regarding Fairfax County's Unit Flow Factors and I/I Rates*, January 22, 2001.

Loudoun County Sanitation Authority, *Loudoun County Sanitation Authority Fiscal Impact Report*, 1998.

M&E/MWCOG meeting with Fairfax County DPWES January 25, 2001.

M&E/MWCOG meeting with LCSA January 30, 2001.

M&E/MWCOG meeting with DCWASA January 26, 2001.

M&E/MWCOG meeting with WSSC January 29, 2001.

O'Brien & Gere Engineers, Inc., *Blue Plains WWTP Service Area Flow Projection Model*, May 1993.

Washington Suburban Sanitary Commission, *Strategic Sewerage Plan, Study Memorandum V-2 Wastewater Quantities and Characteristics,* Revised May 1992.

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Washington Suburban Sanitary Commission, *1999 Wastewater Flow Factors Analysis*, July 1999.

Washington Suburban Sanitary Commission, *Monthly Flow Book*, Flow Monitoring, December 27, 2000.

Water and Sewer Authority, DCWASA Monthly Billing Report, October 1999.

APPENDIX A

RWFFM PROJECT WORK PLAN

Appendix A: Project Work Plan

Regional Wastewater Flow Forecast Model
Blue Plains Service Area Review: Work Plan (as of November 9, 2000)

Notes:
- Tasks will be performed in parallel to the extent possible. For instance, the statistical analysis of hydrologic conditions for selecting a base flow (Task 4) will occur simultaneously with jurisdictional interviews for determining their current flow factors (Task 5).
- All tasks assumed to be done by COG unless otherwise noted (e.g., Metcalf & Eddy).

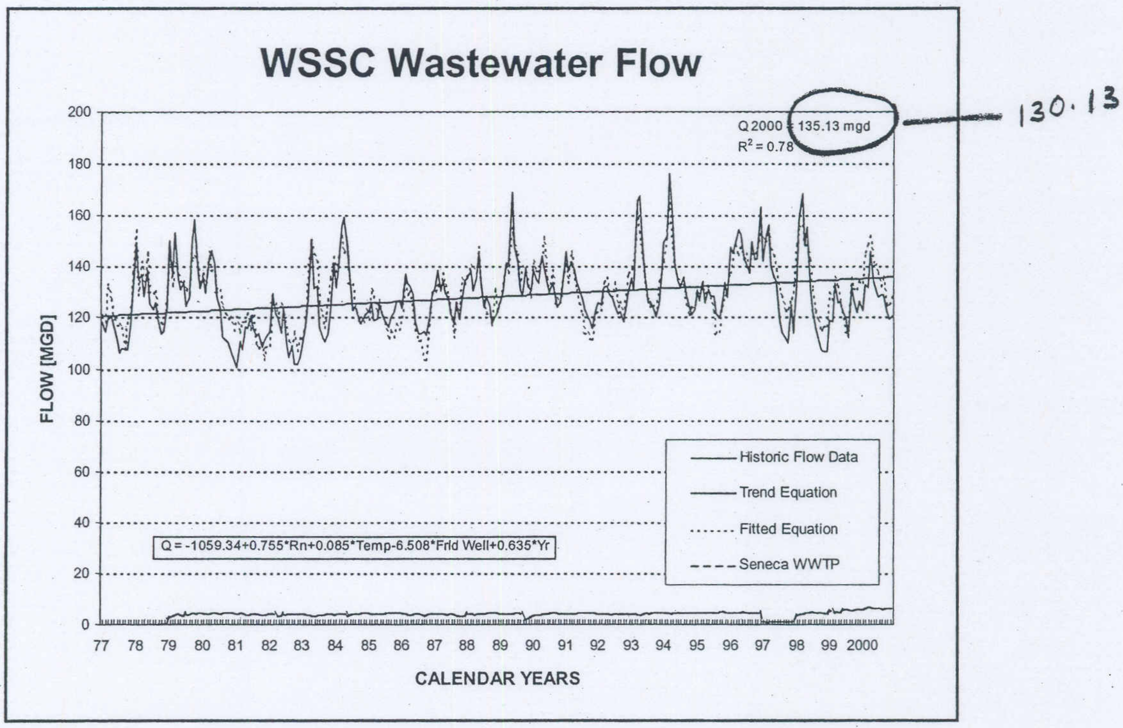
Blue Plains Technical Committee review points:
- August–confirmed overall project direction & provided input on the draft work plan
- November–review Metcalf & Eddy scope of work, proposal, and cost estimate (Task 1)
- November/December–review/comment on memo describing model's background and uses (Task 2)
- December/January–review/comment on technical memo on base flow; select base flow for model (Task 4)
- January–review summary of jurisdictional flow factors (& other parameters) (Task 5)
- February–review M&E report on recommended flow factors, etc. (Task 5)
- March–select flow factors, etc. for Blue Plains service area (Task 5)

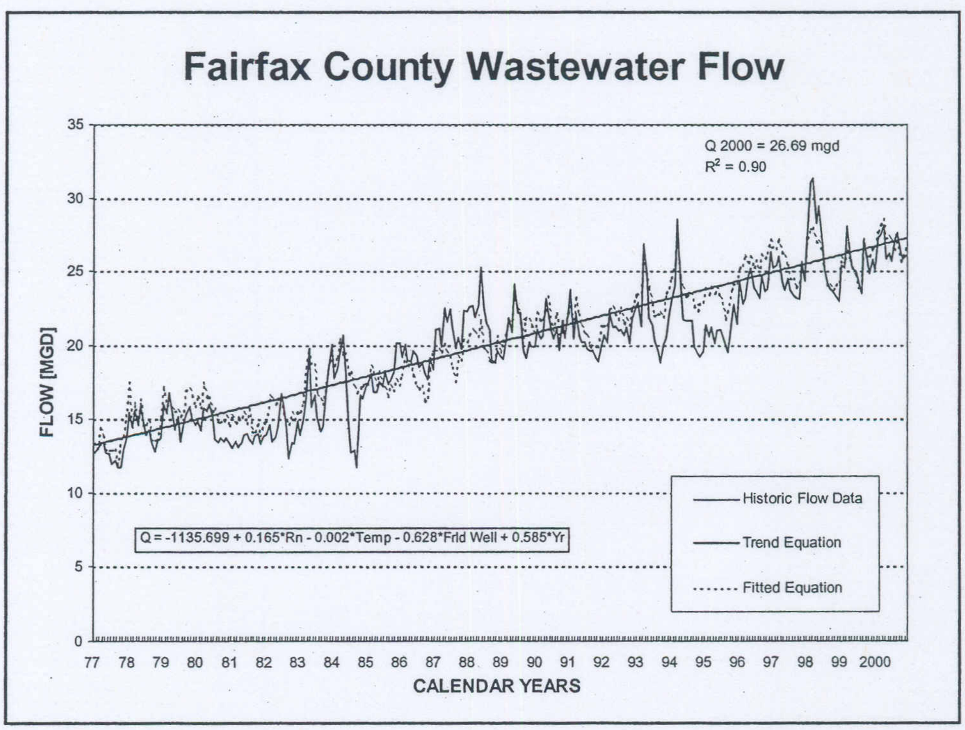
Approximate timeline	Tasks
September-November 2000	1. Contract administration 1.1. Draft consultant scope of work 1.2. Obtain BPTC comments on scope of work 1.3. Initiate contract amendment with M&E
July-November 2000	2. Model summary & review of background material 2.1. Review Blue Plains WWTP Service Area Flow Projection Model ▪ O'Brien & Gere technical documentation ▪ Quattro Pro computer model 2.2. Review Regional Wastewater Flow Forecast Model (RWFFM) ▪ Additional WWTPs ▪ Jurisdictional customization ▪ GIS enhancements ▪ Programming language (Avenue) 2.3. Request BPTC comments on historical perspective and input on potential future uses 2.4. Write Memo to: ▪ Highlight current uses & applications ▪ Describe the jurisdictional review process ▪ Recommend future uses
July-September 2000	3. Preliminary data review 3.1. Assemble hydrologic and wastewater flow data 3.2. List flow factors, I/I rates, non-sewered service conversion rates, and other parameters used by the RWFFM 3.3. Identify any additional data needs & procedure to obtain data
August 2000-January 2001	4. Analysis & selection of base year flow 4.1. Compile & process historic flow records and hydrologic data into usable database 4.2. Write Technical Memo [M&E] on: ▪ Statistical analysis relating hydrologic data & flow data ▪ Recommended base flow 4.3. Select base flow for RWFFM [BPTC]

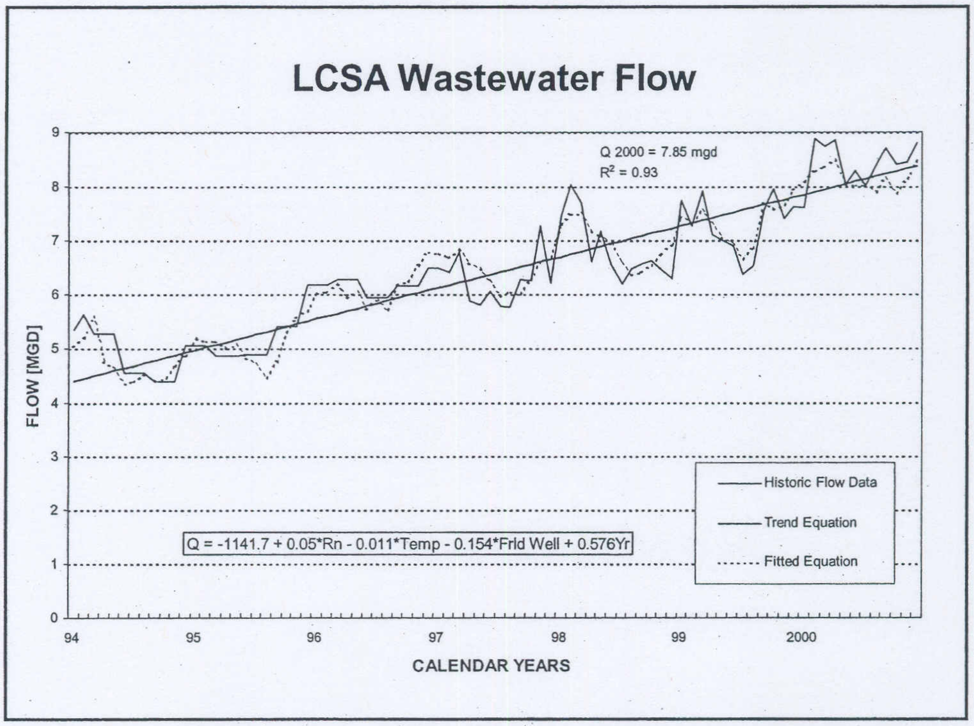
Approximate timeline	Tasks
November 2000-March 2001	5. Analysis & selection of model inputs 5.1. Interview jurisdictions [M&E] to determine the assumptions and values used by each jurisdiction for: ▪ Wastewater flow factors ▪ Infiltration & inflow rates ▪ Peaking factors ▪ Non-sewered service conversion rates ▪ Pumping & facility development information (e.g., Seneca WWTP, Difficult Run pumpover, etc.) not related to COG population projections ▪ Methodology for computing baseline flows ▪ Flow projections generated by the utility 5.2. Write Technical Memo [M&E] to summarize jurisdictions' planning assumptions for flow factors, I/I, etc. 5.3. Develop recommendations for updating the model & inputs ▪ Make recommendations for input parameters [M&E] ▪ Compare flow factors to recorded flows [COG] ▪ Comment on relationship/links between RWFFM and Potomac Interceptor Study model [M&E] 5.4. Select model inputs [BPTC]
February-April 2001	6. Model updates 6.1. Adjust base year flow (as directed by BPTC) 6.2. Modify flow factors, etc. (as selected by BPTC) 6.3. Develop a plan to convert model to Microsoft Access (optional—this step would enhance the model interface to improve its usability and allow increased customization to meet the users' needs)
Spring 2001	7. Flow forecast for Blue Plains Service Area 7.1. Release updated flow forecast for Blue Plains Service Area

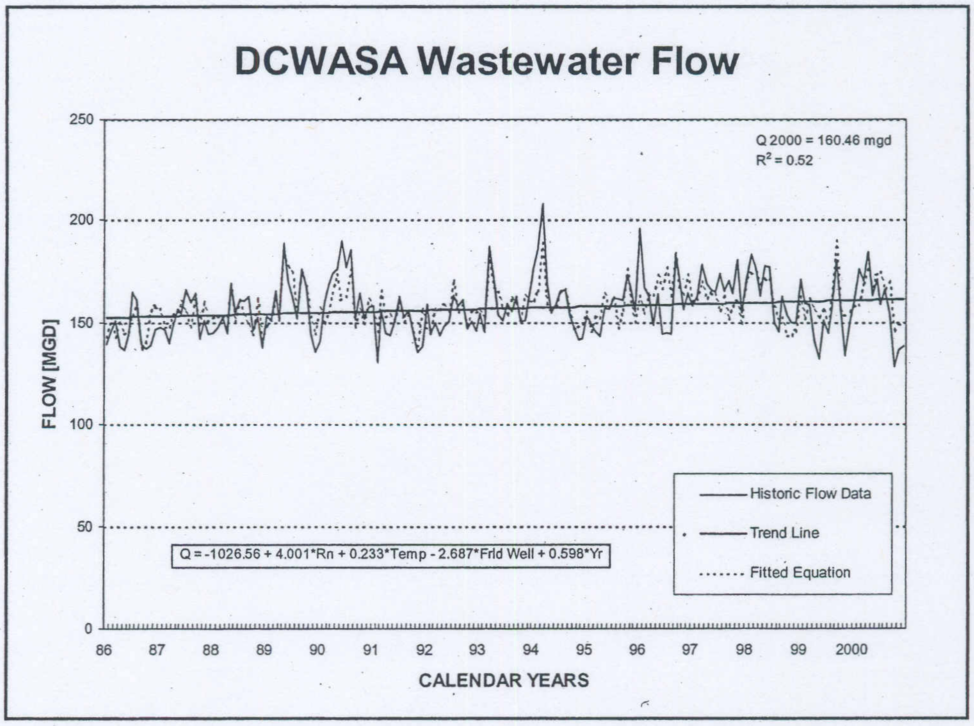
APPENDIX B

LINEAR REGRESSIONS

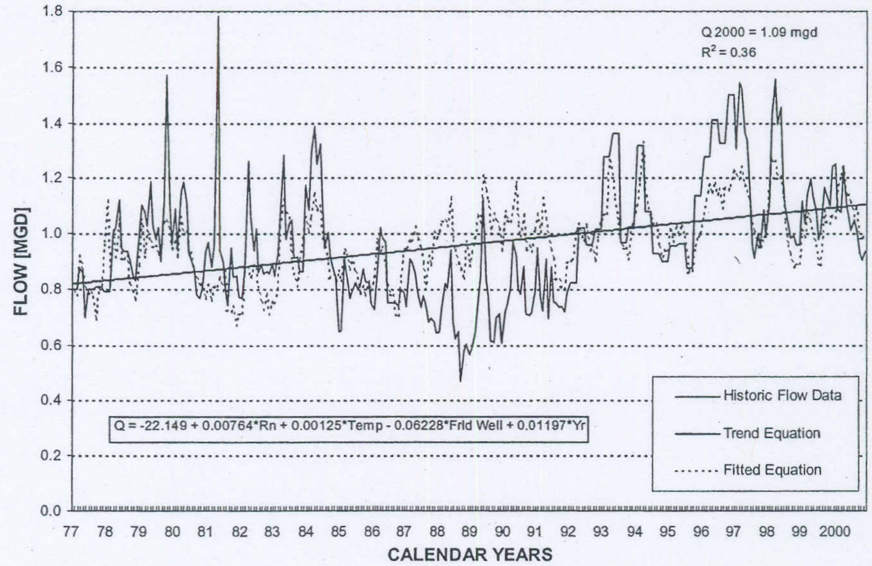

WSSC Wastewater Flow
Q 2000 = 135.13 mgd
R^2 = 0.78
130.13
FLOW [MGD]
Historic Flow Data
Trend Equation
Fitted Equation
Seneca WWTP
Q = -1059.34+0.755*Rn+0.085*Temp-6.508*Frld Well+0.635*Yr
CALENDAR YEARS


Fairfax County Wastewater Flow
Q 2000 = 26.69 mgd
R^2 = 0.90
FLOW [MGD]
Historic Flow Data
Trend Equation
Fitted Equation
Q = -1135.699 + 0.165*Rn - 0.002*Temp - 0.628*Frld Well + 0.585*Yr
CALENDAR YEARS

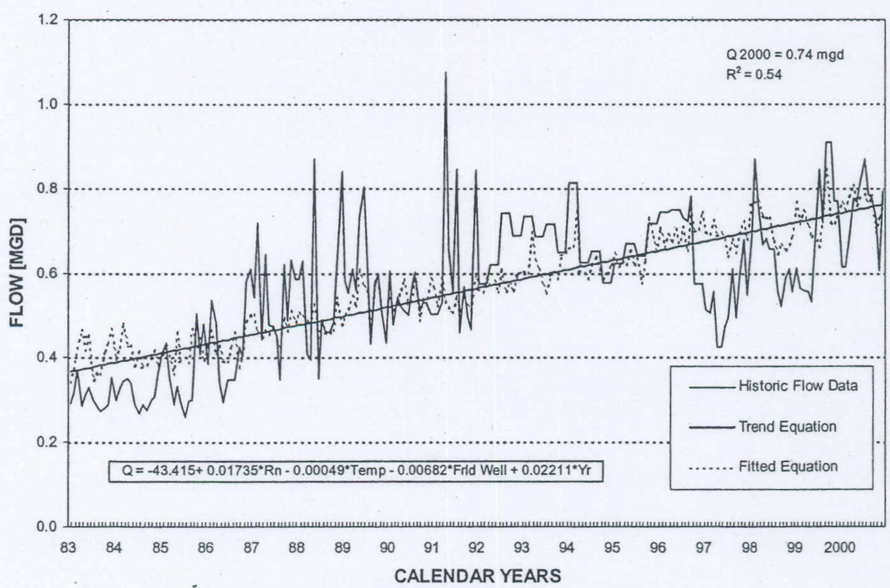

LCSA Wastewater Flow
Q 2000 = 7.85 mgd
R² = 0.93
FLOW [MGD]
Historic Flow Data
Trend Equation
Fitted Equation
Q = -1141.7 + 0.05*Rn - 0.011*Temp - 0.154*Frld Well + 0.576Yr
CALENDAR YEARS
94
95
96
97
98
99
2000


DCWASA Wastewater Flow
Q 2000 = 160.46 mgd
R² = 0.52
FLOW [MGD]
Historic Flow Data
Trend Line
Fitted Equation
Q = -1026.56 + 4.001*Rn + 0.233*Temp - 2.687*Frld Well + 0.598*Yr
CALENDAR YEARS
86
87
88
89
90
91
92
93
94
95
96
97
98
99
2000

Town of Vienna Wastewater Flow



Dulles Airport Wastewater Flow



APPENDIX C

INFORMATION PROVIDED BY JURISDICTIONS

APPENDIX C-1

FAIRFAX COUNTY EMPLOYMENT DATA

Fairfax County VIRGINIA Community

Nonresidential Structures Gross Floor Area by General Activity

by Sewershed, January 1999

Sewershed	Industrial	Office	Retail	Institutional	Total
A1	1,468,865	787,182	549,105	445,828	**3,250,980**
A2		2,165,410	756,784	1,772	**2,923,966**
A3		173,160		105,210	**278,370**
B1	389,339	4,073,404		85,064	**4,547,807**
B2	105,150	2,242,291	1,369,024	847,481	**4,563,946**
B3		1,817	30,327	5,962	**38,106**
B5 1/	636,281	4,439,385	1,585,211	505,604	**7,166,481**
C1		396	11,596	5,924	**17,916**
C2	10,366	40,826	9,212	143,799	**204,203**
D1	383,497	37,072	189,954	137,487	**748,010**
D2	487,852	4,737,719	335,515	618,771	**6,179,857**
D3 2/	1,498,955	13,275,596	4,489,143	1,829,577	**21,093,271**
E1	260,777	9,219,498	4,525,685	252,018	**14,257,978**
E2		6,151	9,422	11,835	**27,408**
F	891	983,907	242,718	412,881	**1,640,397**
G1	158,389	1,988,736	782,692	1,375,327	**4,305,144**
G2		11,825	100,794	98,318	**210,937**
G3		1,472,000		225,288	**1,697,288**
H1	391,105	931,718	2,947,800	312,098	**4,582,721**
H2		2,544,407	324,940		**2,869,347**

H3				3,336	**3,336**
I1	1,283,322	5,609,428	2,504,663	3,185,592	**12,583,005**
I2	23,623	75,371	16,783	558,539	**674,316**
I3	5,660,174	3,086,482	3,178,707	3,395,599	**15,320,962**
I4			484,648	1,676	**486,324**
J1	62,669	381,331	522,406	246,245	**1,212,651**
J2	11,713	82,208	735,499	152,160	**981,580**
J3		185,577	378,736	217,358	**781,671**
J4	1,044	31,459	236,785	544,606	**813,894**
K	69,648	189,988	1,398,425	1,827,275	**3,485,336**
L	245,111	370,828	1,285,129	1,792,113	**3,693,181**
M0	258,117	812,061	209,586	133,573	**1,413,337**
M1		1,529,295	78,404	257,518	**1,865,217**
M2 2/	2,289,534	4,901,608	1,120,379	3,419,804	**11,731,325**
M3	551,500	401,147	221,749	806,814	**1,981,210**
M4	1,660,553	581,471	715,783	1,099,365	**4,057,172**
M5	3,659,074	294,517	356,500	11,984	**4,322,075**
M6	7,709,955	703,461	1,683,125	306,340	**10,402,881**
M7			16,706	3,250	**19,956**
M8		3,922		20,757	**24,679**
M9		3,865,211	2,197,655	46,266	**6,109,132**
N1	776,963	338,803	1,969,813	4,278,902	**7,364,481**
N2	2,376		27,628	189,452	**219,456**
O1				17,429	**17,429**
P	4,000			86,894	**90,894**
P1	206,749	4,760	25,456	4,800	**241,765**
P3	2,952			93,553	**96,505**

Q1	22,572	2,608	7,000	160,945	**193,125**
R1	26,362		45,692	215,201	**287,255**
R2				14,656	**14,656**
R3 3/		20,273	18,973	24,699	**63,945**
R4		3,360		18,257	**21,617**
S1		3,102	186,943	743,071	**933,116**
S2				1,458	**1,458**
T1	6,004,205	1,694,691	764,434	261,900	**8,725,230**
T2	1,791,317	2,963,226	1,274,595	455,809	**6,484,947**
T3		9,484		590,411	**599,895**
T4	42,160	3,482,339	1,691,420	1,015,030	**6,230,949**
T5	69,234	247,734	2,021,362	491,784	**2,830,114**
T6	14,835		3,125	5,468	**23,428**
T7	132,837			15,968	**148,805**
Fairfax County	**38,374,066**	**81,008,245**	**43,638,031**	**34,136,101**	**197,156,443**

Note: Area in Square Feet

1/Town of Herndon

2/Part of Vienna

3/Town of Clifton

Last Updated June 2000

DEMOGRAPHICS PAGE

COMMUNITY PAGE

FAIRFAX COUNTY HOME PAGE

APPENDIX C-2

LCSA PLANNING INFORMATION:

EMU SUMMARY
FLOW PROJECTIONS

WATER & SEWER ACCOUNTS W/ITH EQUIVALENT

rev. 12/01/2000

Meter Size	Wtr & Swr	Wtr Only	Swr Only	Flat Swr	Total
5/8"	33374	179	421	199	34173
Equiv. Metered Units	*33374.0*	*179.0*	*421.0*	*199.0*	*34173.0*
3/4"	42	8	5		55
Equiv. Metered Units	*63.0*	*12.0*	*7.5*	*0.0*	*82.5*
1"	134	19	12		165
Equiv. Metered Units	*455.6*	*64.6*	*40.8*	*0.0*	*561.0*
1 1/2"	205	43	8	1	257
Equiv. Metered Units	*1435.0*	*301.0*	*56.0*	*7.0*	*1799.0*
2"	196	15	6	1	218
Equiv. Metered Units	*1764.0*	*135.0*	*54.0*	*9.0*	*1962.0*
3"	73	3	1		77
Equiv. Metered Units	*1095.0*	*45.0*	*15.0*	*0.0*	*1155.0*
4"	11	1			12
Equiv. Metered Units	*275.0*	*25.0*	*0.0*	*0.0*	*300.0*
6"	1				1
Equiv. Metered Units	*50.0*	*0.0*	*0.0*	*0.0*	*50.0*
Apartment Units	6850				6850
*Equiv. Metered Units**	*4247.0*	*0.0*	*0.0*	*0.0*	*4247.0*
Total	40886	268	453	201	41808
Equiv. Metered Units	*42758.6*	*761.6*	*594.3*	*215.0*	*44329.5*

Accounts	Oct-00	Y-T-D	Total	EMU's
Residential	209	2788	33798	33798.0
Commercial	8	77	1160	6284.5
Apartment**	2	36	418	4247.0
Total	**219**	**2901**	**35376**	**44329.5**

*Apartment Equivalent Metered Units represents 62% of the number of units.

**Apartment Account Total represents number of metered accounts.

APPENDIX D

PRELIMINARY RWFFM FLOW PROJECTIONS

Comparison of RWFFM Results Using Varied Household Flow Factors

Seneca - flows in MGD

Note: in the Base Year 2000, approximately 10-12 MGD of the flows listed for Seneca would actually be treated at Blue Plains. In 2005, the Seneca service area will be separated from the Blue Plains service area, so all projections for 2015-2025 are correctly designated.

Jurisdiction	Flow factor	Base Flow 2000	Flow 2005	Flow 2010	Flow 2015	Flow 2020	Flow 2025
WSSC-Montgomery Co.	M&E	16.50	18.52	20.28	22.42	23.96	24.47
	160	16.50	18.52	20.28	22.42	23.96	24.47
	170	16.50	18.62	20.47	22.74	24.36	24.90
	180	16.50	18.73	20.67	23.06	24.77	25.33

Blue Plains - flows in MGD

Note: these projections incorporate planned operating procedures in which LCSA will direct some flow to the Broad Run Water Reclamation Facility and Fairfax County will direct some flow to the Noman M. Cole, Jr. AWTP or Broad Run to stay within their allocated capacity at Blue Plains.

Jurisdiction	Flow factor	Base Flow 2000	Flow 2005	Flow 2010	Flow 2015	Flow 2020	Flow 2025
Arlington Co.	M&E	1.56	1.55	1.54	1.54	1.54	1.54
(via Fairfax County)	160	1.56	1.55	1.54	1.54	1.54	1.54
	170	1.56	1.55	1.54	1.54	1.54	1.54
	180	1.56	1.54	1.54	1.54	1.54	1.54
District of Columbia/WASA	M&E	160.45	163.51	168.12	172.90	176.53	180.33
	160	160.45	163.46	167.84	172.39	175.83	179.44
	170	160.45	163.50	168.04	172.76	176.33	180.07
	180	160.45	163.53	168.23	173.12	176.83	180.71
Dulles Airport	M&E	0.74	0.94	1.05	1.17	1.34	1.62
	160	0.74	0.94	1.05	1.17	1.34	1.62
	170	0.74	0.94	1.05	1.17	1.34	1.62
	180	0.74	0.94	1.05	1.17	1.34	1.62
Fairfax Co.	M&E	25.13	28.48	29.46	29.46	29.46	29.46
	160	25.13	28.31	29.46	29.46	29.46	29.46
	170	25.13	28.45	29.46	29.46	29.46	29.46
	180	25.13	28.58	29.46	29.46	29.46	29.46
Loudoun Co.	M&E	7.85	12.00	13.80	13.80	13.80	13.80
	160	7.85	11.73	13.80	13.80	13.80	13.80
	170	7.85	11.92	13.80	13.80	13.80	13.80
	180	7.85	12.12	13.80	13.80	13.80	13.80
National Park Service/	M&E	0.04	0.04	0.04	0.04	0.04	0.04
Naval Research Lab	160	0.04	0.04	0.04	0.04	0.04	0.04
	170	0.04	0.04	0.04	0.04	0.04	0.04
	180	0.04	0.04	0.04	0.04	0.04	0.04

Blue Plains - flows in MGD (continued)

Jurisdiction	Flow factor	Base Flow 2000	Flow 2005	Flow 2010	Flow 2015	Flow 2020	Flow 2025
Vienna	M&E	1.09	1.12	1.15	1.19	1.21	1.23
	160	1.09	1.12	1.15	1.18	1.21	1.22
	170	1.09	1.12	1.15	1.19	1.21	1.23
	180	1.09	1.12	1.15	1.19	1.22	1.24
WSSC-Montgomery Co	M&E	75.01	78.69	82.40	85.14	87.61	89.77
	160	75.01	78.69	82.40	85.14	87.61	89.77
	170	75.01	78.84	82.74	85.64	88.23	90.51
	180	75.01	79.00	83.08	86.13	88.86	91.25
WSSC-Prince George's Co.	M&E	43.62	45.22	46.61	48.21	50.27	52.29
	160	43.62	45.22	46.61	48.21	50.27	52.29
	170	43.62	45.27	46.69	48.35	50.47	52.54
	180	43.62	45.31	46.77	48.48	50.67	52.79
	M&E	**315.49**	**331.55**	**344.16**	**353.45**	**361.80**	**370.07**
	160	**315.49**	**331.05**	**343.88**	**352.93**	**361.10**	**369.17**
	170	**315.49**	**331.62**	**344.51**	**353.94**	**362.43**	**370.81**
	180	**315.49**	**332.19**	**345.13**	**354.94**	**363.76**	**372.45**

Flow diversions away from Blue Plains - MGD

Note: these flow diversions would be necessary for Fairfax Co. & LCSA to stay within their allocated capacity at Blue Plains

Jurisdiction	Flow factor	Base Flow 2000	Flow 2005	Flow 2010	Flow 2015	Flow 2020	Flow 2025
Fairfax Co. - to Noman Cole or Broad Run	M&E	0	0	1.94	3.11	4.07	4.91
	160	0	0	1.63	2.75	3.69	4.52
	170	0	0	1.88	3.06	4.03	4.89
	180	0	0	2.13	3.37	4.38	5.27
LCSA - to Broad Run	M&E	0	0	2.22	5.92	9.13	11.56
	160	0	0	1.67	5.14	8.14	10.42
	170	0	0	2.06	5.70	8.85	11.23
	180	0	0	2.45	6.26	9.56	12.05
	M&E	0	0	4.15	9.03	13.20	16.47
	160	0	0	3.30	7.88	11.82	14.94
	170	0	0	3.94	8.76	12.88	16.13
	180	0	0	4.58	9.63	13.93	17.31