APPENDIX A

Regulated Contaminants

The following is a list of drinking water contaminants for which the U.S. Environmental Protection Agency is setting health-based standards (Maximum Contaminant Level Goals, or MCLGs) and enforceable standards (Maximum Contaminant Levels, or MCLs). For some contaminants, there is also a Secondary Maximum Contaminant Level (SMCL), a level set to prevent taste or odor problems. Unless otherwise indicated, the levels presented are milligrams per liter (mg/l). For some contaminants, the MCL is a prescribed treatment. See "Setting the standards for safe drinking water" and contaminant descriptions for more information.

Contaminant	MCLG	MCL	SMCL	Interim
acrylamide	0	.005% dosed at 1 mg/l		
adipates[2]	0.5	0.5		
alachlor	0	0.002		
aldicarb[1]	0.01	0.01		
aldicarb sulfone[1]	0.04	0.04		
aldicarb sulfoxide[1]	0.01	0.01		
alpha particle acitity (gross)[3]				15 pCi/l
antimony[2]	0.003	0.01 or 0.005		
arsenic[4]				0.05
asbestos	7 million fibers/liter			
atrazine	0.003	0.003		
barium[1]	5	5		1
benzene	0	0.005		
beryllium[2]	0	0.001		
beta particle and photon radioactivity[3]			4 mrem/yr	
cadmium	0.005	0.005	0.01	
carbofuran	0.04	0.04		
carbon tetrachloride	0	0.005		
chlordane	0	0.002		
chlorobenzene[1]	0.1	0.1	0.1	
chromium	0.1	0.1		0.05
copper[1]	1.3	1.3		
cyanide[2]	0.2	0.2		
dalapon[2]	0.2	0.2		
dibromochloropropane (DBCP)	0	0.0002		
o-dichlorobenzene	0.6	0.6	0.01	
p-dichlorobenzene	0.075	0.075	0.005	
1,2-dichloroethane	0	0.005		
1,1-dichloroethylene	0.007	0.007		
cis-1,2-dichloroethylene	0.07	0.07		
trans-1,2-dichloroethylene	0.1	0.1		
2,4-dichlorophenoxyacetic acid (2,4-D)	0.07	0.07		0.1
1,2-dichloropropane[1]	0	0.005		
dinoseb[2]	0.007	0.007		
dioxin (2,3,7,8-TCDD)[2]	0	0.00000005		
diquat[2]	0.02	0.02		
endothall[2]	0.1	0.1		
endrin[2]	0.002	0.002		0.0002
epichlorohydrin	0	.01% dosed at 20 mg/l		
ethylbenzene	0.7	0.7	0.03	

[1]proposed May 1989; may be finalized December 1990 [2]proposed July 1990 [3]to be proposed February 1991

Contaminant	MCLG	MCL	SMCL	Interim
ethylene dibromide	0	0.00005		
fluoride	4	4	2	
Giardia lamblia	0	treatment		
glyphosate[2]	0.7	0.7		
heptachlor	0	0.0004		
heptachlor epoxide	0	0.0002		
hexachlorobenzene[2]	0	0.001		
hexachlorocyclopentadiene[2]	0.05	0.05	0.008	
lead[1]	0	0.005		0.05
Legionella	0	treatment		
lindane	0.0002	0.0002		0.004
mercury	0.002	0.002		0.002
methoxychlor	0.04	0.04		0.1
methylene chloride[2]	0	0.005		
nickel[2]	0.1	0.1		
nitrate (as N)	10	10		10
nitrite (as N)	1	1		
pentachlorophenol[1]	0.2	0.2	0.03	
phthalates[2]	0	0.004		
picloram[2]	0.5	0.5		
polychlorinated biphenyls (PCBs)	0	0.0005		
polycyclic aromatic hydrocarbons (PAhs)[2]	0	0.0002		
radium 226 and 228[3]				5 pCi/l
radon[3]				
selenium	0.05	0.05		0.01
simazine[1]	0.001	0.001		
standard plate count		treatment		
styrene	0.1	0.1	0.01	
sulfate[2]	400 or 500	400 or 500		
tetrachloroethylene[1]	0	0.005		
thallium[2]	0.0005	0.002 or 0.001		
toluene	1	1	0.04	
total coliforms	0	treatment		
toxaphene	0	0.003		0.005
trichlorobenzene[2]	0.009	0.009		
1,1,1-trichloroethane	0.2	0.2		
1,1,2-trichloroethane[2]	0.003	0.005		
trichloroethylene	0	0.005		
2,4,5-trichlorophenoxypropionic acid (2,4,5-TP)	0.05	0.05		0.01
turbidity		treatment		
uranium[3]				
vinyl chloride	0	0.002		
viruses	0	treatment		
vydate[2]	0.2	0.2		
xylenes (total)	10	10	0.02	

[4]to be dealt with separately [5]longer than 10 μm

Source: What Do The Standards Mean?: A Citizens' Guide to Drinking Water Contaminants, VA Tech.

POPULATION

APPENDIX B

Table B-1: 1990 U.S. Census Population Counts
Accomack-Northampton Planning District

Locality	Population Counts	Housing Units	people/units Density
Accomack County	31,703	15,840	2.00
Accomack Town	466	205	2.27
Belle haven Town	526	245	2.15
Bloxom Town	357	175	2.04
Chincoteague Town	3,572	3,167	1.13
Hallwood Town	228	115	1.98
Keller Town	235	107	2.20
Melfa Town	428	191	2.24
Onancock Town	1,434	705	2.03
Onley Town	532	276	1.93
Painter Town	259	113	2.29
Parksley Town	779	393	1.98
Saxis Town	367	192	1.91
Tangier Town	659	277	2.38
Wachapreague Town	291	223	1.30
Outside of incorporated towns	21,570	9,456	2.28
Northampton County	13,061	6,183	2.11
Cape Charles Town	1,398	689	2.03
Cheriton Town	515	246	2.09
Eastville Town	185	94	1.97
Exmore Town	1,115	528	2.11
Nassawadox Town	564	227	2.48
Outside of incorporated towns	9,284	4,399	2.11
A-NPD TOTAL	44,764	22,023	2.03

Table B-2: Historical and Projected Population Figures

Year	1950	1960	1970	1980	1985	1990	1995	2000
Population								
Accomack County	33,832	30,635	29,004	31,268	31,200	33,000 31,130*	33,300	34,000 31,990*
Northampton County			14,442	14,625	14,700	15,000	15,000	15,300
A-NPD			43,446	45,893	46,500	48,000	48,300	49,300

Sources: VSWCB Eastern Shore Water Supply Plan, 1988; Accomack County Comprehensive Plan, 1989 (*- A-N PDC linear TMI model). Both used the following sources: US Bureau of the Census, Virginia Department of Health, Tayloe-Murphy Institute.

LAWS AND REGULATIONS APPLICABLE TO STUDY

APPENDIX C

LAWS AND REGULATIONS APPLICABLE TO THE STUDY

Virginia State Water Control Board Statutes, July 1, 1990
Chapter 3.1 - State Water Control Law Article 4 , Regulation of Sewage Discharges

All sewerage and sewage treatment operations are under joint supervision of the State Department of Health and the Board. If a proposed facility will serve more than 400 people and if it has potential for or actual discharge to state waters, owners shall file an application to the Board and the State Department of Health for a certificate before any erection, construction, operation, or expansion can occur. In 1977, owners and operators of sewerage systems and sewerage and industrial waste treatment works conducted a survey in order to determine the physical, chemical, and biological properties of discharge.

Virginia State Water Control Board Statutes, July 1, 1990 Chapter 3.4 - The Groundwater Act of 1973

The basic premise behind this act is that the right of water control belongs to the public, but in order to ensure public welfare, safety, and health, provisions must be made for control of ground water. The Board and the State Department of Health administers and enforces the provisions of this chapter. Special care is taken to protect Groundwater Management Areas (GMA). The Board will initiate a study if it is believed that in a certain area ground water levels are declining, two or more wells are interfering, the ground water supply is or will be overdrawn, or the ground water is or is expected to be polluted. Should an area be deemed a GMA, one must obtain a permit in order to withdraw ground water from such area. No certificate is needed to withdraw from an area that is not declared a GMA, nor for those withdrawing less than 300,000 gallons/month or for agricultural or livestock purposes. The Board may establish regulations which will require only agricultural withdrawal greater than 300,000 gallons/month to be reported.

VR 680-14-01 - State Water Control Board Regulations - Pollution Abatement Permit Regulation

This regulation sets guidelines for pretreatment programs, and identifies procedures and requirements to be followed in connection with Virginia Pollutant Discharge Elimination System (VPDES) and Virginia Pollution Abatement (VPA) permits issued by the Board pursuant to the Clean Water Act or the State Water Control Law. Permits are required for discharge of anything that may alter state waters. Point sources are authorized by a VPDES permit, non-point by a VPA permit. Any spills, unplanned bypasses, or non-compliance which may endanger state waters must be reported by telephone within 24 hours. Animal feeding operations are subject to the VPA permit program if they are considered concentrated (100,000 laying hens or broilers) or intensified (30,000 hens, broilers). Under this regulation, animal feeding operations (animals are stationed or fed on premises for at least 45 days per year) shall maintain no point source discharge of pollutants to state waters except in the case of a 25 year, 24 hour storm event.

VR 680-14-03 - State Water Control Board Regulations , Pollution Abatement Toxics Management Regulation

The purpose of this regulation is to control the levels of toxic pollutants in surface waters discharged from all sources holding VPDES or NPDES permits. It provides standards and procedures to minimize or prevent any toxic discharge in levels dangerous to human health or the environment. Whenever VPDES permits are issued or modified, the Board will determine whether or not there is a need for toxics management. Toxics monitoring must be done if the discharge has actual or potential toxicity, if the permitted works falls into the Industry Class, if the industrial wastewater flow is greater than 500,000 gallons/day, if a Publicly Owned Treatment Works

(POTW) discharges greater than 1 million gallons per day, or if a POTW undergoes a pretreatment program.

State Water Control Board Regulations - Pollution Abatement Regulation No. 8 , Sewerage Regulations

These regulations were adopted jointly by the State Water Control Board and the State Board of Health. They were set up in order to ensure that the design, construction, and operation of sewage treatment works and sewerage systems are consistent with public health and water quality objectives of the Commonwealth of Virginia. The regulations assist owners in preparation of an application, plans, or data and lay the rules by which the Board will review and make decisions in regards to the specifications and applications.

State Water Control Board Regulations - Water Supply Data VR 680-15-01, Water Withdrawal Reporting

Under this regulation, water withdrawal information will be submitted to the Board for the purpose of formulating and preparing plans and programs for the management of water resources in the Commonwealth of Virginia. The data will also be available to local governments and local interests to assist them in their own water supply planning. The regulation applies to every user withdrawing ground water or surface water whose daily average withdrawal during any month exceeds 10,000 gallons/day. It also applies to every user withdrawing ground or surface water for the purpose of irrigating crops whose withdrawal exceeds 1 million gallons in any single month. Industrial VPDES permittees must report their source and location annually. Every nonexempt user other than crop irrigators shall have installed and shall operate a gaging device . Crop irrigators shall comply with measuring provisions by January 31, 1991. Every nonexempt user shall file with the board a reporting form every January 31 of each year.. The information reported includes source(s) and locations of withdrawal, cumulative volume of water withdrawn each month, method of withdrawal measurement, and maximum day withdrawal. Crop irrigators shall comply with reporting provisions by January 31, 1992

State Water Control Board Regulations - Groundwater Rules and Standards for Water Wells

So that equitable development and utilization of ground water is achieved in Virginia, these rules and standards set forth the authority for controlling ground water. Essentially, these rules and standards set provisions to prevent wells from becoming a source or channel for the entry of pollutants or contaminants. Under the jurisdiction of this regulation are: registration statements, construction and maintenance of wells, observational and abandoned wells, data and records, and general requirements. Methods for testing well yield are described.

VR 680-21-00 - State Water Control Board Regulations - Water Quality Standards

The State Water Control Law, Section 62.1-44.15(3), mandates the protection of existing high quality state waters and also provides for the restoration of all other state waters to a condition of quality which will allow all public uses: water-based recreation, public water supply, and growth of balanced populations of fish and wildlife. In this regulation, water quality requirements for surface waters and ground water are described and listed in tables in numeric limits and general terms for specific physical, chemical, biological, and radiological characteristics of water. These limits set the standards that must be met by all discharge applicants. Municipal and industrial discharge mixing zones are viewed separately, and must not threaten recreation and wildlife use. In addition, special standards for shellfish waters are set for the median fecal coliform value. Extra precautions must be made in surface waters so that eating shellfish is not hazardous. The

Board will convene a public hearing to talk about any proposal that would result in the Department of Health condemning shellfish beds.

Acknowledging that ground water quality varies in different areas, the Board has divided the state into four physiographic provinces by which they establish different criteria. The Eastern Shore is in the Coastal Plain region. In order to prevent the entry of pollutants into the ground water in any aquifer, a soil zone or alternate protective measure or device is established to preserve and protect the ground water.

State Board of Health - Waterworks Regulations

These regulations establish that the State Board of Health has the duty to ensure that all water supplies destined for human consumption be pure water. All wells must be constructed by registered Virginia contractors, and wells sampling done by approved laboratories.

Frequent sanitary surveys must be made by the owner to locate and identify health hazards. Once a hazard is identified, the rate it is removed will be determined by the Division of Water Supply Engineering. Sampling frequencies are listed in this regulation, and are based upon the number of people served and whether or not the water supply is community, non-transient community, or non-community. Categories for those to be sampled are coliform bacteria, inorganics, organics (pesticides, VOC's, UC's, THM's), radiological, and physical characteristics like turbidity. Nitrates must be sampled once every three years for community and non-transient community, and every five years for a non-community water works.

When a new water supply system is considered, the capacity of the source must be adequate to sustain anticipated growth. Construction and location requirements for drilled wells are the following:

1) There shall be a distance of at least 50 ft. from the well to the property lines of the well lot.
2) If an access road is needed, it will be counted as part of the well lot.
3) There must be a horizontal distance of 50 ft. from the well to any septic tank, barn yard, privy, pipe carrying sewage, petroleum or chemical storage tank, or pipe line. If plastic well casing is used, the distance is 100 ft.

A water well completion report must be submitted. The report will include yield and drawdown test data for a minimum period of 48 hours.

Chapter 14.1 - Virginia Pesticide Control Act, 1989 Session

This Act establishes a Pesticide Control Board which adopts rules concerning pesticides and the application of them. The Board also serves the public by informing them as to the desirability and availability of non-chemical and less toxic alternatives to chemical pesticides. It promotes the use of Integrated Pest Management techniques and the safe and proper use of pest control products. The Board has the power to restrict or prohibit the use of any particular pesticide. All pesticides must be registered, and all applicators must have a license to do so (researchers excluded). The Board acts as enforcer of rules, and can levee fines as a result of violations. Pesticide accidents must be reported.

VR 115-04-03 - Virginia Department of Agriculture and Consumer Services Rules and Regulations for Enforcement of the Virginia Pesticide Law

These regulations list guidelines for the application, storage, disposal, and sale of pesticides. The concept of "pest" is defined, and the types of pest control are placed into categories. Rules are established for toxicity codes and for labeling pesticides.

VR 115-04-21 - Public Participation Guidelines, Pesticide Control Board
Department of Agriculture and Consumer Services, Pesticide Control Board

These guidelines establish methods for identification and notification of those persons or groups interested in the development of regulations of the Pesticide Control Board. Mailing lists, public meetings, committees, and the process of making a regulation are all described here.

VR 115-04-22 - Virginia Department of Agriculture and Consumer Services Regulations Governing Licensing of Pesticide Business Operating Under Authority of Virginia Pesticide Control Act, September 1990

These regulations introduce procedures and requirements for obtaining a pesticide business license. A license is required for anyone who sells, stores, mixes, applies or recommends pesticides, and this includes pest management consultants. Businesses must demonstrate evidence of financial responsibility and keep records according to the rules. Failure to be properly licensed, financially responsible, or to submit records when asked can result in revocation, suspension, or denial of a business license by the Board.

VR 115-04-23 - Regulations Governing Pesticide Applicator Certification Under Authority of Virginia Pesticide Control Act (Proposed, as of 2/91)

Several sections of VR 115-04-03 are superseded by these proposed regulations. VR 115-04-23 sets standards of certification for persons specified by the statute to require certification, and standards of financial responsibility for commercial applicators. Those who must meet the requirements are individuals, employees, or representatives of government agencies who use or supervise the use of pesticides in the performance of their official duties. All must pass a general examination, and then be tested in a specific category of pesticide application. The general tests assure that all applicators are able to handle accidents, know labels, application techniques, laws and regulations, can identify pests, and are aware of environmental affects of pesticides. Commercial applicators not for hire are required to keep records for two years, while commercial applicators must maintain records of each restricted-use pesticide.

APPENDIX D

EASTERN SHORE OF VIRGINIA GROUND WATER STUDY COMMITTEE

Membership:

The Committee consists of the following representatives from Accomack and Northampton Counties:

2 members from each Board of Supervisors
1 citizen appointee from each Board of Supervisors
the County Administrator from each county
the Executive Director of the Accomack-Northampton Planning District Commission

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Soil Conservation Service
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HYDROGEOLOGIC CALCULATIONS

APPENDIX E

Table E-1: Water Balance for the Eastern Shore of Virginia

Recharge to the Columbia (Unconfined) Aquifer
(After Dunne and Leopold, 1978)

	Average Monthly Precipitation (inches)	Average Monthly Precipitation (mm)	Potential ET (from Thornthwaite method) (mm)	Precipitation minus Potential ET (mm)	Accumulated Potential Water Loss (mm)	Soil Moisture (mm)	Change in soil moisture (mm)	Actual ET (mm)	Soil Moisture Deficit (mm)	Soil Moisture Surplus (mm)	Available for runoff or recharge (mm)	Assume 50% Runoff (mm)	Detention (recharge) (mm)	Detention (recharge) (inches)
January	3.41	86.6	6	81		200	0	6	0	81	136	68	68	2.7
February	3.31	84.1	8	76		200	0	8	0	76	144	72	72	2.8
March	4.13	104.9	24	81		200	0	24	0	81	153	77	77	3.0
April	2.92	74.2	46	28		200	0	46	0	28	105	52	52	2.1
May	3.47	88.1	77	11		200	0	77	0	11	63	32	32	1.2
June	3.51	89.2	103.5	-14	-14	190	-10	99.2	4.4	0	32	16	16	0.6
July	4.10	104.1	118.7	-15	-29	185	-5	109.1	9.6	0	16	8	8	0.3
August	4.28	108.7	111	-2	-31	183	-2	110.7	0.3	0	8	4	4	0.2
September	3.41	86.6	84	2	-29	185	2	84	0	0.2	0.2	0.1	0.1	0.005
October	3.57	90.7	52	39		200	15	52	0	39	39.1	20	20	0.8
November	2.96	75.2	25	50		200	0	25	0	50	70	35	35	1.4
December	3.37	85.6	10	75		200	0	10	0	75	110	55	55	2.2
TOTAL	42.44	1078	665	413		2343		651	14.3	442	876	438	438	**17 inches per year**

Note: Assumes soils with 200 mm (8 inches) of available water capacity

Table E-2: Thorthwaite Method for Evapotranspiration (ET) Calculation

LOCATION: *Eastern Shore, Virginia*
CLIMATOLOGICAL DATA FROM: *Painter, Virginia*
YEARS OF RECORD: *6 (1985-1990)*

	Mean Monthly Air Temperature	Positive Air Temperature Values	Monthly Heat Index	Uncorrected ET (cm/month)	Latitude Correction Factor Latitude =	40° N	Potential ET (cm/month)	Potential ET (in/month)
January	3.94	3.94	0.70	0.76	*January*	0.80	0.61	0.24
February	4.28	4.28	0.79	0.85	*February*	0.89	0.76	0.30
March	9.11	9.11	2.46	2.40	*March*	0.99	2.38	0.94
April	13.72	13.72	4.55	4.21	*April*	1.10	4.63	1.82
May	18.67	18.67	7.21	6.41	*May*	1.20	7.69	3.03
June	22.50	22.50	9.55	8.28	*June*	1.25	10.35	4.08
July	25.17	25.17	11.29	9.65	*July*	1.23	11.87	4.68
August	25.17	25.17	11.29	9.65	*August*	1.15	11.10	4.37
September	22.17	22.17	9.33	8.11	*September*	1.04	8.44	3.32
October	16.83	16.83	6.18	5.56	*October*	0.93	5.18	2.04
November	10.72	10.72	3.14	3.00	*November*	0.83	2.49	0.98
December	5.89	5.89	1.28	1.32	*December*	0.78	1.03	0.41

ANNUAL HEAT INDEX, I = 67.77
"a" factor = 1.37

Total Potential ET = 67 cm/year | 26 in/year

Table E-3: Water Balance for the Eastern Shore of Virginia
Recharge to the Yorktown-Eastover Aquifer

Recharge Rate Calculations:

Derived Equation:
Recharge (R) = [8 T h] ÷ [L^2 - 4 x^2]

Transmissivity (T) in ft2/day
Head (h) in feet (at ground water divide)
x = 0 in all cases (at ground water divide)
Width of peninsula (L) in feet

Recharge values (below) in feet per year

For peninsula width of *4* *miles*

	T = 500	T = 1000	T = 2000	T = 3000	T = 4000	T = 5000
h = 15	0.05	0.10	0.20	0.29	0.39	0.49
h = 18	0.06	0.12	0.24	0.35	0.47	0.59
h = 20	0.07	0.13	0.26	0.39	0.52	0.65
h = 22	0.07	0.14	0.29	0.43	0.58	0.72
h = 24	0.08	0.16	0.31	0.47	0.63	0.79
h = 26	0.09	0.17	0.34	0.51	0.68	0.85
Average R =	0.07	0.14	0.27	0.41	0.55	0.68

Overall Average R* = 0.29 *feet per year

For peninsula width of *6* *miles*

	T = 500	T = 1000	T = 2000	T = 3000	T = 4000	T = 5000
h = 15	0.02	0.04	0.09	0.13	0.17	0.22
h = 18	0.03	0.05	0.10	0.16	0.21	0.26
h = 20	0.03	0.06	0.12	0.17	0.23	0.29
h = 22	0.03	0.06	0.13	0.19	0.26	0.32
h = 24	0.03	0.07	0.14	0.21	0.28	0.35
h = 26	0.04	0.08	0.15	0.23	0.30	0.38
Average R =	0.03	0.06	0.12	0.18	0.24	0.30

Overall Average R* = 0.13 *feet per year

For peninsula width of *8* *miles*

	T = 500	T = 1000	T = 2000	T = 3000	T = 4000	T = 5000
h = 15	0.01	0.02	0.05	0.07	0.10	0.12
h = 18	0.01	0.03	0.06	0.09	0.12	0.15
h = 20	0.02	0.03	0.07	0.10	0.13	0.16
h = 22	0.02	0.04	0.07	0.11	0.14	0.18
h = 24	0.02	0.04	0.08	0.12	0.16	0.20
h = 26	0.02	0.04	0.09	0.13	0.17	0.21
Average R =	0.02	0.03	0.07	0.10	0.14	0.17

Overall Average R* = 0.07 *feet per year

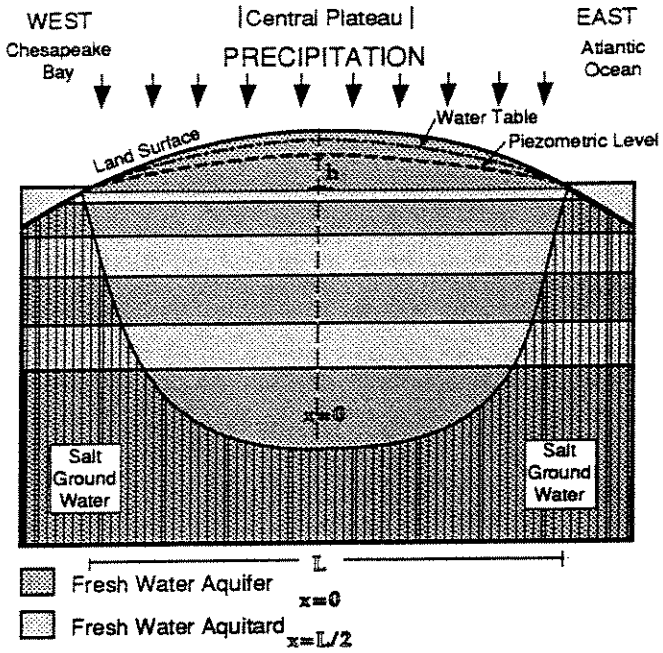
Table E-4: Recharge Calculations for the Yorktown-Eastover Aquifer

Volumetric Recharge Calculations
(All figures in million gallons per day)

Recharge Rate (feet/year)	*Area for Recharge (mi2) 100*	*Area for Recharge (mi2) 150*	*Area for Recharge (mi2) 200*	*Area for Recharge (mi2) 300*	*Area for Recharge (mi2) 400*
0.05	3	4	6	9	11
0.10	6	9	11	17	23
0.20	11	17	23	34	46
0.30	17	26	34	51	69
0.40	23	34	46	69	91
0.50	29	43	57	86	114
0.60	34	51	69	103	137

Comparison of Water Usage on the Eastern Shore with Recharge Volumes
Area of confining layer receiving recharge = 200 square miles
Variable recharge rates
(All figures in million gallons per day)

	Year 1985	*Year 1986*	*Year 1987*	*Year 1988*	*Year 1989*	*Year 1990*	*Permitted Amount*
Public Sources:	1.243	1.264	1.259	1.241	1.415	1.114	4.462
Industrial Sources:	3.412	3.052	3.157	3.064	3.433	3.430	11.143
Total Withdrawals:	4.655	4.316	4.417	4.306	4.848	4.544	15.604
Recharge							
at 0.05 ft/yr	6	6	6	6	6	6	6
Excess or Deficit:	1.1	1.4	1.3	1.4	0.9	1.2	-9.9
at 0.10 ft/yr	11	11	11	11	11	11	11
Excess or Deficit:	6.8	7.1	7.0	7.1	6.6	6.9	-4.2
at 0.20 ft/yr	23	23	23	23	23	23	23
Excess or Deficit:	18.2	18.5	18.4	18.5	18.0	18.3	7.2
at 0.30 ft/yr	34	34	34	34	34	34	34
Excess or Deficit:	29.6	30.0	29.9	30.0	29.4	29.7	18.7
at 0.40 ft/yr	46	46	46	46	46	46	46
Excess or Deficit:	41.1	41.4	41.3	41.4	40.9	41.2	30.1
at 0.50 ft/yr	57	57	57	57	57	57	57
Excess or Deficit:	52.5	52.8	52.7	52.8	52.3	52.6	41.5
at 0.60 ft/yr	69	69	69	69	69	69	69
Excess or Deficit:	63.9	64.2	64.1	64.3	63.7	64.0	53.0



The governing differential equation for steady state flow in one dimension is:

$$d^2h/dx^2 = -w/T. \quad (1)$$

where

h = the hydraulic head of the Yorktown-Eastover aquifer,
x = the lateral distance from the center spine of the peninsula (always positive),
w = the recharge rate of the Yorktown-Eastover aquifer,
T = the transmissivity of the Yorktown-Eastover aquifer, and
L = width of the peninsula.

Integrating once, the equation becomes

$$dh/dx = (-w/T)x + C_1. \quad (2)$$

At the ground water divide, x = 0 and dh/dx = 0. Substituting these values into equation (2) results in the following equation, upon which the constant C_1 can be solved for:

$$0 = -w/T(0) + C_1$$

$$\therefore\ C_1 = 0.$$

Integrating again, the equation becomes

$$h = (-w/2T)x^2 + C_1x + C_2. \quad (3)$$

BUILDOUT NITROGEN LOADING CALCULATIONS

APPENDIX F

Table F-1: WPA (A) Future Nitrogen Loading Calculations

NITROGEN LOADING CALCULATIONS
WPA A Future (spine only, all soils)

INPUT FACTORS

Number of Residential units	579
Sewage flow per house (gal/day)	165
Commercial/Industrial land (acres)	60
Com./Ind. sewage flow per acre	423
N-conc. in sewage effluent (mg/l)	40
Lawn area per house (square feet)	5,000
Pavement per house (square feet)	500
Road area (square feet)	1,481,040
Roof area per house (square feet)	1,500
Agricultural area (acres)	2,359
Landfills (acres)	0
Septage lagoons (gallons/yr)	0
Septage N concentration (mg/l)	45
Animal burial (lbs /yr)	222,081
Total recharge area (acres)	3,417
Recharge rate for pervious area (in/yr)	17
Recharge rate for impervious area (in/yr)	34

INPUT	CALCULATIONS	RESULTS
Sewage (gal/day)		CALCULATED LOADING (LBS/YR)
120,915	x N-conc (mg/l) x 3.785 l/gal x 365 days/yr : 454000 mg/lb	14,718
Lawn area (sq ft)		
2,895,000	x 0.0009 lb N/sq ft	2,606
Pavement area (sq ft)		
1,770,540	x 0.00031 lb N/sq ft	549
Roof area (sq ft)		
868,500	x 0.00015 lb N/sq ft	130
Natural area (acres)		
871	x 43560 sq ft/acre x 0.000005 lb N/sq ft	190
Other Sources		
Agriculture (acres)		
2,359	x 89 lbs N/acre/yr x 25% leaching rate	52,482
Landfills (acres)		
0	1184 lbs N/acre/year	0
Septage Lagoons (gal/year)		
0	x N-conc (mg/l) x 3.785 l/gal: 454000 mg/lb	0
Animal burial (lbs/year)		
222,081	x 3.3 % N concentration	7,329
	TOTAL NITROGEN LOADING (LBS/YR)	78,003
		TOTAL RECHARGE (MG/YR)
Recharge from sew/septage (gal/day)		
120,915	x 365 days/yr : 1,000,000 gal/million gal	44
Total pervious area (sq ft)		
144,898,680	x 17 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	1,535
Total impervious area (sq ft)		
3,945,840	x 34 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	84
	TOTAL RECHARGE (MGAL/YR)	1,663
TOTAL NITROGEN LOAD/TOTAL RECHARGE X 454,000 MG/LB : 3,785,000 L/MGAL		
	=RECHARGE NITROGEN CONCENTRATION (mg/l or ppm)	5.6

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Table F-2: WPA (A) Future Nitrogen Loading Calculations - Developable Soils Only

NITROGEN LOADING CALCULATIONS
WPA A Future (spine only, Arapahoe soils considered undevelopable)

INPUT FACTORS

Number of Residential units	27
Sewage flow per house (gal/day)	165
Commercial/Industrial land (acres)	60
Com./Ind. sewage flow per acre (gal/day)	423
N-conc. in sewage effluent (mg/l)	40
Lawn area per house (square feet)	5,000
Pavement per house (square feet)	500
Road area (square feet)	1,481,040
Roof area per house (square feet)	1,500
Agricultural area (acres)	2,819
Landfills (acres)	0
Septage lagoons (gallons/yr)	0
Septage N concentration (mg/l)	45
Animal burial (lbs /yr)	222,081
Total recharge area (acres)	3,417
Recharge rate for pervious area (in/yr)	17
Recharge rate for impervious area (in/yr)	34

INPUT	CALCULATIONS	RESULTS
Sewage (gal/day)		CALCULATED LOADING (LBS/YR)
29,835	x N-conc (mg/l) x 3.7851/gal x 365 days/yr : 454000 mg/lb	3,632
Lawn area (sq ft)		
135,000	x 0.0009 lb N/sq ft	122
Pavement area (sq ft)		
1,494,540	x 0.00042 lb N/sq ft	628
Roof area (sq ft)		
40,500	x 0.00015 lb N/sq ft	6
Natural area (acres)		
499	x 43560 sq ft/acre x 0.000005 lb N/sq ft	109
Other Sources		
Agriculture (acres)		
2,819	x 89 lbs N/acre/yr *25 % leach	62,733
Landfills (acres)		
0	1184 lbs N/acre/year	0
Septage Lagoons (gal/year)		
0	x N-conc (mg/l) x 3.7851/gal: 454000 mg/lb	0
Animal burial (lbs/year)		
222,081	x 3.3 % N concentration	7,329
	TOTAL NITROGEN LOADING (LBS/YR)	74,557
		TOTAL RECHARGE (MG/YR)
Recharge from sew/septage (gal/day)		
29,835	x 365 days/yr : 1,000,000 gal/million gal	11
Total pervious area (sq ft)		
146,002,680	x 17 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	1,547
Total impervious area (sq ft)		
2,841,840	x 34 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	60
	TOTAL RECHARGE (MGAL/YR)	1,618
TOTAL NITROGEN LOAD/TOTAL RECHARGE X 454,000 MG/LB : 3,785,000 L/MGAL		
	=RECHARGE NITROGEN CONCENTRATION (mg/l or ppm)	5.5

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Table F-3: WPA (B) Future Nitrogen Loading Calculations

NITROGEN LOADING CALCULATIONS
WPA B Future (spine only, all soils)

INPUT FACTORS

Number of Residential units	1,236
Sewage flow per house (gal/day)	165
Commercial/Industrial land (acres)	692
Com./Ind. sewage flow per acre (gal/day)	423
N-conc. in sewage effluent (mg/l)	40
Lawn area per house (square feet)	5,000
Pavement per house (square feet)	500
Road area (square feet)	2,134,440
Roof area per house (square feet)	1,500
Agricultural area (acres)	2,334
Landfills (acres)	150
Septage lagoons (gallons/yr)	450,000
Septage N concentration (mg/l)	45
Animal burial (lbs /yr)	319,449
Total recharge area (acres)	4,915
Recharge rate for pervious area (in/yr)	17
Recharge rate for impervious area (in/yr)	34

INPUT	CALCULATIONS	RESULTS
Sewage (gal/day)		CALCULATED LOADING (LBS/YR)
496,656	x N-conc (mg/l) x 3.7851/gal x 365 days/yr : 454000 mg/lb	60,453
Lawn area (sq ft)		
6,180,000	x 0.0009 lb N/sq ft	5,562
Pavement area (sq ft)		
2,752,440	x 0.00042 lb N/sq ft	1,156
Roof area (sq ft)		
1,854,000	x 0.00015 lb N/sq ft	278
Natural area (acres)		
1,492	x 43560 sq ft/acre x 0.000005 lb N/sq ft	325
Other Sources		
Agriculture (acres)		
2,334	x 89 lbs N/acre/yr * 25 % leach	51,934
Landfills (acres)		
150	1184 lbs N/acre/year	177,126
Septage Lagoons (gal/year)		
450,000	x N-conc (mg/l) x 3.7851/gal: 454000 mg/lb	244
Animal burial (lbs/year)		
319,449	x 3.3 % N concentration	10,542
	TOTAL NITROGEN LOADING (LBS/YR)	307,620
		TOTAL RECHARGE (MG/YR)
Recharge from sew/septage (gal/day)		
496,656	x 365 days/yr : 1,000,000 gal/million gal	182
Total pervious area (sq ft)		
187,902,624	x 17 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	1,991
Total impervious area (sq ft)		
26,194,776	x 34 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	555
	TOTAL RECHARGE (MGAL/YR)	2,728
TOTAL NITROGEN LOAD/TOTAL RECHARGE X 454,000 MG/LB : 3,785,000 L/MGAL		
	=RECHARGE NITROGEN CONCENTRATION (mg/l or ppm)	13.5

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Table F-4: WPA (B) Future Nitrogen Loading Calculations - Developable Soils Only

NITROGEN LOADING CALCULATIONS
WPA B Future (spine only, Arapahoe soils considered undevelopable)

INPUT FACTORS

Number of Residential units	1,211
Sewage flow per house (gal/day)	165
Commercial/Industrial land (acres)	692
Com./Ind. sewage flow per acre (gal/day)	423
N-conc. in sewage effluent (mg/l)	40
Lawn area per house (square feet)	5,000
Pavement per house (square feet)	500
Road area (square feet)	2,134,440
Roof area per house (square feet)	1,500
Agricultural area (acres)	2,355
Landfills (acres)	150
Septage lagoons (gallons/yr)	450,000
Septage N concentration (mg/l)	45
Animal burial (lbs /yr)	319,449
Total recharge area (acres)	4,915
Recharge rate for pervious area (in/yr)	17
Recharge rate for impervious area (in/yr)	34

INPUT	CALCULATIONS	RESULTS
Sewage (gal/day)		CALCULATED LOADING (LBS/YR)
492,531	x N-conc (mg/l) x 3.7851/gal x 365 days/yr : 454000 mg/lb	59,951
Lawn area (sq ft)		
6,055,000	x 0.0009 lb N/sq ft	5,450
Pavement area (sq ft)		
2,739,940	x 0.00042 lb N/sq ft	1,151
Roof area (sq ft)		
1,816,500	x 0.00015 lb N/sq ft	272
Natural area (acres)		
1,474	x 43560 sq ft/acre x 0.000005 lb N/sq ft	321
Other Sources		
Agriculture (acres)		
2,355	x 89 lbs N/acre/yr * 25 % leach	52,407
Landfills (acres)		
150	7184 lbs N/acre/year	177,126
Septage Lagoons (gal/year)		
450,000	x N-conc (mg/l) x 3.7851/gal: 454000 mg/lb	244
Animal burial (lbs/year)		
319,449	x 3.3 % N concentration	10,542
	TOTAL NITROGEN LOADING (LBS/YR)	307,463
		TOTAL RECHARGE (MG/YR)
Recharge from sew/septage (gal/day)		
492,531	x 365 days/yr : 1,000,000 gal/million gal	180
Total pervious area (sq ft)		
187,952,624	x 17 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	1,992
Total impervious area (sq ft)		
26,144,776	x 34 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	554
	TOTAL RECHARGE (MGAL/YR)	2,726
TOTAL NITROGEN LOAD/TOTAL RECHARGE X 454,000 MG/LB : 3,785,000 L/MGAL		
	=RECHARGE NITROGEN CONCENTRATION (mg/l or ppm)	13.5

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NITROGEN LOADING CALCULATIONS
WPA C Future (spine only, all soils)

INPUT FACTORS

Number of Residential units	10,157
Sewage flow per house (gal/day)	165
Commercial/Industrial land (acres)	1,864
Com./Ind. sewage flow per acre (gal/day)	423
N-conc. in sewage effluent (mg/l)	40
Lawn area per house (square feet)	5,000
Pavement per house (square feet)	500
Road area (square feet)	4,138,200
Roof area per house (square feet)	1,500
Agricultural area (acres)	2,629
Landfills (acres)	0
Septage lagoons (gallons/yr)	0
Septage N concentration (mg/l)	45
Animal burial (lbs /yr)	618,024
Total recharge area (acres)	9,509
Recharge rate for pervious area (in/yr)	17
Recharge rate for impervious area (in/yr)	34

INPUT	CALCULATIONS	RESULTS
Sewage (gal/day)		CALCULATED LOADING (LBS/YR)
2,125,977	x N-conc (mg/l) x 3.7851/gal x 365 days/yr : 454000 mg/lb	258,774
Lawn area (sq ft)		
50,785,000	x 0.0009 lb N/sq ft	45,707
Pavement area (sq ft)		
9,216,700	x 0.00042 lb N/sq ft	3,871
Roof area (sq ft)		
15,235,500	x 0.00015 lb N/sq ft	2,285
Natural area (acres)		
4,089	x 43560 sq ft/acre x 0.000005 lb N/sq ft	891
Other Sources		
Agriculture (acres)		
2,629	x 89 lbs N/acre * 25 % leach	58,496
Landfills (acres)		
0	1184 lbs N/acre/year	0
Septage Lagoons (gal/year)		
0	x N-conc (mg/l) x 3.7851/gal: 454000 mg/lb	0
Animal burial (lbs/year)		
618,024	x 3.3 % N concentration	20,395
	TOTAL NITROGEN LOADING (LBS/YR)	390,419
		TOTAL RECHARGE (MG/YR)
Recharge from sew/septage (gal/day)		
2,125,977	x 365 days/yr : 1,000,000 gal/million gal	776
Total pervious area (sq ft)		
366,585,920	x 17 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	3,885
Total impervious area (sq ft)		
47,626,120	x 34 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	1,009
	TOTAL RECHARGE (MGAL/YR)	5,670
TOTAL NITROGEN LOAD/TOTAL RECHARGE X 454,000 MG/LB : 3,785,000 L/MGAL		
	=RECHARGE NITROGEN CONCENTRATION (mg/l or ppm)	8.3

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Table F-6: WPA(D) Future Nitrogen Loading Calculations

NITROGEN LOADING CALCULATIONS
WPA D Future (spine only, all soils)

INPUT FACTORS

Number of Residential units	12,296
Sewage flow per house (gal/day)	165
Commercial/Industrial land (acres)	525
Com./Ind. sewage flow per acre (gal/day)	423
N-conc. in sewage effluent (mg/l)	40
Lawn area per house (square feet)	5,000
Pavement per house (square feet)	500
Road area (square feet)	4,530,240
Roof area per house (square feet)	1,500
Agricultural area (acres)	1,673
Landfills (acres)	0
Septage lagoons (gallons/yr)	0
Septage N concentration (mg/l)	45
Animal burial (lbs /yr)	677,946
Total recharge area (acres)	10,431
Recharge rate for pervious area (in/yr)	17
Recharge rate for impervious area (in/yr)	34

INPUT	CALCULATIONS	RESULTS
Sewage (gal/day)		CALCULATED LOADING (LBS/YR)
2,250,915	x N-conc (mg/l) x 3.7851/gal x 365 days/yr : 454000 mg/lb	273,982
Lawn area (sq ft)		
61,480,000	x 0.0009 lb N/sq ft	55,332
Pavement area (sq ft)		
10,678,240	x 0.00042 lb N/sq ft	4,485
Roof area (sq ft)		
18,444,000	x 0.00015 lb N/sq ft	2,767
Natural area (acres)		
6,153	x 43560 sq ft/acre x 0.000005 lb N/sq ft	1,340
Other Sources		
Agriculture (acres)		
1,673	x 84 lbs N/acre x 25 % leach	35,129
Landfills (acres)		
0	1184 lbs N/acre/year	0
Septage Lagoons (gal/year)		
0	x N-conc (mg/l) x 3.7851/gal: 454000 mg/lb	0
Animal burial (lbs/year)		
677,946	x 3.3 % N concentration	22,372
	TOTAL NITROGEN LOADING (LBS/YR)	395,407
		TOTAL RECHARGE (MG/YR)
Recharge from sew/septage (gal/day)		
2,250,915	x 365 days/yr : 1,000,000 gal/million gal	822
Total pervious area (sq ft)		
413,817,620	x 17 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	4,385
Total impervious area (sq ft)		
40,556,740	x 34 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	860
	TOTAL RECHARGE (MGAL/YR)	6,066
TOTAL NITROGEN LOAD/TOTAL RECHARGE X 454,000 MG/LB : 3,785,000 L/MGAL		
	=RECHARGE NITROGEN CONCENTRATION (mg/l or ppm)	7.8

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NITROGEN LOADING CALCULATIONS
WPA E Future (spine only, all soils)

INPUT FACTORS

Number of Residential units	13,409
Sewage flow per house (gal/day)	165
Commercial/Industrial land (acres)	239
Com./Ind. sewage flow per acre (gal/day)	423
N-conc. in sewage effluent (mg/l)	40
Lawn area per house (square feet)	5,000
Pavement per house (square feet)	500
Road area (square feet)	4,704,480
Roof area per house (square feet)	1,500
Agricultural area (acres)	728
Landfills (acres)	0
Septage lagoons (gallons/yr)	0
Septage N concentration (mg/l)	45
Animal burial (lbs /yr)	0
Total recharge area (acres)	10,796
Recharge rate for pervious area (in/yr)	17
Recharge rate for impervious area (in/yr)	34

INPUT	CALCULATIONS	RESULTS
Sewage (gal/day)		CALCULATED LOADING (LBS/YR)
2,313,582	x N-conc (mg/l) x 3.7851/gal x 365 days/yr : 454000 mg/lb	281,610
Lawn area (sq ft)		
67,045,000	x 0.0009 lb N/sq ft	60,341
Pavement area (sq ft)		
11,408,980	x 0.00042 lb N/sq ft	4,792
Roof area (sq ft)		
20,113,500	x 0.00015 lb N/sq ft	3,017
Natural area (acres)		
7,567	x 43560 sq ft/acre x 0.000005 lb N/sq ft	1,648
Other Sources		
Agriculture (acres)		
728	x 79 lbs N/acre x 25 % leach	14,370
Landfills (acres)		
0	1184 lbs N/acre/year	0
Septage Lagoons (gal/year)		
0	x N-conc (mg/l) x 3.7851/gal: 454000 mg/lb	0
Animal burial (lbs/year)		
0	x 3.3 % N concentration	0
	TOTAL NITROGEN LOADING (LBS/YR)	365,777
		TOTAL RECHARGE (MG/YR)
Recharge from sew/septage (gal/day)		
2,313,582	x 365 days/yr : 1,000,000 gal/million gal	844
Total pervious area (sq ft)		
433,545,860	x 17 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	4,594
Total impervious area (sq ft)		
36,727,900	x 34 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	778
	TOTAL RECHARGE (MGAL/YR)	6,217
TOTAL NITROGEN LOAD/TOTAL RECHARGE X 454,000 MG/LB : 3,785,000 L/MGAL		
	=RECHARGE NITROGEN CONCENTRATION (mg/l or ppm)	7.1

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APPENDIX G

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