PHOSPHORUS LOADS DISCHARGED FROM THE POTWS IN THE CHESAPEAKE BAY DRAINAGE BASIN

Prepared for

THE SOAP AND DETERGENT ASSOCIATION
New York, NY

March, 1984

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1. Introduction and Purpose

Nutrient enrichment has been one of the water quality concerns in the Chesapeake Bay region in the past two decades. Phosphorus is the nutrient currently being controlled at many point source discharges in the Chesapeake basin. A recent report prepared by the U.S. EPA Chesapeake Bay Program discusses phosphorus inputs from municipal wastewater treatment plants (EPA, 1983). Appendix B of the report contains an inventory of all publicly owned treatment works (POTW) with discharges greater than 0.5 mgd located above and below the fall line, as well as some smaller POTWs below the fall line.

A review of the EPA inventory list of the POTWs has indicated first that some POTWs are missing from the list (e.g., Aberdeen Proving Ground in the western Chesapeake). Second, many flows and phosphorus concentrations in the inventory list are not the actual flows and concentrations in 1980. In addition, many POTWs are listed as practicing phosphorus removal that, in fact, are currently secondary treatment facilities at best, without any chemical addition for the purpose of phosphorus removal.

Further, many POTWs which do not have phosphorus removal are not required to monitor and report phosphorus concentrations in their effluents. In the EPA inventory list, various effluent phosphorus concentrations are assigned to these POTWs with no justifications. As a result, the reported phosphorus loads from these POTWs to the Chesapeake Bay may not be correct.

There have been changes at many POTWs since 1980. For example, the Army Base and Boat Harbor plants in the Hampton Roads Sanitation District, Virginia were primary treatment facilities with the addition of alum to reduce BOD levels in 1980. Incidental phosphorus removal was also

achieved. These two plants have since been upgraded to secondary treatment facilities. Alum addition is, however, no longer practiced. As a result, the effluent phosphorus concentrations (without the benefit of alum addition) currently (1983) reported are higher than those reported in 1980.

On the other hand, some plants have since been upgraded to have phosphorus removal capability. Others which already had phosphorus removal have been operating more efficiently to further lower their effluent phosphorus levels. For example, the total phosphorus concentration in the Blue Plains final effluent is currently (1983) averaging 0.38 mg/l compared with 0.58 mg/l reported in 1980.

Further, a few new municipal wastewater treatment plants have been constructed and started operations since 1980. Concurrently, some older or out-of-date POTWs have been closed and their wastewater flows are either being diverted to these new treatment plants or being routed to the nearby existing plants for treatment. To name a few, the new Mooney STP in northern Virginia is in operation to receive the flows from the old Belmont plant. In the Hampton Roads Sanitation District, Virginia, 3 new plants (Atlantic, Nansemond, and York) started operation in 1983. As a result, portions of the flows from the existing facilities such as Chesapeake/Elizabeth, James River, and Lamberts Point have been routed to these new plants.

Based on the above discussions, there is a need to revise and update the inventory list of the POTWs so that the phosphorus loads to the Bay can be determined more accurately. This study is designed to address this issue and to put the point source phosphorus loads to the Chesapeake Bay into perspective by revising the 1980 loads as well as by updating the loads to the 1983 conditions. In order to estimate the phosphorus loads from many POTWs where effluent phosphorus concentrations are <u>not</u> measured, default values are developed based on measured and reported phosphorus concentrations at a number of plants in the region.

Therefore, the objectives of this study can be summarized as follows:

1. to check the 1980 loads listed in the EPA inventory;
2. to update the phosphorus loads to the current (1983) conditions;and
3. to develop sound default values for the effluent concentration.

The scope of this revision and updating effort includes the POTWs (with flows greater than 1 mgd) in the subbasins of the Chesapeake Bay: upper and lower Susquehanna; western Chesapeake and Upper Bay; Eastern Shore; Patuxent; Potomac; Rappahannock; York; and James River basins in the States of Pennsylvania, Maryland, Virginia, and the District of Columbia. No projections of future phosphorus loads from these POTWs are being made in this study. The phosphorus loads from the POTWs which have flows under 1 mgd are collectively determined. These loads represent only a small portion of the total POTW phosphorus loads in the basin as demonstrated in a latter section of this report.

2. Sources of Data

A number of regulatory agencies, institutions, and individuals responsible for water pollution control have been contacted to obtain available effluent data for the POTWs. Appendix A of this report summarizes the sources and contents of information gathered for this report. The data obtained serve the following uses:

1. to determine the annual average flows and effluent phosphorus concentrations, where available, from the Discharge Monitoring Reports (DMR), for the POTWs in the Chesapeake Bay region in 1980 and 1983;
2. to develop default valuesfor the average phosphorus concentrations in primary and secondary effluents not reporting such cncentration; and
3. to summarize the current treatment level and current phosphorus limit(s), if any, in the NPDES permit of individual POTWs (flows greater than 1 mgd) in the Chesapeake Bay region.

3. Development of Default Effluent Phosphorus Concentrations

This section describes the data base assembled and methodology developed in this study to derive the average phosphorus concentrations in primary and secondary effluents. The derived concentrations are then used as the average phosphorus levels to estimate the phosphorus loads from the POTWs which do not measure and report phosphorus concentrations. The following paragraphs present the results of analyses.

Table 1 presents some phosphorus data reported in the literature. First, Metcalf & Eddy, Inc. (1979) gives an average influent phosphorus level of 8 mg/l with a range between 4 mg/l and 15 mg/l. In general, 10% of the phosphorus in the influent is in insoluble form and therefore may be removed in the primary settling process (EPA, 1976). Overall, about 20 to 40% of the influent phosphorus may be removed without chemical addition by facilities having secondary treatment (trickling filter or activated sludge). There is, however, some relatively high concentrations reported in secondary effluents (7.3 mg/l by Tofflemire and Hetling, 1973).

Table 1. Phosphorus Concentrations in Domestic Wastewater

Type of Wastewater	Avg Conc/% Removal	Source
Untreated Domestic Sewage	8.0 mg/l*	Metcalf & Eddy (1979)
After Primary Settling	10% removal	Kugelman (1976)
	5-10% removal	EPA (1976)
Secondary Effluent (no chemical added)	20-40% removal	Kugelman (1976) and EPA (1976)
	7.3 mg/l*	Tofflemire and Hetling (1973)

* values derived from earlier data and believed to be higher than most of the recently reported values.

Table 2 shows the average flow and effluent phosphorus concentrations reported by 20 POTWs in the Chesapeake basin. An arithmetic average of the concentrations is 5.42 mg/l with a standard deviation of ±1.50 mg/l while a flow-weighted average is 5.02 mg/l. These average effluent values

are substantially lower than 7.0 mg/l, currently used by the Maryland State Department of Health and Hygiene (1984) for secondary treatment facilities. A further examination of the recent operation data reveals that the influent concen- trations in many POTWs are much lower than the 8 mg/l level suggested by Metcalf & Eddy (see Table 1). For example, Table 3 presents the flow, influent, and effluent concentration data gathered from a number of facilities in Maryland and Virginia. The flow-weighted average influent concentration is 6.19 mg/l which is lower than the 7.0 mg/l effluent concentration used by the State of Maryland. For comparison purpose, an influent phosphorus concentration of 6.5 mg/l has been reported for 58 major wastewater treatment plants in Michigan prior to the ban of phosphate detergents (Hartig, 1981).

Table 2. Phosphorus Concentrations in Effluents from POTWs* in Chesapeake Bay Region Utilizing the Activated Sludge Process and not Adding Coagulating Chemicals

POTW	Avg Flow (mgd)	Avg Conc (mg/l)
Dover Borough, Pa	0.22	8.75
Damascus, Md	0.29	7.47
Freedom District, Md	1.20	4.00
Westminster, Md	2.10	5.00
Bowie, Md	2.40	6.10
Hanover, Pa	2.60	6.01
Patuxent, Md	3.50	4.10
Nansemond, Va	5.40	5.50
Hagerstown, Md	6.00	3.90
James River, Va	6.82	5.10
Falling Creek, Va	7.22	8.40
Springettsburg, Pa	7.52	3.89
Petersburg, Va	8.25	8.00
Lancaster South, Pa	9.54	5.04
Army Base, Va	11.20	4.50
Chesapeake/Elizabeth, Va	11.20	5.80
Boat Harbor, Va	16.07	3.90
Atlantic, Va	18.60	5.50
Patapsco, Md	32.00	4.90
Richmond, Va	54.90	4.50

Average Concentration = 5.42 mg/l (±1.50 standard deviation)
Flow-weighted Average = 5.02 mg/l

* Data from 1982 or 1983 Discharge Monitoring Reports

Table 3. Operation Data from POTWs in Maryland[1] and Virginia[2]

POTW	Flow (mgd)	Influent P (mg/l)	Effluent P (mg/l)	P Removal (%)	BOD_5 Removal (%)
Primary w/alum:					
Lamberts Point, Va	20.61	4.90	2.50	49	34
Secondary:					
Army Base, Va	11.20	5.40	4.50	17	97
Boat Harbor, Va	16.07	6.00	3.90	35	95
Chesapeake/ Elizabeth, Va	11.20	8.90	5.80	35	88
James River, Va	6.82	7.40	5.10	31	97
Damascus, Md	0.29	10.65	7.47	30	99
Advanced Secondary:[3]					
Western Branch, Md	11.79	6.12	2.29	63	98
Parkway, Md	4.80	6.73	2.19	67	94
Horsepen, Md	0.39	7.10	2.47	63	99
Phosphorus Removal:					
Piscataway, Md	17.28	5.36	0.13	98	99
Senaca Creek, Md	4.03	6.51	1.37	79	99

Flow-weighted Average = 6.19 mg/l

1. 1983 annual average
2. 1982 annual average
3. chemicals added to remove BOD

Also shown in Table 3 is the phosphorus and BOD removal rates for these facilities. Except for the Lamberts Point, Va, plant which is a primary treatment facility, the BOD removal rates are quite high, usually over 90%. On the other hand, phosphorus removal rates vary considerably from one plant to another. In general, the secondary treatment facilities without chemical addition yield phosphorus concentrations from 3.9 mg/l to 7.47 mg/l and their removal rates range from 17% to 35%. Any chemical addition, even in the primary treatment (see the 49% removal rate reported at the Lamberts Point plant), would result in much higher phosphorus removal rates. That is, the advanced secondary (with chemical addition but not necessarily for the purpose of removing phosphorus) facilities such as Western Branch, Parkway, and Horsepen (all in Maryland) yield

phosphorus removal rates over 60%. Of course, when chemicals are added for the sole purpose of removing phosphorus, the removal rate goes up sharply (see the Piscataway and Seneca Creek plants in Table 3).

Based on the above analysis, if a 5% removal rate in the primary treatment process and an influent concentration of 6.5 mg/l are assumed, a phosphorus concentration in the primary effluent is 6.2 mg/l. Further, if a range of 20-40% removal rates is assumed for secondary facilities without chemical addition, a range of phosphorus concentrations in the secondary effluent can be derived to be between 3.90 mg/l and 5.20 mg/l. Finally, a plot of the effluent concentrations for the 20 POTWs listed in Table 2 is shown in Figure 1, with the range of 3.90 mg/l - 5.20 mg/l also displayed. Most of the effluent levels fall within this range.

4. Phosphorus Loads from POTWs in Chesapeake Bay Region

The tabulation of POTW flows, phosphorus concentrations and load is presented in a number of tables in Appendix B on a subbasin by subbasin basis. Also shown in each table are the current treatment level (e.g., primary, secondary, or phosphorus removal) and current phosphorus limit in the NPDES permit. For the purpose of comparison, flows, phosphorus concentrations and loads developed in this study are summarized for 1980 and 1983. In the event that no phosphorus concentration is available, the default value (6.2 mg/l or 5.0 mg/l, depending upon the treatment level), is used.

In general, Appendix B shows, from one subbasin to another, varying degrees of difference in the 1980 phosphorus loads between the EPA estimates and the estimates for this study. In addition, our analyses indicate that there is a slow trend of decreasing phosphorus loads from 1980 to 1983 in all subbasins. It is believed that continuing construction of new plants (although not many), and expansion and upgrading of existing POTWs contribute to such load reductions. The following paragraphs highlight these aspects for individual subbasins.

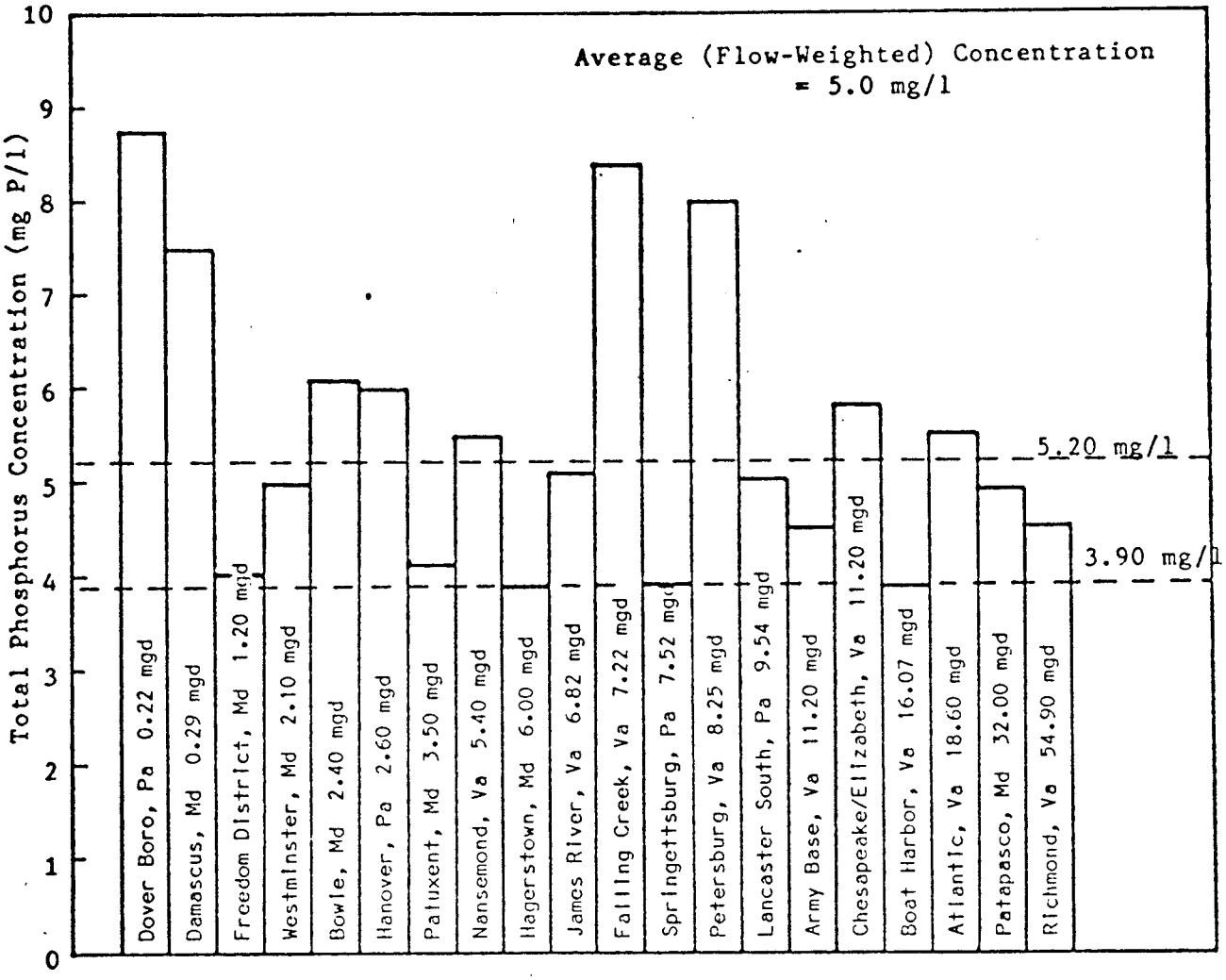

FIGURE 1. PHOSPHORUS CONCENTRATIONS IN EFFLUENTS OF SECONDARY TREATMENT FACILITIES IN THE CHESAPEAKE BAY BASIN

In the upper Susquehanna, no phosphorus removal is required. In the lower Susquehanna, most POTWs are practicing phosphorus removal to comply a current phosphorus limit of 2.0 mg/l, the Pennsylvania policy. The POTWs currently at a secondary treatment level will be required to meet this limit if they consider facility expansion or upgrading.

In the western Chesapeake and Upper Bay area of Maryland, the existing policy also requires a 2.0 mg/l limit. The Baltimore Back River plant is currently practicing phosphorus removal. As a result, a significant reduction of phosphorus loads has been achieved since 1980.

The phosphorus loads from the eastern shore of Maryland are relatively insignificant when compared with those from other subbasins. Currently, the Northeast River plant is practicing phosphorus removal while the Elkton STP is in Step 3 of the facility planning which includes phosphorus removal.

In the Patuxent River basin, the primary difference in the 1980 loads between the EPA estimates and our estimates is the use of different effluent phosphorus concentrations in the calculation (see Columns a and b in the table). Our estimates of the 1980 effluent loads are based on the use of the default value, 5.0 mg/l for each of the plant in the subbasin. Nevertheless, a number of POTWs in the Patuxent reported relatively lower effluent phosphorus levels in 1983, resulting in lower phosphorus loads than 1980.

In the Potomac River basin, every POTW in Maryland and Virginia located below the fall line is practicing phosphorus removal to meet various phosphorus limits. Noticeable improvement in effluent quality (i.e., reduction in effluent phosphorus concentrations) marks reductions in loads from 1980 to 1983.

The phosphorus loads from the POTWs in the Rappahannock River basin are not significant. Although the Culpeper STP does not have a phosphorus limit in its NPDES permit, it generates relatively low phosphorus levels in the effluent.

The new York River STP in the York River basin started operation in 1983 and has since been receiving partial flows from the James River plant in the James River basin.

The James River basin shows a slight reduction in phosphorus loads from 1980 to 1983. None of the POTWs has phosphorus removal at the present time although chemicals are used for BOD removal at the Lamberts Point plant which causes additional phosphorus removal.

The total wastewater flow from the POTWs with flows less than 1 mgd is about 44 mgd (based on the EPA inventory list), which represents a small (3.7%) portion of the total POTW flows in the Chesapeake Bay basin. Using a default phosphorus concentration of 5 mg/l, one can derive a phosphorus loading rate of 1,850 lb/day, which is about 6% of the total loads from all POTWs. (Appendix C).

5. References

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Hartig, J.H. and F.J. Horvath, 1982. A Prelinimary Assessment of Michigan's Detergent Ban. Journal of Water Pollution Control Federation, Vol. 54, p.193.

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Metcalf & Eddy, Inc. 1979. Wastewater Engineering, McGraw-Hill, pp. 64-65.

Tofflemire, T.J. and L.J. Hetling, 1973. A Guide to Chemical and Clarifier Selection for Wastewater Treatment. N.Y. State Department of Environmental conservation, Technical Paper No. 29, pp.7-13.

APPENDIX A. SUMMARY OF DATA GATHERED AND USED IN THIS STUDY

Data and Information	Source/Contact(s)
• Average flows of POTWs in the upper Susquehanna in 1980 and 1983.	• P.J. Koval, Pennsylvania Dept. of Environmental Resources, Wilkes-Barre Regional Office.
• Average flows and phosphorus concentrations of POTWs in the lower Susquehanna and Potomac River basins in 1980 and 1983, current treatment levels and phosphorus levels.	• S.B. Dale, Pennsylvania Dept. of Environmental Resources, Harrisburg Regional Office.
• Average flows and phosphorus concentrations of POTWs in Maryland (including western Chesapeake and upper Bay, eastern shore, Potomac, and Patuxent River basins).	• J. Rein, Maryland Dept. of Environmental Health and Mental Hygiene.
• Treatment levels and phosphorus limits of POTWs in Maryland.	• from the report entitled, "Evaluation of Cost for Reducing Maryland POTW Phosphorus Discharges to Chesapeake Bay." Prepared by Rummel, Klepper & Kahl for The Soap and Detergent Association.
• Average flows and phosphorus concentrations (1980 and 1983) of treatment plants operated by the Washington Suburban Sanitary Commission (WSSC).	• C. Sheetz, WSSC.
• Average flows and phosphorus concentrations of the Blue Plains effluent in 1983.	• Metropolitan Washington Council of Governments.
• Average flows and phosphorus concentrations of POTWs in Potomac and Rappahannock River basins of Virginia in 1980 and 1983.	• S. Wilson and G. Moore, Virginia State Water Control Board (SWCB), Northern Virginia Regional Office.
• Average flows and phosphorus concentrations (1980 and 1983) of POTWs operated by the Hampton Roads Sanitation District (HRSD), influent phosphorus concentrations.	• R.W. Lawrence, HRSD.
• Average flows and phosphorus concentrations of POTWs in James River basin.	• W. Woodfin and W. Bullard, Virginia SWCB, Tidewater Regional Office.

APPENDIX B.
PHOSPHORUS LOADS TO CHESAPEAKE BAY FROM POTWs
WITH FLOWS GREATER THAN 1 MGD

PHOSPHORUS LOADS TO CHESAPEAKE BAY FROM POTWs
WITH FLOWS GREATER THAN 1 MGD

(Upper Susquehanna River)

Facility	Current Treatment Level	Current P Limit (mg/l)	Avg Flow (mgd) 1980[a]	Avg Flow (mgd) 1980[b]	Avg Flow (mgd) 1983	Avg P (mg/l) 1980[a]	Avg P (mg/l) 1980[b]	Avg P (mg/l) 1983	Avg Load (lb/day) 1980[a]	Avg Load (lb/day) 1980[b]	Avg Load (lb/day) 1983
Dallas Area Municipal Auth	Secondary	None	1.65	1.86	1.92	1.50	5.00	5.00	20.6	77.6	80.1
Hazelton	Secondary	None	7.00	7.00	5.70	8.00	5.00	5.00	467.0	291.9	237.7
Jermym-Archbold	Secondary	None	2.30	3.14	2.81	8.00	5.00	5.00	153.5	130.9	117.2
Lower Lackawanna	Secondary	None	2.10	2.12	2.58	1.50	5.00	5.00	26.3	88.4	103.4
Scranton	Secondary	None	21.20	16.67	14.23	8.00	5.00	5.00	1,414	695.1	593.4
Throop	Secondary	None	2.98	3.87	4.18	8.00	5.00	5.00	198.8	161.4	174.3
Wyoming Valley	Primary	None	40.00	31.94	25.35	9.50	6.20	6.20	3,169	1,652	1,207
TOTAL (Upper Susquehanna River)			77.23	66.60	56.67				5,449	3,097	2,513

a. 1980 flows and phosphorus concentrations reported in the 1983 EPA Chesapeake Bay report
b. 1980 flows and phosphorus concentrations developed from data gathered for this study

PHOSPHORUS LOADS TO CHESAPEAKE BAY FROM POTWs
WITH FLOWS GREATER THAN 1 MGD

(Lower Susquehanna River)

Facility	Current Treatment Level	Current P Limit (mg/l)	Avg Flow (mgd) 1980[a]	Avg Flow (mgd) 1980[b]	Avg Flow (mgd) 1983	Avg P (mg/l) 1980[a]	Avg P (mg/l) 1980[b]	Avg P (mg/l) 1983	Avg Load (lb/day) 1980[a]	Avg Load (lb/day) 1980[b]	Avg Load (lb/day) 1983
Altoona East	Secondary	None	6.20	6.10	5.18	8.00	5.00	5.00	413.7	254.4	216.0
Altoona West	Secondary	None	6.26	6.30	5.84	1.50	5.00	5.00	78.3	262.7	243.5
Carlisle Borough	Secondary P removal	1.0	2.87	2.87	2.86	8.00	5.00	0.83	191.5	119.7	19.8
Derry Township	Secondary P removal	2.0	1.71	1.73	2.41	1.50	2.77	1.17	21.4	40.0	23.5
Dover Township	Secondary P removal	2.0	1.92	1.42	1.40	1.50	5.00	5.00	24.0	59.2	58.4
Dover Borough	Secondary	None	-	0.21	0.22	-	5.00	8.75	-	8.8	16.0
East Pennsboro	Secondary P removal	2.0	1.74	1.73	2.09	1.50	3.10	1.24	21.8	44.7	21.6
Elizabethtown	Secondary P removal	2.0	1.15	0.89	2.05	1.50	5.00	1.60	14.4	37.1	27.4
Ephrata STP[c]	Secondary	2.0	2.41	2.15	2.80	8.00	5.00	5.00	160.8	89.7	116.8
Hampden STP	Secondary P removal	2.0	1.00	1.99	1.31	1.50	2.00	2.88	12.5	33.2	31.5
Hanover	Secondary	None	2.68	2.46	2.60	1.50	5.00	6.01	33.5	102.6	130.3
Harrisburg	Secondary P removal	2.0	20.45	22.80	24.68	1.50	1.58	1.05	255.8	300.4	216.1
Huntington	Primary	None	1.85	1.93	1.58	9.50	6.20	6.20	146.6	99.8	81.7
Lancaster (LASA)	Secondary	None	2.85	2.46	4.37	1.50	5.00	5.00	35.7	102.6	182.2
Lancaster North	Secondary	None	8.25	8.28	9.80	8.00	5.00	1.69	550.4	345.3	138.1
Lancaster South	Secondary	None	8.50	8.66	9.54	8.00	5.00	5.04	567.1	361.1	401.0
Lebanon STP	Secondary P removal	2.0	5.50	3.94	3.95	1.50	1.38	1.67	68.8	45.4	55.0
Lemoyne	Secondary P removal	2.0	1.80	1.48	1.54	1.50	3.96	2.16	22.5	48.9	27.7
Hampden Township	Secondary P removal	2.0	-	3.62	1.36	-	5.00	1.80	-	151.0	20.4
Lititz STP	Secondary P removal	2.0	1.50	1.37	1.38	1.50	5.00	1.73	18.8	57.1	19.9
Lower Allen	Secondary P removal	2.0	1.96	1.90	1.97	1.50	2.16	1.67	24.5	34.2	27.4
Mechanicsburg	Secondary P removal	2.0	1.03	1.02	1.32	8.00	5.00	1.74	68.7	42.5	19.2
New Cumberland	Secondary P removal	2.0	1.10	1.07	0.59	1.50	2.08	2.51	13.8	18.6	12.4
Penn Township	Secondary P removal	2.0	1.33	1.54	1.64	1.50	3.40	1.03	16.6	43.7	14.1
Shippensburg	Secondary P removal	0.5	1.21	1.20	1.51	1.50	5.00	0.51	15.1	50.0	6.4
Springettsburg	Secondary	None	6.20	6.61	7.52	1.50	5.00	3.89	77.6	275.6	244.0
Swatara	Secondary	None	2.80	1.67	2.70	1.50	5.00	5.00	35.0	69.6	112.6
Tyrone	Secondary	None	4.90	6.50	4.87	1.50	5.00	5.00	61.3	352.4	203.1
York	Secondary P removal	2.0	16.25	9.48 6.77	10.12 8.15	1.50	3.37 2.39	3.09 1.93	203.3	266.4 134.9	260.8 131.2
Mt. Holly Springs	Secordary P removal	2.0	-	0.55	0.60	-	5.00	0.89	-	22.9	4.6
TOTAL (Lower Susquehanna River)			115.4	120.7	128.0				3,153	3,600	3,083

a. 1980 flows and phosphorus concentrations reported in the 1983 EPA Chesapeake Bay report
b. 1980 flows and phosphorus concentrations developed from data gathered for this study
c. upgraded in 1983

PHOSPHORUS LOADS TO CHESAPEAKE BAY FROM POTWs
WITH FLOWS GREATER THAN 1 MGD

(Western Chesapeake & Upper Bay Area)

Facility	Current Treatment Level	Current P Limit (mg/l)	Avg Flow (mgd) 1980[a]	1980[b]	1983	Avg P (mg/l) 1980[a]	1980[b]	1983	Avg Load (lb/day) 1980[a]	1980[b]	1983
Aberdeen City	Secondary P removal	2.0	1.50	1.20	1.10	4.60	5.00	1.00	38.4	50.0	9.2
Aberdeen Proving Ground	Secondary P removal	2.0[c]	-	1.00	0.90	-	5.00	2.00	-	41.7	15.0
Annapolis	Secondary	None	4.70	4.70	5.60	4.50	5.00	5.00	176.4	196.0	233.5
Back River	Secondary P removal	2.0	180.60	180.0	56.00	5.60	5.00	1.00[d]	8,438	7,506	467.0
					131.0			3.70[e]			4,042
Broad Creek	Secondary	None	0.22	0.22	0.23	8.00	5.00	5.00	14.7	9.2	9.6
Broad Neck	Secondary	None	2.10	2.10	3.20	4.50	5.00	5.00	78.8	87.6	133.4
Broadwater	Secondary	None	0.40	0.40	0.68	2.00	5.00	5.00	6.7	16.7	28.4
Cox Creek	Secondary	2.0[f]	6.40	6.40	9.70	7.90	5.00	5.00	421.7	266.4	404.5
Edgewood Arsenal	Secondary P removal	2.0	0.97	0.97	1.30	4.00	5.00	0.90	32.4	40.5	9.8
Freedom District	Secondary	None	0.80	0.80	1.20	6.80	5.00	4.00	45.4	33.4	40.0
Havre de Grace	Primary	2.0[g]	1.10	1.10	1.50	9.50	7.40	7.40	87.2	45.9	92.6
Patapsco	Secondary	2.0[f]	30.00	26.00	32.00	6.50	5.00	4.90	1,626	1,084	1,307
Perryville	Secondary	2.0	0.78	0.78	0.44	8.00	5.00	5.00	52.0	32.5	18.4
Sod Run - Perryman	Secondary P removal	2.0	2.90	3.40	5.20	1.50	5.00	0.65	36.3	141.8	28.2
	(TOTAL)		132.5	229.1	250.0				11054	9,552	6,840

a. 1980 flows and phosphorus concentrations reported in the 1983 EPA Chesapeake Bay report
b. 1980 flows and phosphorus concentrations developed from data gathered for this study
c. not listed in the 1983 EPA Chesapeake BAy report
d. activated sludge process
e. trickling filter process
f. in facility planning
g. step 3 grant funding - under construction

PHOSPHORUS LOADS TO CHESAPEAKE BAY FROM POTWs
WITH FLOWS GREATER THAN 1 MGD

(Eastern Shore, Maryland)

Facility	Current Treatment Level	Current P Limit (mg/l)	Avg Flow (mgd)			Avg P (mg/l)			Avg Load (lb/day)		
			1980[a]	1980[b]	1983	1980[a]	1980[b]	1983	1980[a]	1980[b]	1983
Cambridge	Secondary	None	4.40	4.40	4.50	4.60	5.00	5.00	168.8	183.5	187.6
Crisfield	Secondary	None	0.76	0.76	0.78	4.40	5.00	5.00	27.9	31.7	32.4
Eastern	Secondary	None	1.80	1.60	1.80	8.60	5.00	5.00	129.1	66.7	75.1
Elkton	Secondary	2.0[c]	0.80	0.80	0.88	7.00	5.00	5.00	46.7	33.4	36.7
Hurlock	Secondary	None	1.10	1.00	1.00	8.50	5.00	5.00	78.0	41.7	41.7
Northeast River	Secondary P removal	2.0	-	0.25	0.34	-	5.00	0.40	-	10.4	1.1
Pocomoke City	Secondary	None	1.10	0.81	0.90	8.00	5.00	5.00	73.4	33.8	37.5
Salisbury	Secondary	None	3.50	3.50	3.30	5.60	5.00	5.00	163.5	145.9	137.6
TOTAL (Eastern Shore, Maryland)			13.50	13.10	13.50				687.4	547.1	549.1

a. 1980 flows and phosphorus concentrations reported in the 1983 EPA Chesapeake Bay report
b. 1980 flows and phosphorus concentrations developed from data gathered for this study
c. step 3 grant funding - under construction

PHOSPHORUS LOADS TO CHESAPEAKE BAY FROM POTWs
WITH FLOWS GREATER THAN 1 MGD

(Patuxent River)

Facility	Current Treatment Level	Current P Limit (mg/l)	Avg Flow(mgd) 1980[a]	Avg Flow(mgd) 1980[b]	Avg Flow(mgd) 1983	Avg P (mg/l) 1980[a]	Avg P (mg/l) 1980[b]	Avg P (mg/l) 1983	Avg Load (lb/day) 1980[a]	Avg Load (lb/day) 1980[b]	Avg Load (lb/day) 1983
Bowie	Secondary	1.0[c]	2.50	2.50	2.40	8.80	5.00	6.10	183.5	104.3	122.1
Ft. Meade	Secondary P removal	0.3	3.20	2.40	2.50	8.00	5.00	0.66	213.5	100.0	13.8
Horsepen	Secondary	None	-	-	0.37	-	-	2.62	-	-	8.1
Maryland City	Secondary	1.0	0.70	0.70	0.60	9.60	5.00	5.00	56.0	29.2	25.0
Md House of Correction	Secondary	2.0	0.85	0.85	1.15	8.50	5.00	5.00	60.3	35.4	47.9
Parkway	Secondary	1.0[c]	5.20	5.20	4.80	2.00	5.00	2.18	86.7	216.9	85.1
Patuxent	Secondary	1.0[c]	3.60	3.60	3.50	5.50	5.00	4.10	165.1	150.1	119.7
Savage	Secondary P removal	1.0	7.50	7.50	10.20	8.00	5.00	1.90	500.4	312.8	161.6
Western Branch	Secondary	1.0[d]	13.90	12.60	11.79	8.50	5.00	2.29	985.4	525.4	224.4
TOTAL (Patuxent River)			37.50	35.40	37.30				2,250	1,474	807.7

a. 1980 flows and phosphorus concentrations reported in 1983 EPA Chesapeake Bay report
b. 1980 flows and phosphorus concentrations developed from data gathered for this study
c. In facility planning
d. In planning

PHOSPHORUS LOADS TO CHESAPEAKE BAY FROM POTWs
WITH FLOWS GREATER THAN 1 MGD

(Potomac River)

Facility	Current Treatment Level	Current P Limit (mg/l)	Avg Flow (mgd) 1980[a]	Avg Flow (mgd) 1980[b]	Avg Flow (mgd) 1983	Avg P (mg/l) 1980[a]	Avg P (mg/l) 1980[b]	Avg P (mg/l) 1983	Avg Load (lb/day) 1980[a]	Avg Load (lb/day) 1980[b]	Avg Load (lb/day) 1983
Alexandria	AWT w/ P revomal	1.0	26.96	26.96	29.78	0.90	0.90	0.51	203.8	203.8	153.7
Aquia Regional	AWT w/ P removal	0.2	0.90	-	1.26	1.50	-	0.28	11.3	-	3.1
Arlington	AWT w/ P removal	1.0	22.27	22.27	24.59	3.10	2.41	0.92	575.8	450.8	182.1
Belmont[c]	-	-	1.40	-	-	1.50	-	-	17.5	-	-
Dale Service	AWT w/ P removal	0.4	2.30	3.10	3.16	1.50	0.40	0.39	28.8	10.4	4.7
Fishersville	Secondary	None	0.60	0.89	1.02	1.50	5.00	5.00	7.5	37.1	42.5
Front Royal	Secondary	None	1.34	1.30	2.02	8.00	5.00	5.00	89.4	54.2	84.2
Harrisonburg	Secondary	None	4.90	5.68	6.90	1.50	5.00	5.00	61.3	236.9	287.7
Leesburg	AST	None	0.90	1.03	1.31	1.50	0.20	0.67	11.3	1.7	7.4
Little Hunting Creek	AST	None	4.20	4.74	4.22	1.50	0.34	0.22	52.5	13.5	7.8
Lower Potomac	AWT w/ P removal	0.2	22.20	17.86	29.66	2.30	2.10	0.50	425.8	315.1	126.0
Mainside[d]	AWT w/ P removal	0.5	-	1.30	1.45	-	1.30	0.15	-	14.2	1.9
Mooney[e]	AWT w/ P removal	0.2	6.20	-	8.21	1.50	-	0.25	77.6	-	20.3
Staunton	Secondary	None	1.55	2.62	2.47	1.50	5.00	5.00	19.4	109.3	103.0
Upper Occoquan	AWT w/ P removal	0.1	7.25	6.94	8.60	0.0	.032	.028	0.0	1.9	2.0
Waynesboro	Secondary	None	2.39	2.70	3.50	8.50	5.00	5.00	169.4	112.6	146.0
Winchester	Secondary	None	2.79	3.77	3.58	1.50	5.00	5.00	34.9	157.2	149.3
TOTAL (Virginia Plants)			108.2	101.2	131.7				1,786	1,719	1,322
Cumberland	Secondary	None	9.00	10.10	10.50	4.10	5.00	5.00	307.8	421.1	437.9
Ft. Dietrick	Secondary	None	1.03	1.03	0.76	7.00	5.00	5.00	60.1	42.9	31.7
Frederick	Secondary	None	4.40	4.40	5.00	9.30	5.00	5.00	341.3	182.5	208.5
Hagerstown	Secondary	None	5.74	6.20	6.00	4.60	5.00	5.00	220.2	258.6	195.2
Halfway	Secondary	None	0.90	0.90	1.43	8.50	5.00	5.00	63.8	37.5	59.6
La Plata	Secondary	2.0	0.20	0.39	0.59	6.00	5.00	5.00	10.0	16.2	24.6
Mattawoman	Secondary	None	2.20	2.20	4.30	5.00	5.00	5.00	91.7	91.7	179.3
Pine Hill Run	Secondary	None	2.20	2.20	3.18	5.00	5.00	5.00	91.7	91.7	132.6
Piscataway	Secondary P removal	0.2	15.00	15.00	17.28	0.70	5.00	0.13	87.6	584.6	18.8
Seneca Creek	Secondary P removal	1.3	4.70	4.20	4.03	0.50	2.00	1.37	19.6	70.1	46.3
Westminster	Secondary	None	1.90	1.90	2.10	6.00	5.00	5.00	95.1	79.2	87.6
TOTAL (Maryland Plants)			47.3	48.5	55.0				1,389	1,877	1,422
Blue Plains	Secondary P removal	0.23	317.0	317.0	236.6	1.20	0.58	0.38	3,172	1,533	994.7
Chambersburg	Secondary P removal	None	2.65	3.54	2.74	1.50	1.30	1.30	33.2	38.4	29.7
Gettysburg	Secondary	None	1.39	1.39	1.50	8.00	6.25	5.00	92.7	72.5	62.6
Waynesboro	Secondary	None	0.81	0.48	0.83	8.00	5.00	5.00	54.0	20.0	34.6
TOTAL (Pennsylvania Plants)			4.85	5.41	5.07				179.9	130.9	126.9

a. 1980 flows and phosphorus concentrations reported in the 1983 EPA Chesapeake Bay report
b. 1980 flows and phosphorus concentrations developed from data gathered for this study
c. off-line since 1980 and its flow routed to the new Mooney STP
d. not listed in the 1983 EPA Chesapeake Bay report
e. new plant started in 1980

PHOSPHORUS LOADS TO CHESAPEAKE BAY FROM POTWs
WITH FLOWS GREATER THAN 1 MGD

(Rappahannock River)

Facility	Current Treatment Level	Current P Limit (mg/l)	Avg Flow (mgd)			Avg P (mg/l)			Avg Load (lb/day)		
			1980[a]	1980[b]	1983	1980[a]	1980[b]	1983	1980[a]	1980[b]	1983
Culpeper	AWT	None	1.38	1.38	1.30	8.00	5.40	0.20	92.1	62.6	2.2
Fredericksburg	Secondary	None	2.00	2.03	2.58	8.00	2.95	2.00	133.4	50.3	43.3
Massaponax	Secondary	None	1.30	1.21	1.53	8.00	4.92	6.27	86.7	50.0	80.6
TOTAL (Rappahannock River)			4.68	4.62	5.41				312.2	162.9	126.1

a. 1980 flows and phosphorus concentrations reported in the 1983 EPA Chesapeake Bay report
b. 1980 flows and phosphorus concentrations developed from data gathered for this study

PHOSPHORUS LOADS TO CHESAPEAKE BAY FROM POTWs
WITH FLOWS GREATER THAN 1 MGD

(James River)

Facility	Current Treatment Level	Current P Limit (mg/l)	Avg Flow (mgd) 1980[a]	Avg Flow (mgd) 1980[b]	Avg Flow (mgd) 1983	Avg P (mg/l) 1980[a]	Avg P (mg/l) 1980[b]	Avg P (mg/l) 1983	Avg Load (lb/day) 1980[a]	Avg Load (lb/day) 1980[b]	Avg Load (lb/day) 1983
Army Base	Secondary[c]	None	12.38	12.38	11.20	5.60	5.60	4.50	582.4	582.4	423.4
Atlantic	Secondary[d]	None	-	-	18.60	-	-	5.50	-	-	859.3
Boat Harbor	Secondary[c]	None	17.60	19.12	16.07	3.50	3.50	3.90	513.7	562.1	526.5
Chesapeake/ Elizabeth	Secondary	None	19.70	23.09	11.20[e]	6.10	6.10	5.80	1,002	1,183	545.7
Clifton Forge	Secondary	None	0.72	0.56	1.42	8.00	5.00	5.00	48.0	23.4	59.2
Covington	Primary	None	1.60	1.90	1.68	8.50	5.00	5.00	113.2	79.2	70.1
Deep Creek[f]	-	-	1.02	1.37	-	8.50	5.00	-	72.3	57.1	-
Falling Creek	Secondary	None	7.58	7.58	9.32	8.50	8.40	8.40	537.4	505.7	621.8
Hopewell	Secondary	None	33.63	36.31	34.16	1.00	5.00	5.00	280.4	1,514	1,425
James River	Secondary	None	13.70	14.26	6.82[g]	7.40	7.40	5.10	845.5	886.4	292.2
Lamperts Pt	Primary w/ alum	None	20.63	20.61	14.42[h]	4.50	4.50	2.50	774.2	773.5	302.8
Lynchburg	Secondary	None	11.55	11.50	13.04	8.00	5.00	5.00	770.6	479.6	543.8
Nansemond	Secondary[d]	None	-	-	5.40	-	-	5.50	-	-	249.5
Petersburg	Secondary	None	9.50	11.18	10.38	6.20	8.00	8.00	491.2	745.9	692.6
Planners Pt	Primary	None	9.69	9.06	9.59	6.20	6.20	6.20	501.0	468.5	495.9
Richmond	Secondary	None	61.03	61.03	66.20	7.50	4.50	4.50	3,817	2,290	2,485
Western Branch[f]	-	-	1.92	2.30	-	9.50	7.70	-	152.1	147.7	-
Williamsburg	Secondary	None	8.90	7.27	7.98	8.00	3.70	1.80	593.8	226.0	120.7
TOTAL (James River)			231.2	239.5	237.5				11095	10524	9714

a. 1980 flows and phosphorus concentrations reported in the 1983 EPA Chesapeake Bay report
b. 1980 flows and phosphorus concentrations developed from data gathered for this study
c. primary with alum addition in 1980 and upgraded to secondary level in 1981
d. new plants started operation in 1983 by Hampton Roads Sanitation District
e. partial flow diverted to the new Atlantic plant in 1983
f. facilities closed and flows diverted to the new Atlantic plant in 1983
g. partial flow diverted to the new York plant (in the York River basin) in 1983
h. partial flow diverted to the new Nansemond plant in 1983

APPENDIX C.
PHOSPHORUS LOADS FROM POTWs
WITH FLOWS LESS THAN 1 MGD

Subbasin	Avg Flow (mgd)	P load (lb/day)
Susquehanna River:		
New York	2.85	118.9
Pennsylvania	17.78	741.4
Western Chesapeake and Upper Bay:	2.41	100.5
Eastern Shore:	6.11	254.8
Patuxent River:	-	-
Potomac River:		
Pennsylvania	-	-
Maryland	0.73	30.4
Virginia	7.19	299.8
West Virginia	0.53	22.1
Rappahannock River:	0.59	24.6
York River:	1.16	48.4
James River:	4.62	192.7
TOTAL	43.97	1850.0