Appendix B
Onsite Sewage Disposal Systems: Identification, Categorization and Prioritization

Onsite Sewage Disposal Systems: Identification, Categorization and Prioritization

PREPARED FOR: Anne Arundel County

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Harms & Associates, Inc.

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Attachments

Purpose and Background

Anne Arundel County, Maryland, is conducting a countywide evaluation of service options for properties with onsite sewage disposal systems (OSDS, commonly referred to as septic systems). The overall goal of this effort is to assist the County in preparing a plan for implementation of the Chesapeake Bay Watershed Restoration Fund (the "Flush Fee"). This Technical Memorandum documents the results of the first task in this study, which is to identify, categorize and prioritize projects to address nutrient loads associated with OSDS countywide.

The County has recently updated a database containing the number and location of properties on OSDS throughout the County, which will be subject to the Flush Fee starting in early 2006. There are about 40,684 properties on OSDS according the most recent County database, out of more than 193,346 properties countywide.

CH2M HILL, and our subcontractors Harms & Associates and Stearns & Wheler, is currently working on the Comprehensive Sewer Strategic Plan (CSSP) for six of the County's sewer service areas (SSAs): Annapolis, Baltimore City, Broadneck, Cox Creek, Maryland City, and Patuxent. The Septic System Evaluation Study leverages GIS data and related wastewater flow forecasting tasks from that project by looking at OSDS within those six SSAs, and by extending the analysis and information used to cover the unserved rural areas and the unserved areas within the remaining SSAs, which include:

- Broadwater
- Mayo–Glebe Heights
- Rose Haven
- Bodkin Pt–Pinehurst
- Ft. George Meade
- Piney Orchard

The Septic System Evaluation Study includes the following four tasks:

- **Task 1**—Identifying, Categorizing, and Prioritizing OSDS
- **Task 2**—Preliminary Cost Analysis of Onsite Septic System Upgrades and Cluster Community Wastewater Systems
- **Task 3**—Preliminary Cost Analysis of Sewer System Extensions
- **Task 4**—Implementation Plan and Final Report

This TM documents the results of Task 1, whose purpose is to:

- **Identify OSDS** by assembling a GIS database of all OSDS countywide
- **Categorize OSDS** based on potential for four categories of alternatives:
  - sewer service
  - cluster type of community sewer service
  - enhanced nitrogen removal, OSDS upgrades
  - leave on existing septic system
- **Develop an Initial Prioritization** based on potential for nitrogen contamination

The categorization of OSDS above includes categorization of OSDS in rural SSAs, including the possibility of extending sewer service from existing water reclamation facilities (WRFs).

Identification

Anne Arundel County has developed a database of the location of properties with OSDS. The process started with the County's Consolidated Property File (CPF), which is a database the County maintains that is initially derived from property records maintained by the State Department of Assessment and Taxation, to which the County adds additional information such as water and sewer billing records. The first pass of OSDS identification was based on known locations from other County databases. The next step was to determine where development has occurred on the remainder of the properties on a case-by-case basis. Properties were determined to be developed based on assessed value of the improvements, using a cutoff of $10,000. For developed properties, the next step was to determine if the area is served by water and wastewater. The County Health Department made site visits to all of the developed properties that have been identified as not being served by water and wastewater.

The net result is a GIS point coverage that indicates whether the property is developed or undeveloped, adjacent to wastewater service, and either on septic or sewer. The point coverage is limited to a generalized point representing each parcel and does not include any location information of OSDS within that parcel polygon. The point coverage also does not contain site-specific information on the type of OSDS or its operation and maintenance status. However, the land use on each property is available from the CPF, thus allowing residential and nonresidential properties to be distinguished. The County anticipates completing a parcel map in 2007, which should provide more information.

Tables 1, 2, and 3 summarize the number of OSDS by watershed, by sewer service area (SSA), and planned sewer service type. These tables also present summaries of the percentage of all developed properties are served by OSDS versus public sewer. Figure 1 shows the location and density of OSDS countywide. Attachment A tabulates the number of OSDS by sewer service type within each SSA and by SSA within each watershed. There are 36,120 (89 percent) OSDS that serve residential properties and 4,440 (11 percent) that serve nonresidential properties. Table 4 provides a breakdown of OSDS based on the land use type, assigned by overlaying the CPF on the County's current land use layer.

TABLE 1
Inventory of OSDS by Watershed
Anne Arundel County Septic Evaluation Study

WATERSHED	NUMBER OF OSDS	PERCENT OF OSDS	NUMBER OF DEVELOPED ACCOUNTS	PERCENT SERVED BY OSDS
Bodkin Creek	3,093	7.6%	3,214	96.2%
Herring Bay	1,041	2.6%	4,008	26.0%
Little Patuxent	793	1.9%	19,336	4.1%
Magothy River	9,626	23.7%	25,744	37.4%
Middle Patuxent	2,206	5.4%	2,266	97.4%
Patapsco Non-tidal	1,120	2.8%	9,056	12.4%
Patapsco Tidal	2,163	5.3%	41,914	5.2%

TABLE 1
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Anne Arundel County Septic Evaluation Study

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Bodkin Creek	3,093	7.6%	3,214	96.2%
Herring Bay	1,041	2.6%	4,008	26.0%
Rhode River	430	1.1%	1,890	22.8%
Severn River	11,926	29.3%	31,251	38.2%
South River	6,084	15.0%	17,696	34.4%
Upper Patuxent	1,715	4.2%	3,446	49.8%
West River	351	0.9%	2,406	14.6%
(blank)	136	0.3%	762	17.8%
Grand Total	40,684	100.0%	162,989	25.0%

Note: (blank) watershed means the OSDS mapping location in the GIS data layer is in the water. This happens for some properties on the water's edge.

TABLE 2
Inventory of OSDS by Sewer Service Area
Anne Arundel County Septic Evaluation Study

SEWER SERVICE AREA	NUMBER OF OSDS	PERCENT OF OSDS	NUMBER OF DEVELOPED ACCOUNTS	PERCENT SERVED BY OSDS
Annapolis	3,201	7.9%	16,601	19.3%
Baltimore City	1,446	3.6%	11,777	12.3%
Bodkin Pt-Pinehurst	140	0.3%	160	87.5%
Broadneck	9,957	24.5%	30,302	32.9%
Broadwater	291	0.7%	4,887	6.0%
Cox Creek	2,513	6.2%	42,037	6.0%
Ft. George Meade	2	0.0%	10	20.0%
Maryland City	160	0.4%	4,336	3.7%
Mayo-Glebe Heights	104	0.3%	3,192	3.3%
Patuxent	892	2.2%	22,902	3.9%
Piney Orchard	17	0.0%	3,629	0.5%
Rose Haven	4	0.0%	378	1.1%
Rural	21,815	53.6%	22,189	98.3%
(blank)	142	0.3%	589	24.1%

TABLE 2
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Anne Arundel County Septic Evaluation Study

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Annapolis	3,201	7.9%	16,601	19.3%
Baltimore City	1,446	3.6%	11,777	12.3%
Bodkin Pt-Pinehurst	140	0.3%	160	87.5%
Grand Total	40,684	100.0%	162,989	25.0%

Note: (blank) Sewer Service Area means the OSDS mapping location in the GIS data layer is in the water. This happens for some properties on the water's edge.

TABLE 3
Inventory of OSDS by Planned Sewer Service Type
Anne Arundel County Septic Evaluation Study

PLANNED SEWER SERVICE TYPE	NUMBER OF OSDS	PERCENT OF OSDS	NUMBER OF DEVELOPED ACCOUNTS	PERCENT SERVED BY OSDS
Existing Service	1,881	4.6%	118,181	1.6%
Future Service	8,322	20.5%	8,674	95.9%
No Public Service	23,041	56.6%	23,449	98.3%
Other	18	0.0%	38	47.4%
Park	22	0.1%	45	48.9%
Planned Service	5,676	14.0%	9,792	58.0%
Resource Conservation Area	1,584	3.9%	2,165	73.2%
(blank)	140	0.3%	587	23.9%
Grand Total	40,684	100.0%	162,931	25.0%

Note: (blank) Planned Sewer Service Type means the OSDS mapping location in the GIS data layer is in the water. This happens for some properties on the water's edge.

TABLE 4
Inventory of OSDS by Land Use of Property Served
Anne Arundel County Septic Evaluation Study

LAND USE TYPE	NUMBER OF OSDS	PERCENT OF OSDS	NUMBER OF DEVELOPED ACCOUNTS	PERCENT SERVED BY OSDS
Agricultural	673	1.7%	873	77.1%
City of Annapolis	3	0.0%	3	100.0%
Government/Institutional	219	0.5%	745	29.4%
Industrial	299	0.7%	643	46.5%
Multiple Family Dwelling	5	0.0%	5,834	0.1%
Natural Open Space	449	1.1%	2,171	20.7%
Office	224	0.6%	794	28.2%
Recreation and Parks	131	0.3%	1,369	9.6%
Retail	623	1.5%	2,966	21.0%
Single Family Dwelling	36,102	88.7%	116,412	31.0%
Townhouse	13	0.0%	24,159	0.1%
Transportation/Utility	92	0.2%	498	18.5%
Vacant	1,708	4.2%	5,749	29.7%
Water	19	0.0%	74	25.7%
(blank)	124	0.3%	700	17.7%
Grand Total	40,684	100.0%	162,989	25.0%

Note: (blank) Land Use Type means the OSDS mapping location in the GIS data layer is off shore. This happens for some properties on the water's edge.

Figure 1. Septic System Location
Anne Arundel County
Maryland

CH2MHILL

August 14, 2006

Categorization for Prioritization of Problems

Prioritization Process and Evaluation Criteria

In this study, the process for prioritizing OSDS and determining which potential alternatives can be applied was a two-step process. The first step was to categorize and prioritize the problem by ranking each OSDS in terms of its potential to cause negative environmental impacts either through pollutant discharges to the Chesapeake Bay or to drinking water supplies. In other words, the first step was to prioritize each system based on the potential severity of its environmental and public health impact.

Through a series of three workshops with County staff, eight evaluation criteria were developed, as listed in Table 5. In addition to these eight evaluation criteria, several others were also considered, including Distance to Wetlands (MD Department of Natural Resources' [DNR's] Wetlands of Special State Concern) and OSDS density. Distance to wetlands was dropped as being essentially covered by the distance to surface water criterion. Septic system density is used later in the process to evaluate alternatives.

The relative importance of each of the eight criteria was ranked by all County staff participating in the workshops. The average weights are shown in Table 5 and reflect the priorities of County staff. Attachment B contains the raw weights assigned by County staff. In addition, a scoring system was developed for each criterion allowing each OSDS to be scored on a scale from 1 to 5, with a 5 representing the worst potential environmental threat. Stated differently, a score of 5 is the highest potential environmental benefit from mitigation. Table 6 summarizes the performance scales used to score OSDS relative to each criterion. The basis for this scoring system was developed through a literature search of relevant criteria and refined through the workshops with County staff, and is discussed below with the results for the *Frequency and Location of OSDS by Evaluation Criteria.*

The final step of the prioritization of each OSDS was to develop a composite benefit score. This is simply the sum of the product of each criteria score and the criteria weight, for up to eight evaluation criteria. For example, if a given OSDS has a score of 1 for each of the 8 criteria, then its weighted benefit score is 557 (1x100 + 1x96.3 + 1x86.6 + 1x63.1 + 1x59.9 + 1x 52.4 + 1x49.7 + 1x49.2). For ease of understanding and comparison to individual criteria, the weighted benefit score was normalized to a range from 1 to 5 by dividing by the sum of the criteria weights (557, if all eight criteria are used).

Four different prioritization approaches were considered to rank each of the 40,684 OSDS in the Anne Arundel County OSDS database.

- **Prioritization Approach No. 1**: use all eight criteria, weighted as shown in Table 5. This approach was developed and presented to County staff and subsequently dropped because of data quality concerns. A sensitivity analysis comparing this approach to the other three is presented in Attachment C. Attachment D contains summary tables from the initial prioritization based on all 4 criteria.
- **Prioritization Approach No. 2**: use six of the eight criteria, dropping the depth to groundwater and soil percolation rate because of concerns about data completeness and accuracy for these two criteria, as explained further below. This approach was

developed and presented to County staff and subsequently dropped because of concerns that including too many criteria dilutes the prioritization when based on the highest ranked criteria in Table 5. The sensitivity analysis comparing this approach to the other three shows this dilution effect (see Attachment C).

- **Prioritization Approach No. 3**: use only small number of criteria, so as not to dilute priority scores for the most important criteria relative to total nitrogen loading. The following criteria were used: proximity to surface water, location in Chesapeake Critical Areas, location in Health Department OSDS Problem Areas and slope. The sensitivity analysis comparing this approach to the other three is presented in Attachment C.
- **Prioritization Approach No. 4** is similar to Approach No. 3, but without including the OSDS Problem Areas. The reasoning is that OSDS problem areas integrate a number of factors known to be associated with high potential for failure of conventional OSDS. By focusing on substandard OSDS systems these areas focus implicitly on potential sources of pathogen contamination and not necessarily on sources of nitrogen, which is the primary focus of this study because of the Chesapeake Bay Restoration Fund. An OSDS that is operating correctly is still a potential source of nitrogen because OSDS systems do not remove significant nitrogen and nitrate nitrogen is highly mobile in most soils. Therefore, results presented below are based on this fourth approach. The sensitivity analysis comparing this approach to the other three is presented in Attachment C.

TABLE 5
Evaluation Criteria and Criteria Weights Assigned by County Staff
Anne Arundel County Septic Evaluation Study

	Evaluation Criteria	Average	Average Normalized
1	Distance from Health Dept. OSDS Problem Areas (ft)	93.5	100
2	Distance to (Surface) Water (ft)	90	96.3
3	Distance from Chesapeake Critical Area (ft)	81	86.6
4	Depth to Groundwater (ft)	59	63.1
5	Distance from Bogs (ft)	56	59.9
6	Slope (%)	49	52.4
7	Soil Percolation Rates (in/hr)	46.5	49.7
8	Distance from Well Head Protection Areas (ft)	46	49.2

Criteria weights are from 0 to 100, 100 is most important. Scores do not have to add up to 100. Relative values were used by County staff to assign relative importance. For example, all could be assigned a weight of 100, if all were considered equally important or 50 if half as important as a 100.

TABLE 6
Performance Scales for Evaluation Criteria
Anne Arundel County Septic Evaluation Study

	Evaluation Criteria	**Suggested Score and Measurement Scale (High Scores are Poor Environmental Performance or High Environmental Benefit from Mitigation)**				
		5 = Poor Environmental Performance, or High Environmental Benefit	**4 = Fair**	**3 = Moderate**	**2 = Good**	**1 = Excellent Environmental. Performance, or Low Mitigation Benefit**
1	In or Out of Health Dept. OSDS Problem Areas	Within Problem Areas				Outside Problem Areas
2	*Distance to Water (ft)*	0 - 100 ft	100 - 300 ft	300 - 500 ft	500 - 1000 ft	> 1000 ft
3	In or Out of *Chesapeake Critical Area*	Within RCA	Within LDA	Within IDA		Outside CCA
4	*Depth to Groundwater (ft)*	0-1 ft	1-2 ft	2-4 ft (or NA)		> 4 ft
5	*Distance from Bogs*	0-50 ft	50-100 ft	100 - 300 ft		>300 ft
6	*Slope (%)*	>25%	15-25%	12-15%		<12%
7	*Soil Percolation Rates (in/hr)*	0-0.5 in/hr	0.5-1 in/hr	1-2 in/hr		>2 in/hr
8	*Distance from Wellhead Protection Areas (WHPA): Semi-Confined (SCON) and Confined (CON) – or Deep Aquifer Recharge Areas(ft)*	0-100 ft of SCON	0-100 ft of CON	Within Recharge Area		Outside WHPA or Recharge Area

In the second step of the prioritization process, the priority OSDS were categorized relative to potential alternatives for mitigation based on planned sewer service type, proximity to sewer service, and density of OSDS. In subsequent tasks, these categories will allow the high-priority problems to be sorted into those best suited for:

- Extension of sewer service
- Cluster type of community sewer service
- Enhanced nitrogen removal, OSDS upgrades
- No Action: Leave on existing septic system

Data sources for these analyses and data processing steps for these analyses are summarized below, followed by summaries of the frequency and location of OSDS in each of the evaluation criteria.

Data Sources and Data Processing

Septic system data and various GIS data layers for this study were obtained from the County and other state and federal agencies. Data source and processing information are summarized in Attachment E. All GIS data processing was performed in an ESRI ArcGIS environment unless otherwise indicated. ArcGIS Spatial Analyst and 3D Analyst were used to perform the septic density, slope, and spot elevation analysis. Spatial join and overlay analyses were used to compute the proximity of OSDS to evaluation criteria features in Table 6.

Soil Percolation Rate Data Sources and Processing

The NRCS soil survey data for the county were summarized based on soil map units. An approximate depth range of interest was defined as 24 to 60 inches below the soil surface, based on a likely drain field installation depth for systems that are not mound systems. Soil survey data provide estimates of the range in soil percolation rate or soil permeability based on differences in soil horizons. Values provided are a mixture of some limited laboratory data combined with professional judgment of the soil scientists who conducted the survey. Soil permeability data tend to vary over several orders of magnitude because small differences in soil pore sizes result in large differences in permeability. The combination of these factors leads to a wide range in estimates of permeability for each soil map unit. A further complication in the soil survey data is the frequent use of soil complexes (i.e., areas that are mixtures of two or more soil series). The typical proportion of the individual soils in the complex is provided in the soil survey, and can be used to weight the data.

For example, the AdA soil map unit consists of 50 percent Adelphia and 30 percent Holmdel soils. For the Adelphia soil, the range of permeability suggested is 1.4 to 14 µm/sec for the 24- to 60-inch depth range. For the Holmdel soil, the range is 4.2 to 14.1. Weighting these ranges based on the percentages of each soil in the soil map unit results, and converting units to inches per hour, results in a weighted average “low” estimate of 0.35 inches per hour, and a weighted average “high” estimate of 1.99 inches per hour. These weighted average values were input values for layers in the GIS.

Frequency and Location of OSDS by Evaluation Criteria

Health Department OSDS Problem Areas

The County Health Department manages a GIS layer containing 37 OSDS problem areas within the County, referred to in previous County Water and Sewer Master Plan as Wastewater Management Problem Areas. These problem areas are based on the following factors:

- High water table
- Steep slopes
- Poor percolation tests
- Lot size
- Historical use of alternative OSDS technologies

County staff ranked the location of OSDS inside the Health Department OSDS problem areas as the most significant criterion in terms of potential environmental benefit.

Figure 2 shows the frequency distribution and cumulative distribution of OSDS inside and outside of problem areas: 14.3 percent of all OSDS are in problem areas. Attachment F tabulates the frequency distribution data shown in Figure 2. Figure 3 shows a detailed view of OSDS concentrated in a problem area.

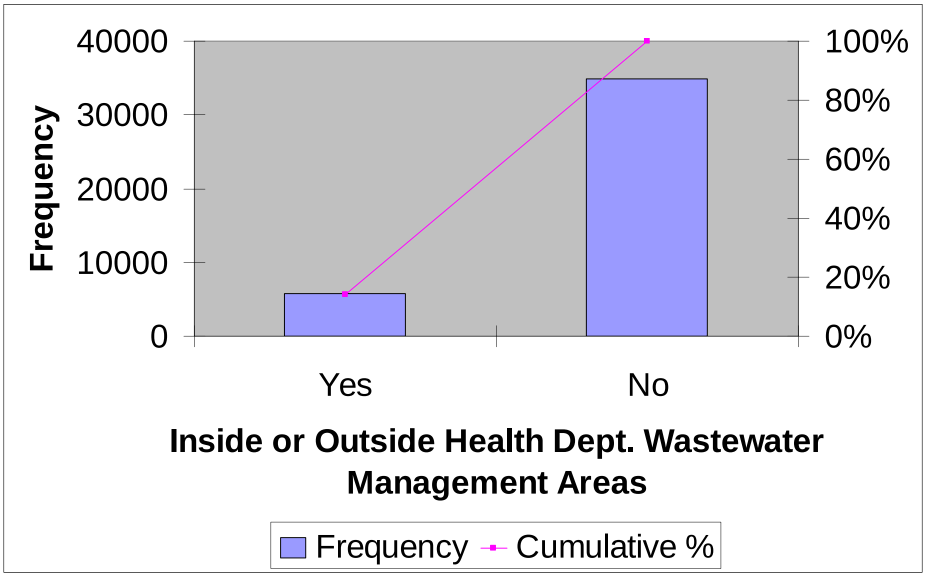


FIGURE 2. FREQUENCY DISTRIBUTION OF OSDS INSIDE OR OUTSIDE HEALTH DEPARTMENT PROBLEM AREAS.

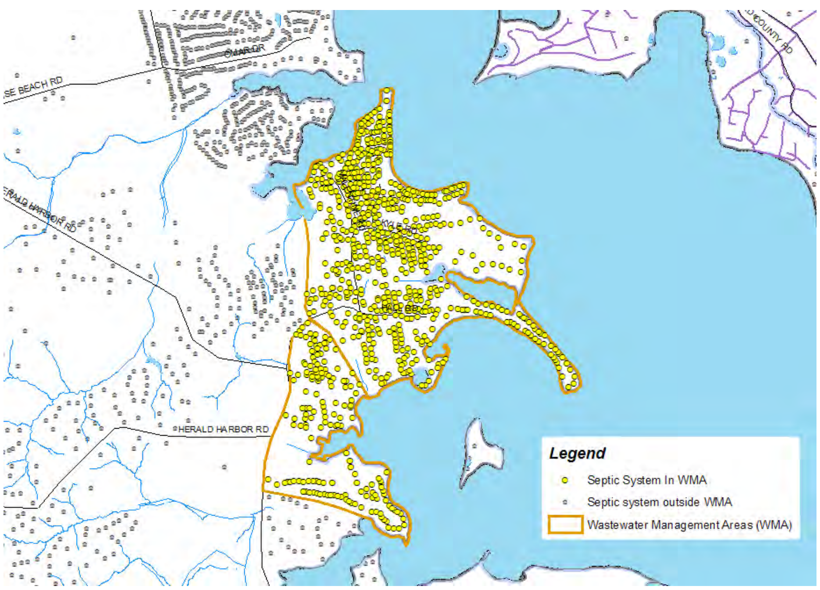


FIGURE 3. OSDS INSIDE HEALTH DEPARTMENT PROBLEM AREAS (SAMPLE DATA).

Distance to Surface Water

County staff ranked the location of OSDS relative to surface water as the second most significant criterion in terms of potential environmental benefit. Based on the literature review, it was recognized that proximity to surface water was likely to result in higher delivery of nitrogen to the Chesapeake Bay and its tributaries because of the mobility of nitrate nitrogen through the soil. However, it was also considered important to look at all surface water, both tidal and nontidal, rather than just the areas near tidal surface water represented by the 1000-ft buffer in the Chesapeake Bay Critical Areas.

Figure 4 shows the frequency distribution and cumulative distribution of OSDS as a function of distance from all surface waters. Figure 5 shows a detailed view of OSDS as a function of distance from all surface waters, with OSDS categorized per the scoring system in Table 6. Attachment F tabulates the frequency distribution data shown in Figure 4: 9 percent, 33 percent, and 86 percent of all OSDS are within 100, 300, and 1000 ft of the water's edge, respectively. This is considerably more than in the 1000-ft buffer for the Critical Areas, as discussed below.

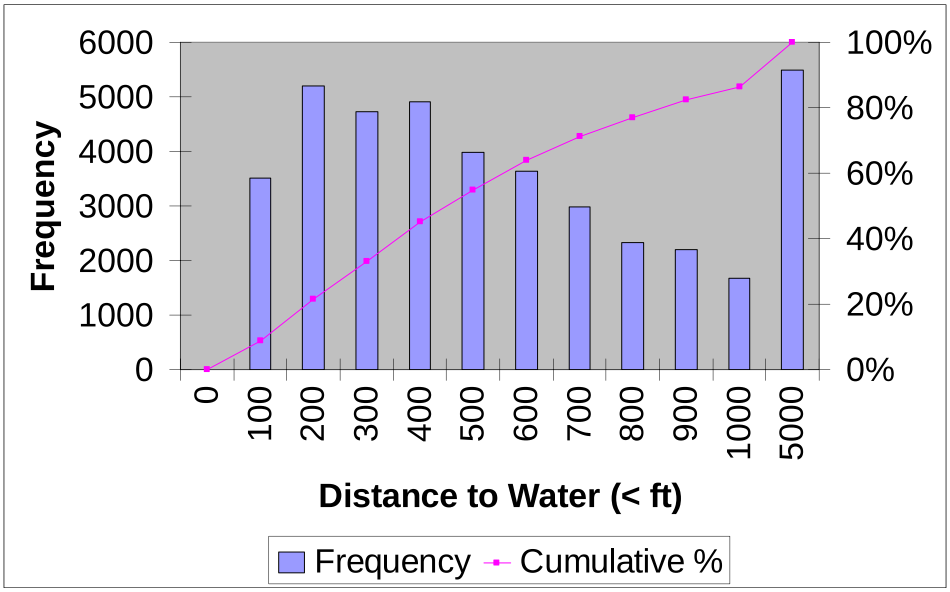


FIGURE 4. FREQUENCY DISTRIBUTION OF OSDS BY DISTANCE FROM SURFACE WATER.

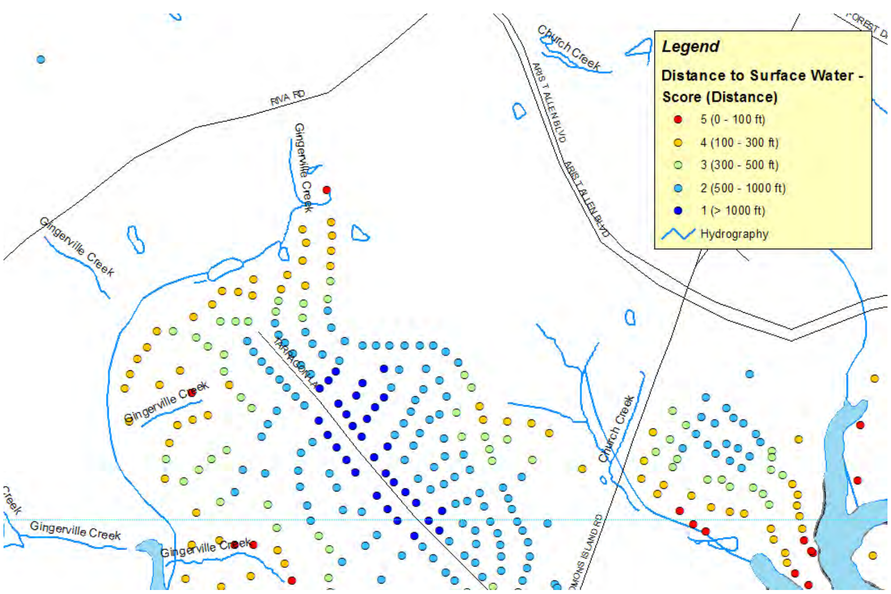


FIGURE 5. OSDS CATEGORIZED BY DISTANCE FROM SURFACE WATER (SAMPLE DATA).

Distance to Critical Areas

County staff ranked the location of OSDS inside the Chesapeake Bay Critical Areas as the third most significant criterion in terms of potential environmental benefit.

Figure 6 shows the frequency distribution and cumulative distribution of OSDS inside and outside the Critical Areas, broken into Resource Conservation Areas (RCAs), Limited Development Areas (LDAs) and Intensely Developed Areas (IDAs). Figure 7 shows a detailed view of OSDS in the Critical Areas, with OSDS categorized into RCA, LDA, and IDA per the scoring system in Table 6. Attachment F tabulates the frequency distribution data shown in Figure 6—32 percent of OSDS are within the Critical Areas, considerably less than the 86 percent within 1000 ft of all surface waters. The 32 percent are broken into 2 percent, 27 percent, and 3 percent in IDAs, LDAs, and RCAs, respectively.

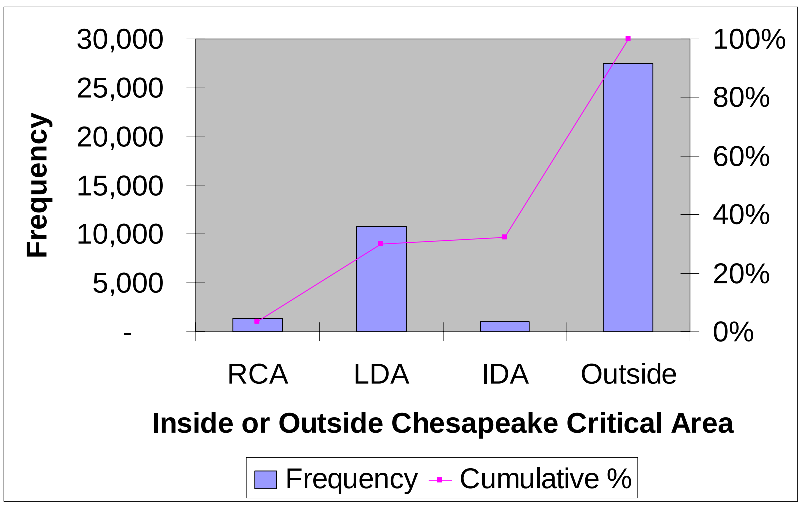


FIGURE 6. FREQUENCY DISTRIBUTION OF OSDS WITHIN THE CHESAPEAKE BAY CRITICAL AREAS.

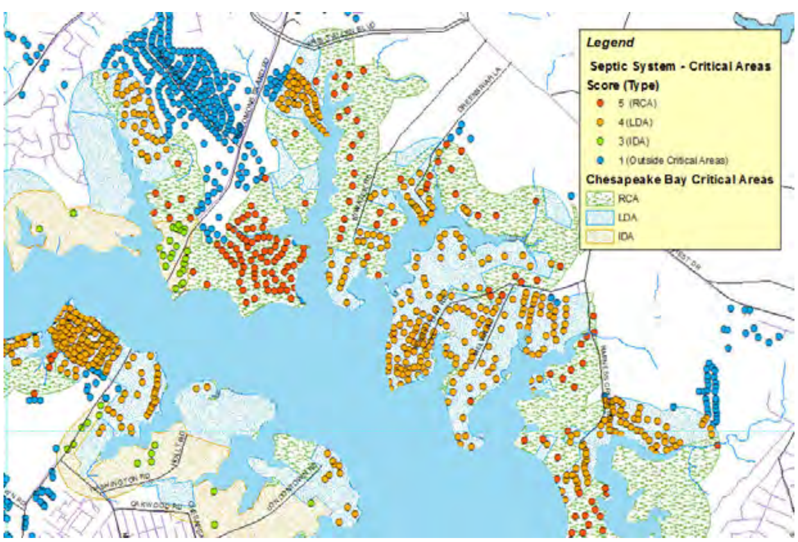


FIGURE 7. OSDS CATEGORIZED WITHIN THE CHESAPEAKE BAY CRITICAL AREAS (SAMPLE DATA).

Depth to Groundwater

County staff ranked the depth to groundwater of OSDS as the fourth most significant criterion in terms of potential environmental benefit, because high groundwater contributes to OSDS failure to remove pollutants. In subsequent discussion with County staff it was decided to remove depth to groundwater as an evaluation criterion to use in prioritizing OSDS because of the lack of reliable local data on depth to groundwater for each OSDS, as discussed below.

Depth to groundwater data were broken into categories representing County Health Department standards for different types of systems: 0–2 ft requires use of mound systems, 2–4 requires alternative systems, and over 4 ft allows the use of conventional systems. The depth to groundwater GIS data are based on available information on seasonal high water in the NRCS soil survey. Unfortunately, many soil types in that soil survey do not have information on depth to groundwater (36 percent of all OSDS lack this data). For these, a neutral score of 3 was applied, per the scoring system in Table 6. Figure 8 shows the frequency distribution and cumulative distribution of OSDS as a function of depth to groundwater. Figure 9 shows a detailed view of OSDS as a function of depth to groundwater, with OSDS categorized per the scoring system in Table 6. Attachment F tabulates the frequency distribution data shown in Figure 8: 36 percent of all OSDS have no depth to groundwater data in the soils layer; 5 percent of all systems are within 2 ft of groundwater levels; and 30 percent of all systems are within 4 ft of groundwater levels.

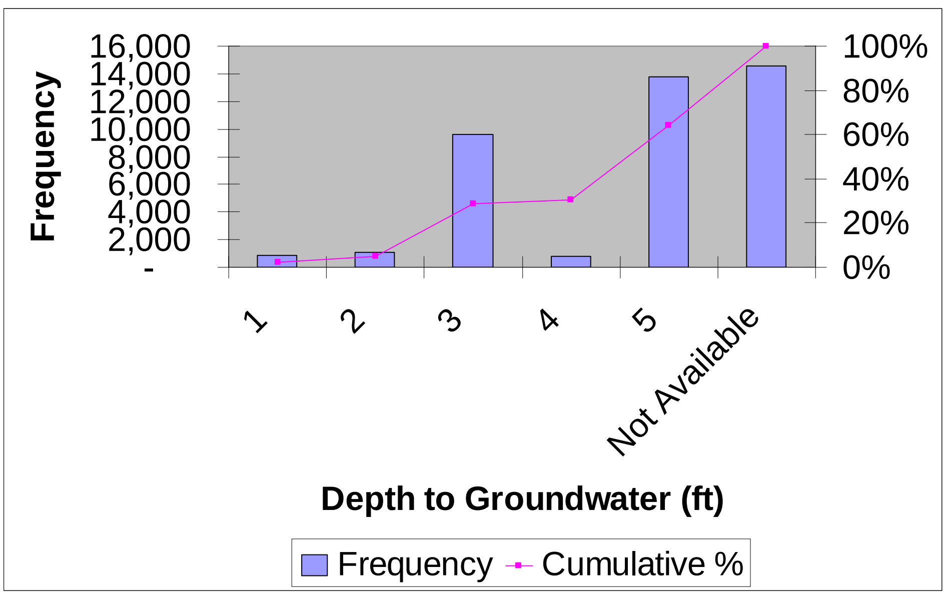


FIGURE 8. FREQUENCY DISTRIBUTION OF OSDS BY DEPTH TO GROUNDWATER.

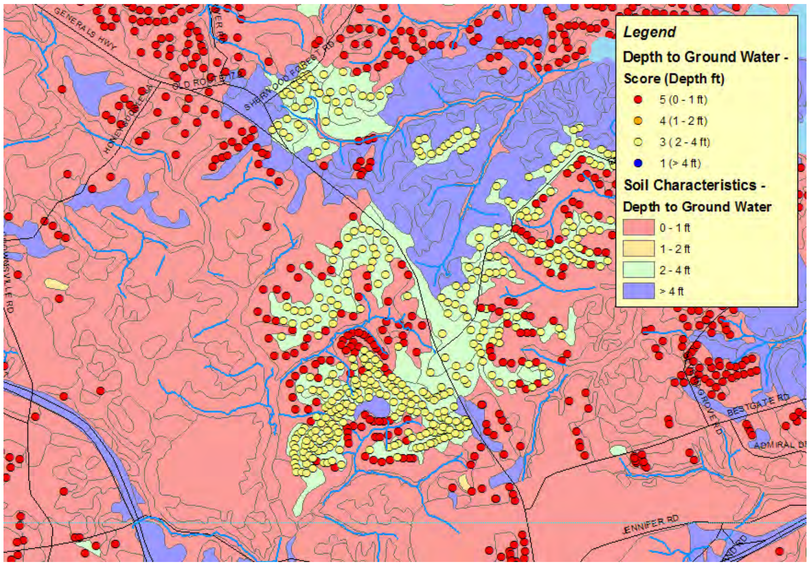


FIGURE 9. OSDS CATEGORIZED BY DEPTH TO GROUNDWATER (SAMPLE DATA).

Distance to Bogs

County staff ranked the distance of OSDS relative to bogs as the fifth most significant criterion in terms of potential environmental benefit, because of their environmental sensitivity to pollutant loads and presence of threatened and endangered species.

Figure 10 shows the frequency distribution and cumulative distribution of OSDS as a function of distance from bogs. Figure 11 shows a detailed view of OSDS as a function of distance from bogs, with OSDS categorized per the scoring system in Table 6. Attachment F tabulates the frequency distribution data shown in Figure 10: 8 OSDS (0.02 percent) are inside bogs and 818 (2 percent) OSDS are within 300 ft of bogs.

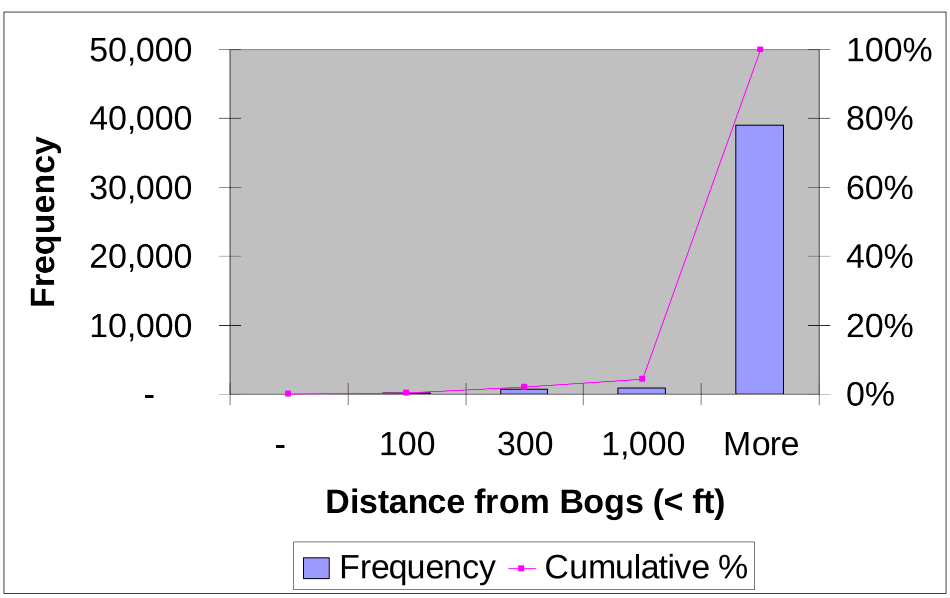


FIGURE 10. FREQUENCY DISTRIBUTION OF OSDS BY DISTANCE FROM BOGS.

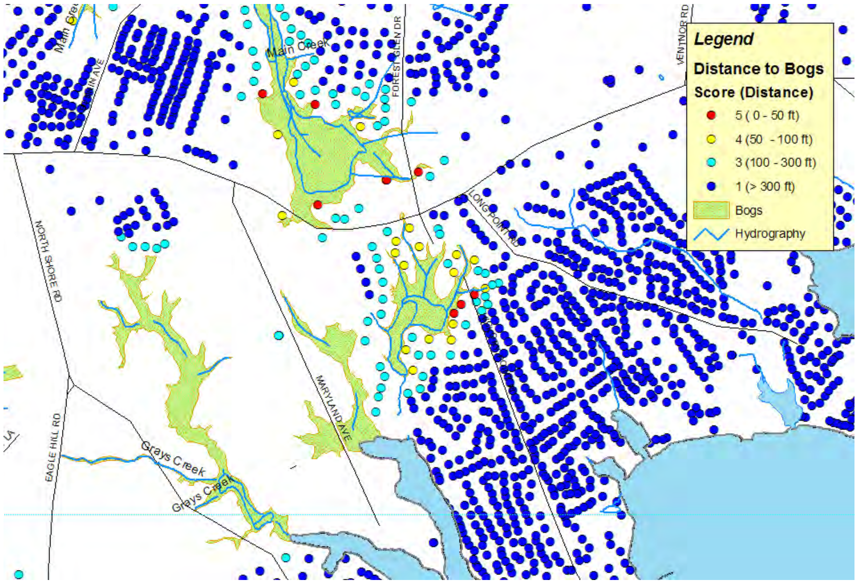


FIGURE 11. OSDS CATEGORIZED BY DISTANCE FROM BOGS (SAMPLE DATA).

Ground Slope

County staff ranked the ground slope as the sixth most significant criterion in terms of potential environmental benefit, because higher slopes result in a higher probability of system failure. Slope data were broken into categories representing County Health Department standards for different types of systems—0 to 12 percent, 12 to 15 percent, 15 to 25 percent, and more than 25 percent.

Slope data were developed based on a 15-ft grid resampled from a 2-meter DEM, as explained in Attachment E. Given the approximate nature of the OSDS location data and the averaging inherent in the slope data development, the accuracy of the slope data used in this analysis cannot be determined without site specific measurements. However, the slope data are considered sufficiently accurate for this planning level study.

Figure 12 shows the frequency distribution and cumulative distribution of OSDS as a function of ground slope. Figure 13 shows a detailed view of OSDS as a function of ground slope, with OSDS categorized per the scoring system in Table 6. Attachment F tabulates the frequency distribution data shown in Figure 12: 78 percent of OSDS are in the flat slope range under 12 percent; however, 6 percent of OSDS have more than 25 percent slope, and 10 and 6 percent are between 15 and 25 percent slope and between 12 and 15 percent slope, respectively.

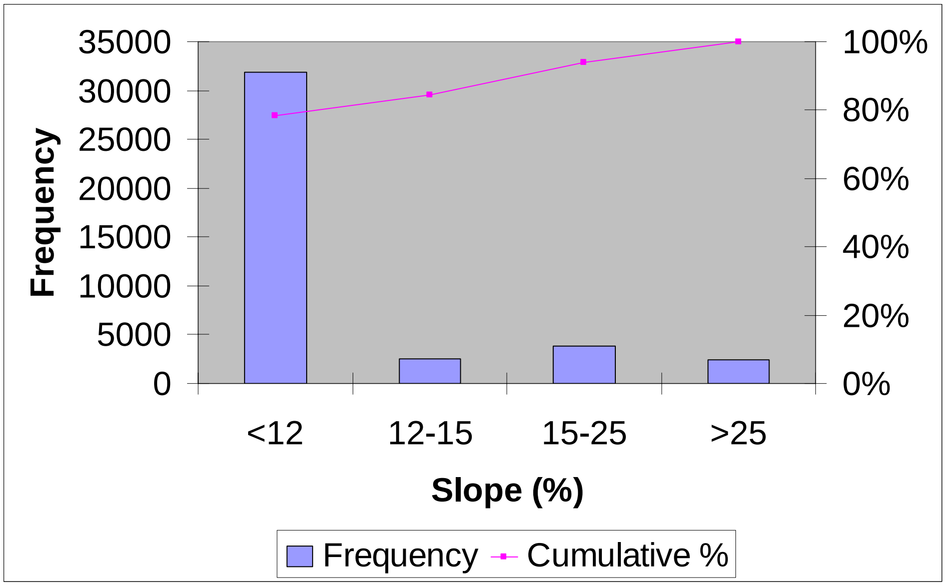


FIGURE 12. FREQUENCY DISTRIBUTION OF OSDS BY GROUND SLOPE.

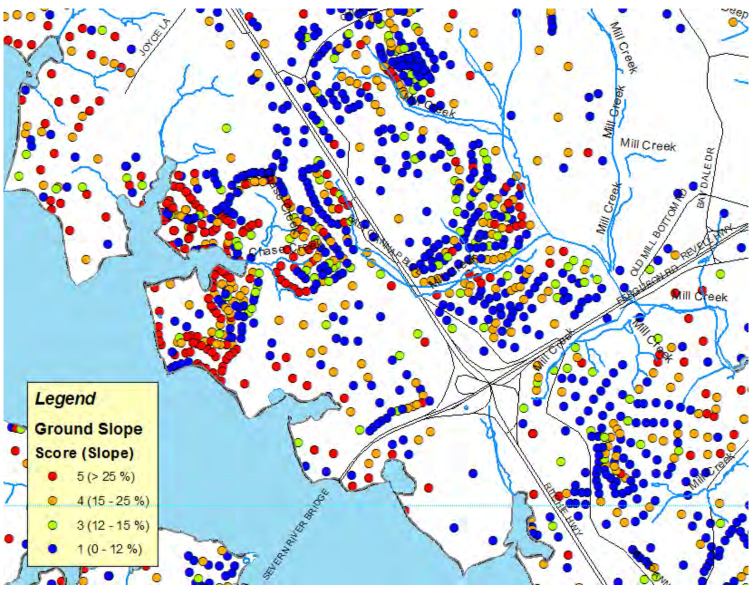


FIGURE 13. OSDS CATEGORIZED BY GROUND SLOPE (SAMPLE DATA).

Soil Percolation Rate

County staff ranked the soil percolation rate as the seventh most significant criterion in terms of potential environmental benefit, because lower percolation rates result in a higher probability of system failure. In subsequent discussion with County staff it was decided to remove soil percolation rate as an evaluation criterion to use in prioritizing OSDS because of the lack of reliable local data on soil percolation rate for each OSDS, as discussed below.

Percolation rate data were broken into categories representing County Health Department standards for different types of systems:

- Traditional onsite systems—1 to 30 min/in. (greater than 2 in./hr)
- Alternative onsite systems—30 to 60 min/in.(1 to 2 in./hr)
- Mound systems—60 to 120 min/in. (0.5 to 1 in./hr)

It should be noted that soil percolation rate data are based on available information in the NRCS soil survey. Many soil types in that soil survey contain a very wide range of potential soil percolation rates, which is why the Health Department relies on site-specific percolation tests. For this evaluation, the middle of the range of percolation rates was used. Figure 14 shows the frequency distribution and cumulative distribution of OSDS as a function of median soil percolation rate. Figure 15 shows a detailed view of OSDS as a function of median soil percolation rate, with OSDS categorized per the scoring system in Table 6. Attachment F tabulates the frequency distribution data shown in Figure 14: 87 percent of OSDS are in the high range over 2 inches per hour; however, 9 percent of OSDS have percolation rates in the range requiring alternate onsite systems (1–2 in./hr) and 4 percent are in the low percolation rate range requiring mound systems (0.5–1 in./hr).

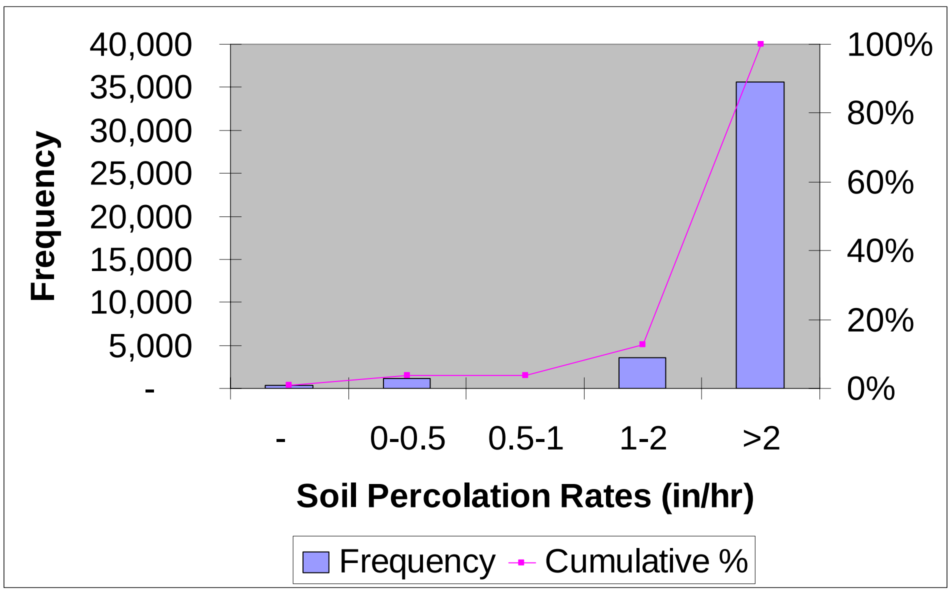


FIGURE 14. FREQUENCY DISTRIBUTION OF OSDS BY SOIL PERCOLATION RATE.

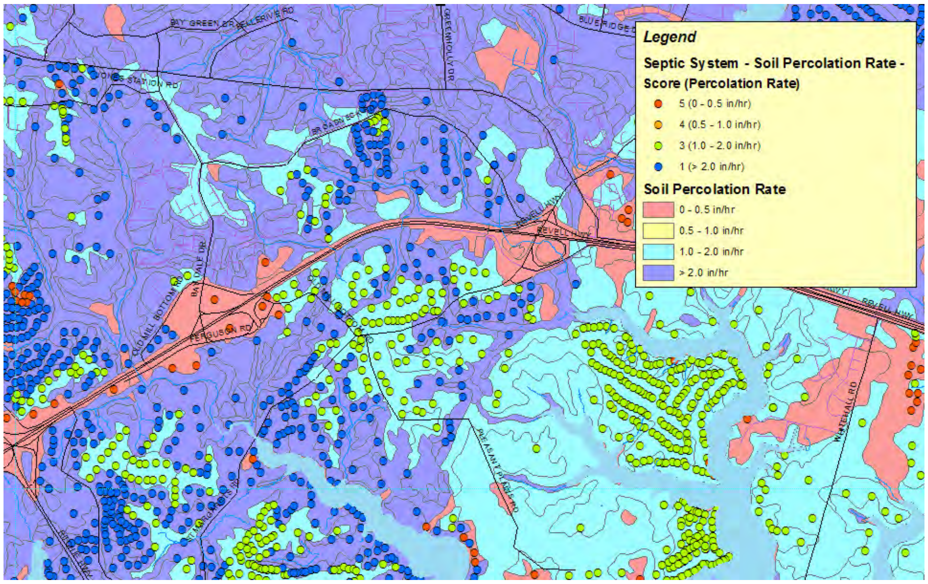


FIGURE 15. OSDS CATEGORIZED BY SOIL PERCOLATION RATE (SAMPLE DATA).

Distance to Well Head Protection Areas (WHPA): Semi-Confined and Confined, and Aquifer Recharge Areas

County staff ranked the location relative to wellhead protection areas (WHPA) and aquifer recharge areas as the eighth most significant criterion in terms of potential environmental benefit, because pollutant load from OSDS in these areas represents a higher risk of contamination of the County's groundwater-based drinking water supply. The 10-year time of travel WHPA derived by the Maryland Department of the Environment was used for this analysis, along with the County's delineated deep aquifer recharge area.

Figure 16 shows the frequency distribution and cumulative distribution of OSDS as a function of distance from WHPAs and aquifer recharge areas. Note that the data are tabulated in order of precedence, with location in a semi-confined WHPA being listed before a confined WHPA and that before location in a recharge area; in other words, a OSDS located in a semi-confined WHPA may also be in the deep aquifer recharge area. Figure 17 shows a detailed view of OSDS as a function of location in WHPAs and recharge areas, with OSDS categorized per the scoring system in Table 6. Attachment F tabulates the frequency distribution data shown in Figure 16. Forty-one percent of OSDS are outside any WHPA or aquifer recharge area; however, 4 percent of OSDS are in the semi-confined WHPA and 4 percent are in the confined WHPA, and 51 percent are in the aquifer recharge area.

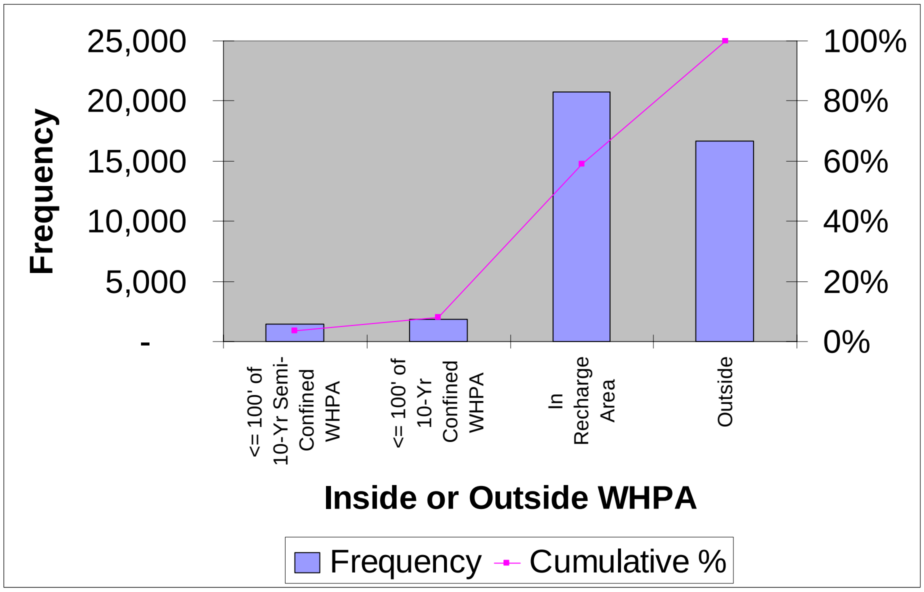


FIGURE 16. FREQUENCY DISTRIBUTION OF OSDS BY LOCATION IN WELLHEAD PROTECTION AREAS AND RECHARGE AREAS.

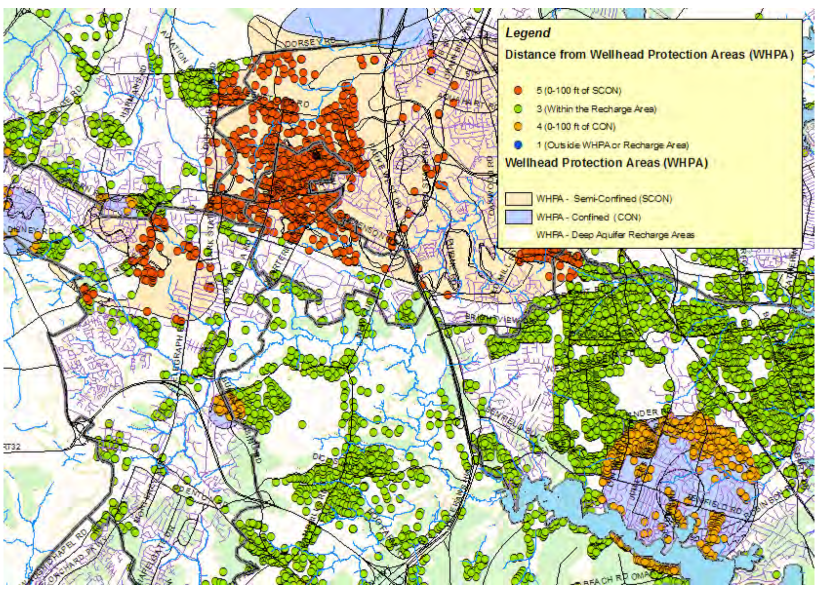


FIGURE 17. OSDS CATEGORIZED BY LOCATION IN WELLHEAD PROTECTION AREAS AND RECHARGE AREAS (SAMPLE DATA).

Prioritization

As discussed previously, four different prioritization schemes were considered to rank each of the 40,684 OSDS in the Anne Arundel County OSDS database. Only the last approach based on three criteria (distance to water, Critical Area and slope) is presented below. Attachment C presents a sensitivity analysis comparing all four prioritization schemes and Attachment D presents the initial prioritization that factored in all eight evaluation criteria.

Each of the OSDS in the County database was scored against each of the three evaluation criteria, and those scores were weighted based on the criteria weights assigned by County staff. This resulted in a single prioritization score being assigned to each OSDS countywide. The priority score is also referred to as a benefit score because the higher the score, the higher the benefit that would result from environmental mitigation. That priority score was normalized to a range from 1 to 5 to facilitate comparison to individual criteria scores (see Figure 18). That score was also normalized to a range from 1 to 100 to provide for more discretization of the relative priority rank (see Figure 19). This different presentation emphasizes that the scores should be used as a relative rank and not an absolute measure of environmental impact. Attachment F tabulates the frequency distribution data shown in Figures 18 and 19:

Figure 20 shows the priority rank of OSDS spatially throughout the County.

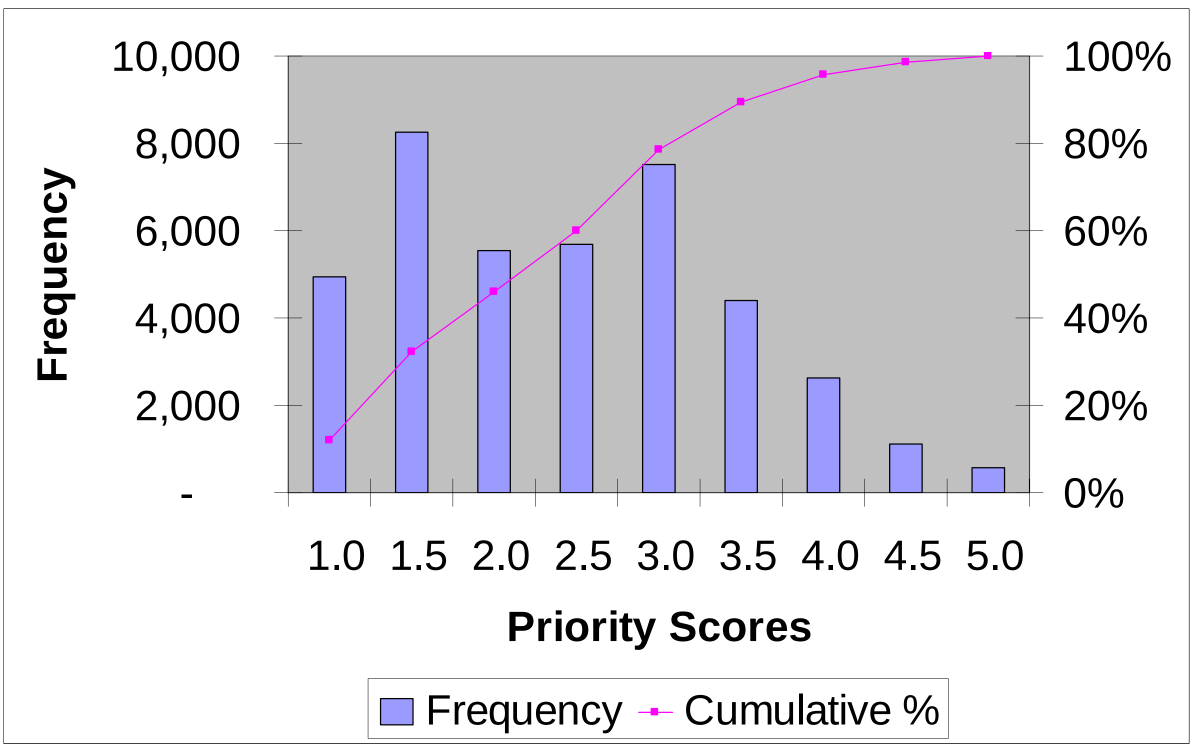


FIGURE 18. FREQUENCY DISTRIBUTION OF OSDS BY WEIGHTED PRIORITY SCORE, NORMALIZED TO A RANGE FROM 1 TO 5.

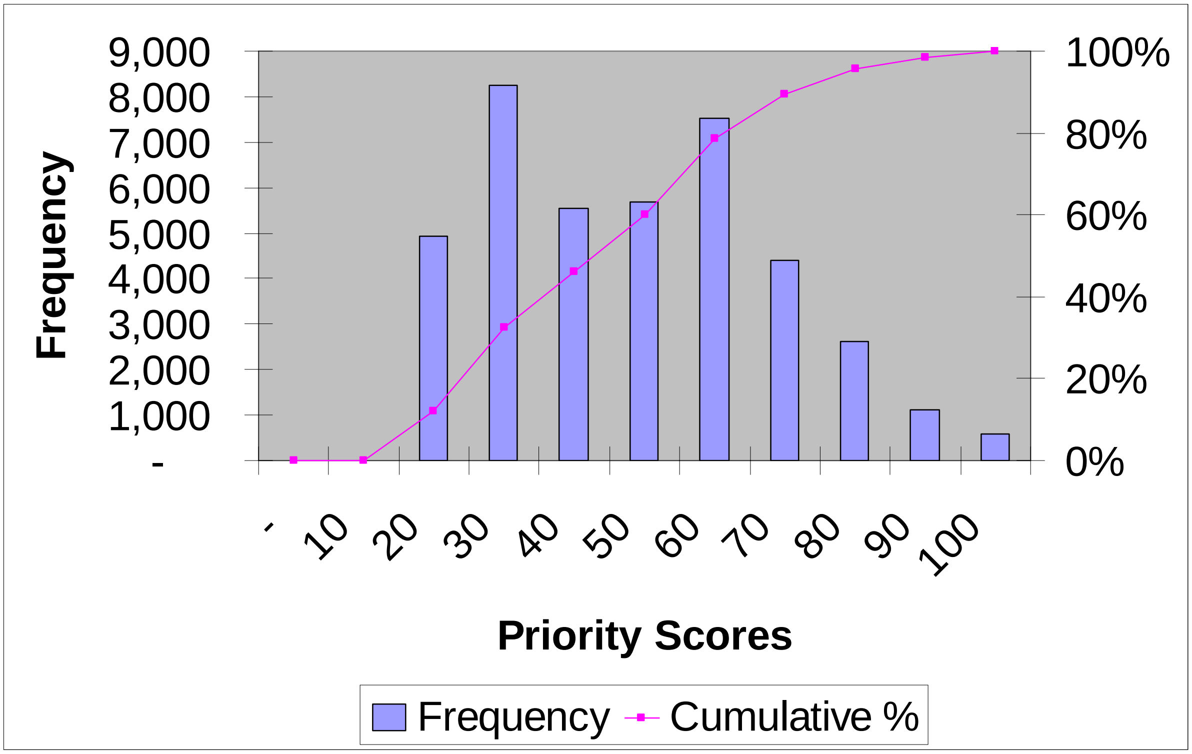
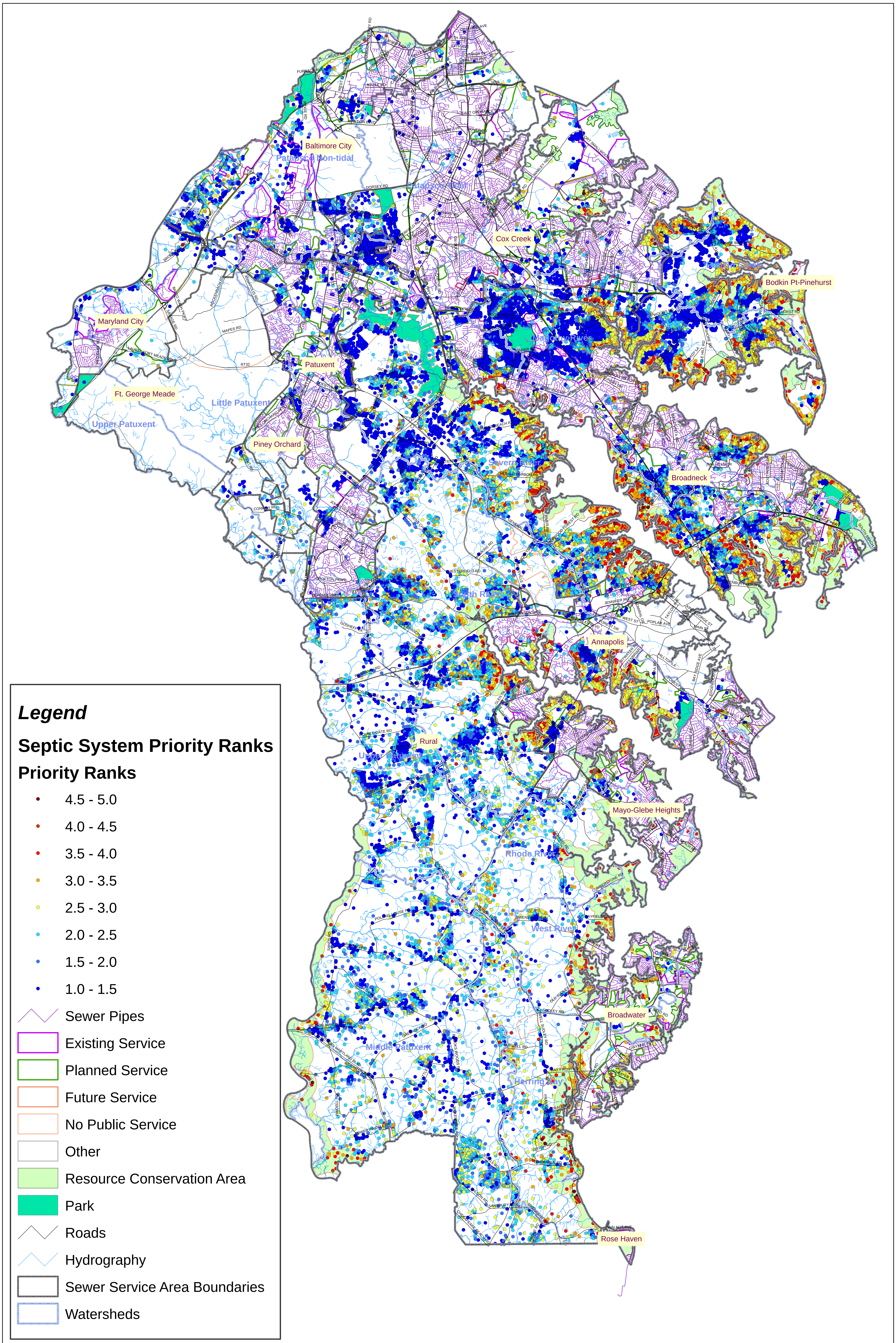


FIGURE 19. FREQUENCY DISTRIBUTION OF OSDS BY WEIGHTED PRIORITY SCORE, NORMALIZED TO A RANGE FROM 1 TO 100.

It should be noted that the priority score has the strength of integrating multiple criteria. But because there are multiple criteria, a given group of OSDS may have a low total priority score if it scores high in only 1 or two criteria and low in others. This is especially true of OSDS that rank low relative to highly-weighted criteria such as those that are not in the Health Department Problem Areas or near bogs or in the Critical Areas, but perhaps ought to be high priority due to proximity to non-tidal surface waters, steep slopes, low percolation rate soils and/or high groundwater, all of which are likely to contribute to high nutrient loads being discharged to receiving waters. For example, a system that scores a 5 for proximity to water (0-100 ft), a 4 for steep slope (15-25 percent) and a 1 for all other criteria would get a weighted total priority score of 2.1. This score would put it on the low end of the priority rank and is typical of many systems in the headwaters of Mill Creek on the ridgeline between the Magothy and Severn River. However, these systems probably contribute similar nutrient loads to other systems near the water, but they are closer to existing sewer lines and are probably easier to hook up to sewer than systems closer to the tidal waters edge. Therefore, while the overall prioritization score is a useful indicator of overall priority, it may not be the best indicator of project rank based on a cost/benefit analysis of potential for nitrogen load reduction. Further evaluation is needed, factoring in cost and projected nutrient load.



0 2 Miles

N

Figure 20. Septic System Priority Ranks Based on Three Criteria (Distance to Surface Water, Distance to Chesapeake Critical Area, and Slope)
Anne Arundel County
Maryland

CH2MHILL

January 04, 2006

Categorization of Prioritized Systems Based Potential Alternatives

The ultimate goal of this evaluation is to determine the priority for mitigating pollutant load from OSDS, and for those priority systems to determine what is the most feasible and cost-effective alternative based on potential for four categories of alternatives that either provide:

- sewer service
- cluster-type of community sewer service
- enhanced nitrogen removal OSDS upgrades
- no action: remain on existing septic system

To help identify opportunities for these alternatives, the prioritized OSDS were further categorized based on:

- Planned Sewer Service Type, which indicates areas that fit within the County's current long-range plans for public sewer service
- Proximity to Sewer, which indicates areas that are reasonably close to existing sewer service
- Density, which indicates areas of higher density that might be able to be clustered with a small community sewer service system

As shown earlier in Table 3, about 40 percent of all OSDS are in areas of existing, planned, or future sewer service. Table 7 below shows the breakdown of OSDS by priority category, based on planned sewer service type. Looking at OSDS with scores over 2.5 illustrates that about 40 percent are in this higher-priority ranking, based on three evaluation criteria. However, only 12 percent of OSDS in this higher priority are in areas of existing, planned, or future sewer service.

Figure 21 shows the distribution of OSDS based on distance from the existing sewer system, for all OSDS regardless of location relative to areas planned for future sewer service. Attachment F tabulates the data shown in Figure 21—32 percent of all OSDS are within 2,000 ft of the existing sewer system. Table 8 shows a further breakdown based on proximity to the existing sewer system, for those OSDS in areas of existing, planned, or future sewer service.

TABLE 7
Priority OSDS Categorized by Planned Sewer Service Type
Anne Arundel County Septic Evaluation Study

Priority Score Category	Existing Service	Planned Service	Future Service	No Public Service	Resource Conservation Area	Park	Other	Grand Total
1.0-1.5	752	3483	2912	5960	71	4	4	13186
1.5-2.0	207	707	1096	3524	6	4	2	5546
2.0-2.5	325	608	973	3760	15	5	10	5696
2.5-3.0	338	449	1497	4812	300	5	2	7403
3.0-3.5	115	262	916	2716	372	2		4383
3.5-4.0	60	74	411	1193	478	2		2218
4.0-4.5	74	78	362	817	203			1534
4.5-5.0	10	15	155	259	139			578
Grand Total	1881	5676	8322	23041	1584	22	18	40544

TABLE 8
Priority OSDS Categorized by Proximity to the Existing Sewer System (Distance in ft), within Areas of Planned Sewer Service
Anne Arundel County Septic Evaluation Study

	Existing Service					Existing Service Total	Planned Service						Planned Service Total	Future Service						Future Service Total	Grand Total
Priority Score Category	0-500 ft	500-1000 ft	1000-1500 ft	1500-2000 ft	2000-5000 ft		0-500 ft	500-1000 ft	1000-1500 ft	1500-2000 ft	2000-5000 ft	>5000 ft		0-500 ft	500-1000 ft	1000-1500 ft	1500-2000 ft	2000-5000 ft	>5000 ft		
1.0-1.5	657	85	7	3		752	983	1118	509	284	560	29	3483	152	352	436	507	1280	185	2912	7147
1.5-2.0	181	24	2			207	206	225	116	57	96	7	707	61	110	193	154	507	71	1096	2010
2.0-2.5	292	30	2		1	325	189	199	97	43	74	6	608	62	129	119	161	418	84	973	1906
2.5-3.0	317	20			1	338	157	114	81	38	55	4	449	51	176	192	171	815	92	1497	2284
3.0-3.5	99	16				115	68	113	58	14	8	1	262	16	130	148	111	427	84	916	1293
3.5-4.0	52	8				60	24	33	12	3	1	1	74	7	31	38	38	208	89	411	545
4.0-4.5	63	11				74	41	29	8				78	5	40	42	37	158	80	362	514
4.5-5.0	9	1				10	4	9	2				15	4	9	22	21	61	38	155	180
Grand Total	1670	195	11	3	2	1881	1672	1840	883	439	794	48	5676	358	977	1190	1200	3874	723	8322	15879

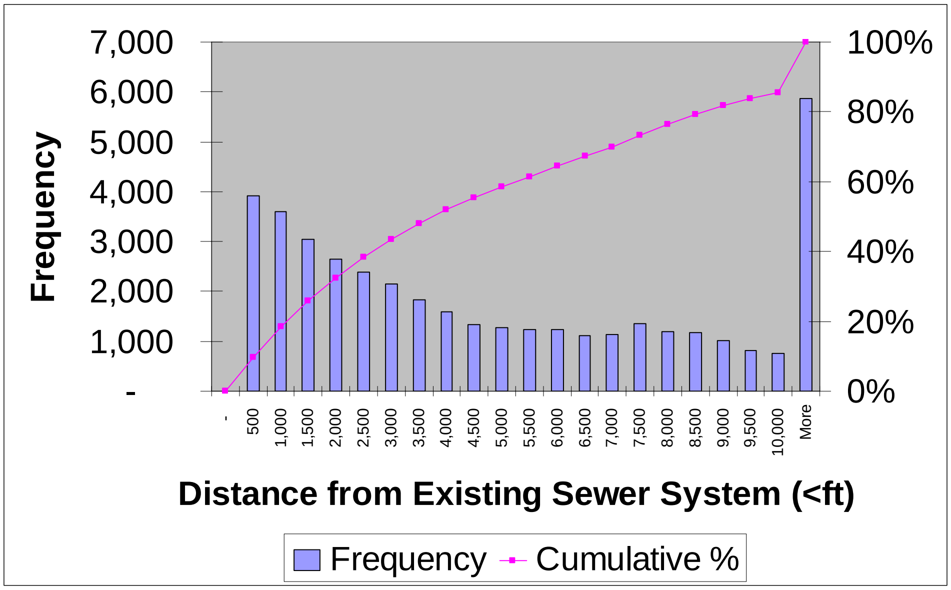


FIGURE 21. FREQUENCY DISTRIBUTION OF OSDS BY DISTANCE FROM EXISTING SEWER SYSTEM.

Figure 22 shows the distribution of OSDS based on density, for all OSDS regardless of location in areas planned for future sewer service. Figure 23 shows a countywide view of OSDS density, with the same density categories as shown in Figure 22. Attachment F tabulates the data shown in Figure 22—17 percent of all OSDS are in areas with a density of at least 1 OSDS per acre, and an additional 31 percent are in areas with a density of between 0.5 and 1 OSDS per acre. Table 9 shows the breakdown of OSDS by priority category, based on density. About 40 percent of all OSDS have priority scores over 2.5. However, 9,147 OSDS that are in this higher priority (23 percent of all systems) are in areas of density of at least 0.5 OSDS per acre, and 3,309 (8 percent of all systems) are in areas of higher density of at least 1 OSDS per acre.

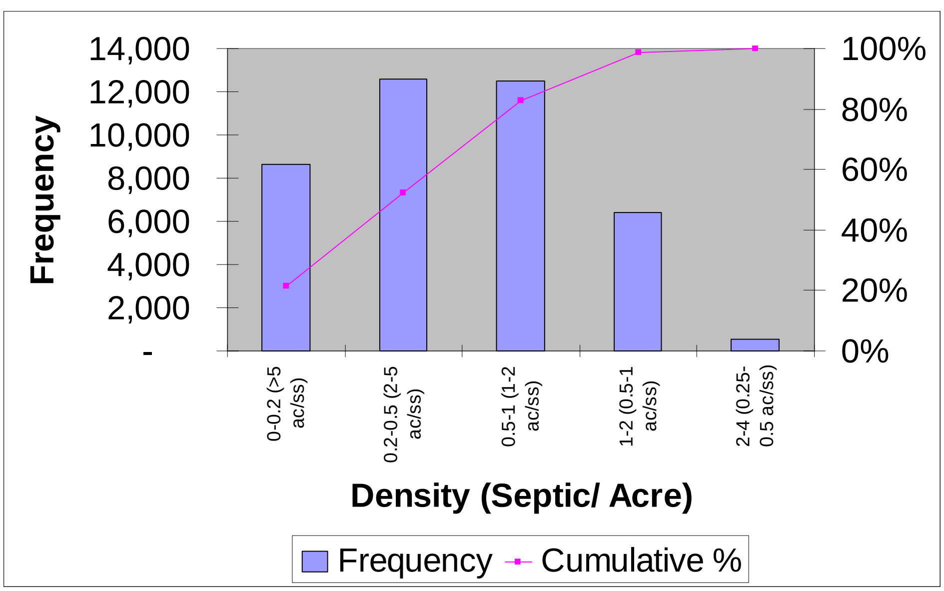


FIGURE 22. FREQUENCY DISTRIBUTION OF OSDS BY DENSITY.

TABLE 9
Priority OSDS Categorized by Density
Anne Arundel County Septic Evaluation Study

	Density (Acres/Septic System)					
	>5	2 to 5	1 to 2	0.5 to 1	0.25-0.5	
	Density (OSDS/Acre)					
Priority Score Category	**0-0.2**	**0.2-0.5**	**0.5-1**	**1-2**	**2-4**	**Grand Total**
1.0-1.5	2789	4149	4017	2231		13186
1.5-2.0	1463	1842	1307	451	483	5546
2.0-2.5	1697	2270	1272	456	1	5696
2.5-3.0	1248	1774	2406	1928	47	7403
3.0-3.5	719	1280	1699	685		4383
3.5-4.0	416	610	875	316	1	2218
4.0-4.5	235	427	615	257		1534
4.5-5.0	74	186	243	75		578
Grand Total	8641	12538	12434	6399	532	40544

A more detailed alternatives analysis will be conducted when cost data are assigned to different alternatives and priority systems. This will be addressed in a later report.

Figure 23. Septic System Density
Anne Arundel County
Maryland

CH2MHILL

August 15, 2006

Load Calculations

Total Nitrogen Load Assumptions and Sensitivity Analysis

Total nitrogen (TN) load calculations were done for all OSDS countywide. Variables used in the computation include:

- TN load per person from septic leach field (lb/day)
- Persons per dwelling unit (persons/edu)
- Nonresidential flow rate (gpd/acct)
- TN from nonresidential septic leach field (mg/L)
- TN for denitrifying onsite sewage disposal systems (OSDS) (mg/L)
- TN for sewer connection (mg/L)
- Delivery ratio, as a function of distance from the OSDS to the waters edge (%)

Several different scenarios were developed to show the sensitivity of the pollutant load to different assumptions for the input variables. Table 10 shows the values assumed for the base case and the different scenarios.

The TN load per person from conventional OSDS, 9.5 pounds per year, is the value suggested by MDE in *Maryland's 2006 TMDL Implementation Guidance for Local Governments* (MDE, 2006). This equates to a concentration of 40 mg/L at a flow rate of 78 gallons per person per day. All cases presented in Table 10 are with the person load at 9.5 lb/yr, except Case 2, which increases it to 11.9 lb/yr and is equivalent to a concentration of 50 mg/L, the high of the range suggested by MDE.

Persons per household numbers, 2.60, were derived from the census data for Anne Arundel County, reported by the Maryland Department of Planning (http://www.mdp.state.md.us/msdc/dw_popproj.htm). These were held constant for all scenarios.

Residential flow rates are not used in the computations; instead, total loads per person are used, as suggested by MDE during a meeting on August 3, 2006. However, residential flow rates that correspond to those loads are back calculated based on assumed concentrations. For most cases, the residential flow rate is 202.8 gpd. County planning guidance suggests using a flow rate of 250 gpd. Using billing records for OSDS on public water supply in the county CPF database indicates an average water consumption of 177 gpd for the 827 households assumed to be on public water supply (all those with non-zero water consumption in the billing records). Because load was computed directly from load per person, residential flow rates did not enter into the calculation.

Nonresidential flow rates were assumed to be 1,300 gpd per account, based on County recommended flow factors. These were held constant for all scenarios in Table 10, except Case 1, where nonresidential flows were set to 202.8 gpd to equate to residential flows. This resulted in a reduction of the total load by about 38 percent, which shows that more than a third of the load from OSDS is from nonresidential systems.

TABLE 10
Total Nitrogen Load Assumptions and Sensitivity Analysis
Anne Arundel County Septic Evaluation Study

	Base Case	Case 1	Case 2	Case 3	Case 4	Case 5
TN Load per person for conventional OSDS (lb/cap/yr)	9.5	9.5	11.9	9.5	9.5	9.5
Persons/household (cap/edu)	2.6	2.6	2.6	2.6	2.6	2.6
Residential Flow Rate (gpd/edu)	202.8	202.8	202.8	202.8	202.8	202.8
Nonresidential Flow Rate (gpd/acct)	1300	202.8	1300	1300	1300	1300
TN from Septic Leach Field for conventional OSDS (mg/L)	40	40	50	40	40	40
TN Load per person for denitrifying OSDS (lb/cap/yr)	4.8	4.8	4.8	4.8	4.8	4.8
TN for denitrifying OSDS (mg/L)	20	20	20	20	20	20
TN load per person for sewer connection (lb/cap/yr)	0.71	0.71	0.71	0.71	0.71	0.71
TN for sewer connection (mg/L)	3	3	3	3	3	3
Distance to Water (ft)	**Delivery Ratio Assumption (%)**					
0	100%	100%	100%	100%	60%	40%
100	95%	95%	95%	75%	60%	40%
200	90%	90%	90%	50%	60%	40%
300	85%	85%	85%	25%	60%	40%
400	80%	80%	80%	0%	60%	40%
500	75%	75%	75%	0%	60%	40%
600	70%	70%	70%	0%	60%	40%
700	65%	65%	65%	0%	60%	40%
800	60%	60%	60%	0%	60%	40%
900	55%	55%	55%	0%	60%	40%
1000	50%	50%	50%	0%	60%	40%
5000	40%	40%	40%	0%	60%	40%
>5000	40%	40%	40%	0%	60%	40%
TN (lb/yr)	**1,241,400**	**775,837**	**1,553,565**	**458,585**	**959,002**	**639,335**

Using billing records for OSDS on public water supply in the county CPF database indicates an average water consumption of 2,157 gpd for the 51 nonresidential accounts assumed to be on public water supply (all those with non-zero water consumption in the billing records). This value was not used in the load computation because there are 4,434 nonresidential accounts and a sample size of 51 properties was not considered adequate to extrapolate to all nonresidential properties.

Total nitrogen load per capita for denitrifying systems was derived by assuming a concentration of 20 mg/L as recommended by MDE.

Total nitrogen load per capita for hooking up to sewer was derived by assuming a concentration of 3 mg/L as recommended by MDE for enhanced nutrient removal level of wastewater treatment.

Delivery ratios reflect the fraction of TN that is delivered to receiving waters. These are impacted by many variables, complexities of different soils, distances of systems to the nearest water body, plant uptake, and depth to the saturation zone. MDE's Total Maximum Daily Load (TMDL) guidance suggests an average delivery ratio of 60 percent, which was used in Case 4. The Chesapeake Bay Program model reportedly used an average delivery ratio of 40 percent, which was used in Case 5. Most nitrogen from OSDS moves through the groundwater in the form of nitrate. The Chesapeake Bay Program has summarized the literature on nitrate removal from shallow groundwater in Water Quality Functions of Riparian Forest Buffer Systems in the Chesapeake Bay Watershed (EPA, 1995). Studies show a wide range of delivery ratios from 75 to 10 percent. Therefore, the Base Case and Cases 1 and 2 all have delivery ratios varying from 100 percent at the water's edge to 40 percent for those systems 5000 ft away. Case 3 limits delivery to only those systems within 300 ft of the waters edge. This scenario results in the lowest TN load estimate of all scenarios, followed by the scenario with all delivery ratios set at 40 percent, which reflects the critical importance of understanding transport and uptake mechanisms for nitrogen. However, even with the most conservative assumptions in Case 3, the total nitrogen load from OSDS is similar to the total load from the County's six largest wastewater plants at ENR limits: 516,000 lb/yr (Stearns & Wheler, 2006).

Total Nitrogen Load Results by Watershed, SSA, Planned Sewer Service Type and Priority Score

Figures 24, 25, 26 and 27 show the variation in TN load for the base case as a function of watershed, sewer service area, planned sewer service type, and priority score, respectively. Tables 11, 12, 13, and 14 tabulate this same information. The majority of the load is in the Severn, Magothy and South River watersheds, which represent 60 percent of the total load (see Figure 24 and Table 11). The rural SSA contains the largest fraction (56 percent) of the TN load (see Figure 25 and Table 12), because it has no planned sewer service. That is followed by the Broadneck SSA at 19 percent. In terms of the County's planned areas of sewer service, the largest fraction of TN load is in the area with no planned sewer service (56 percent), but the TN load of OSDS in areas of existing, planned or future service is substantial at 37 percent (see Figure 26 and Table 13). Lastly, the priority scores over 2.5 represent only 16 percent of total load; therefore, to achieve reductions greater than 16 percent, OSDS with scores under 2.5 should be targeted. Forty-one percent of total load is associated with systems with scores over 2.0.

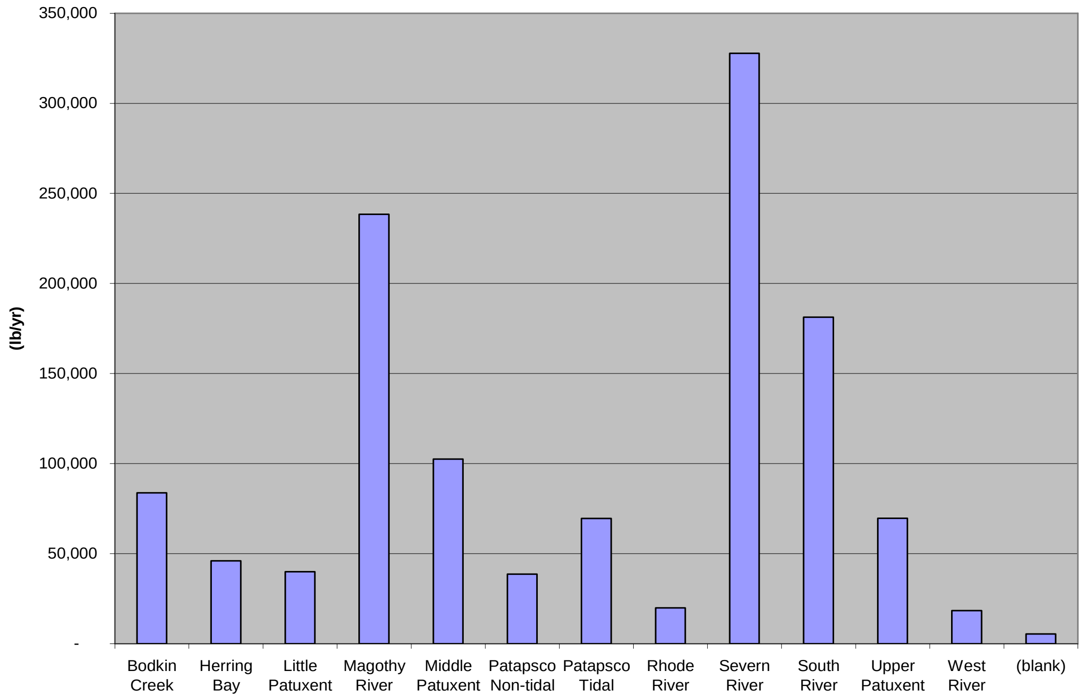


FIGURE 24. TOTAL NITROGEN DELIVERED FROM OSDS TO RECEIVING WATERS, BY WATERSHED.

TABLE 11
Total Nitrogen Delivered from OSDS to Receiving Waters, by Watershed
Anne Arundel County Septic Evaluation Study

WATERSHED	Total Nitrogen (lb/yr)	Percent
Bodkin Creek	83,764	6.7%
Herring Bay	45,987	3.7%
Little Patuxent	39,987	3.2%
Magothy River	238,468	19.2%
Middle Patuxent	102,514	8.3%
Patapsco Non-tidal	38,657	3.1%
Patapsco Tidal	69,543	5.6%
Rhode River	19,867	1.6%
Severn River	327,783	26.4%
South River	181,314	14.6%
Upper Patuxent	69,660	5.6%
West River	18,420	1.5%
(blank)	5,436	0.4%
Grand Total	1,241,400	100.0%

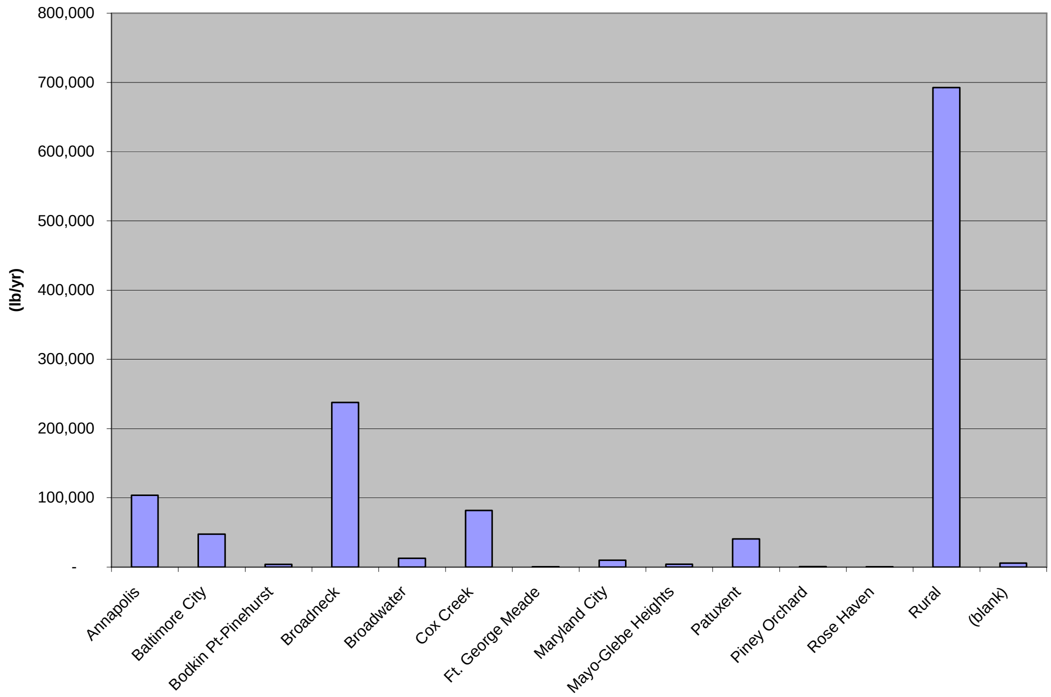


FIGURE 25. TOTAL NITROGEN DELIVERED FROM OSDS TO RECEIVING WATERS, BY SEWER SERVICE AREA

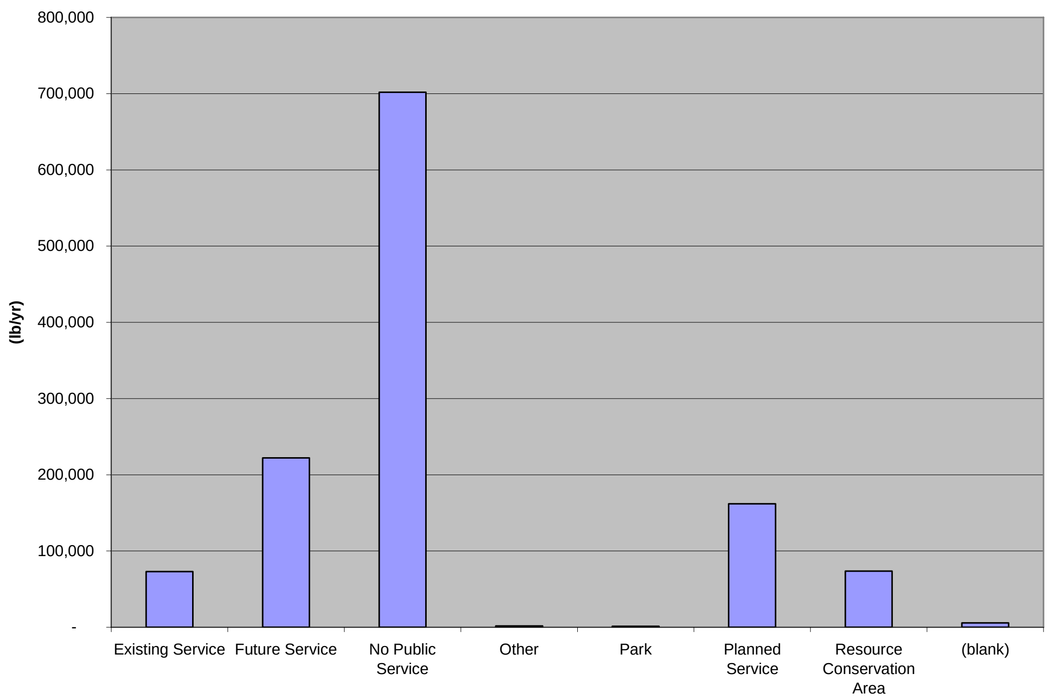


FIGURE 26. TOTAL NITROGEN DELIVERED FROM OSDS TO RECEIVING WATERS, BY SEWER SERVICE TYPE

TABLE 12
Total Nitrogen Delivered from OSDS to Receiving Waters, by Sewer Service Area
Anne Arundel County Septic Evaluation Study

Sewer Service Area	Total Nitrogen (lb/yr)	Percent
Annapolis	103,680	8.4%
Baltimore City	47,479	3.8%
Bodkin Pt-Pinehurst	3,936	0.3%
Broadneck	237,784	19.2%
Broadwater	12,633	1.0%
Cox Creek	81,903	6.6%
Ft. George Meade	198	0.0%
Maryland City	9,917	0.8%
Mayo-Glebe Heights	4,116	0.3%
Patuxent	40,485	3.3%
Piney Orchard	670	0.1%
Rose Haven	205	0.0%
Rural	692,544	55.8%
(blank)	5,850	0.5%
Grand Total	1,241,400	100.0%

TABLE 13
Total Nitrogen Delivered from OSDS to Receiving Waters, by Planned Sewer Service Type
Anne Arundel County Septic Evaluation Study

Planned Sewer Service Type	Total Nitrogen (lb/yr)	Percent
Existing Service	72,998	5.9%
Future Service	222,197	17.9%
No Public Service	701,870	56.5%
Other	1,833	0.1%
Park	1,354	0.1%
Planned Service	161,875	13.0%
Resource Conservation Area	73,472	5.9%
(blank)	5,801	0.5%
Grand Total	1,241,400	100.0%

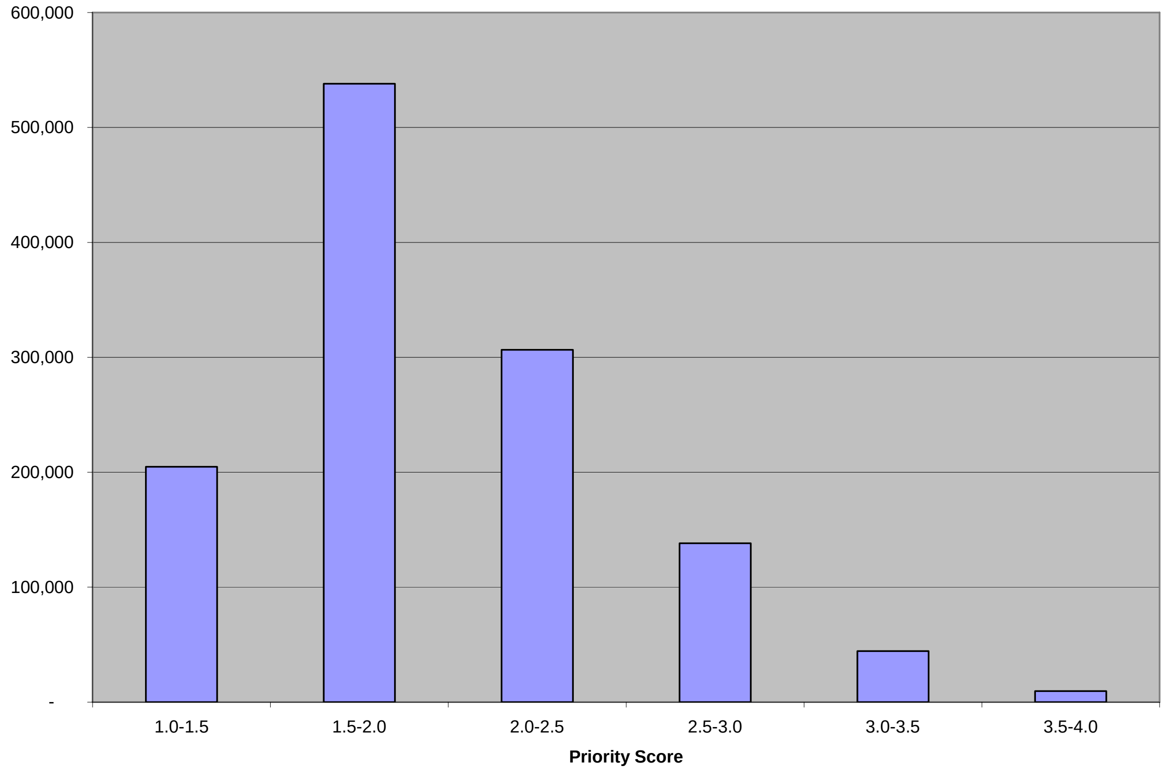


FIGURE 27. TOTAL NITROGEN DELIVERED FROM OSDS TO RECEIVING WATERS, BY PRIORITY SCORE

TABLE 14
Total Nitrogen Delivered from OSDS to Receiving Waters, by Priority Score
Anne Arundel County Septic Evaluation Study

Priority Score Category	Total Nitrogen (lb/yr)	Percent
1.0-1.5	320,948	26%
1.5-2.0	179,511	14%
2.0-2.5	226,295	18%
2.5-3.0	222,946	18%
3.0-3.5	142,301	11%
3.5-4.0	79,380	6%
4.0-4.5	49,822	4%
4.5-5.0	20,198	2%
Grand Total	1,241,400	100%

Potential for Obtaining Nitrogen Credits from Septic System Connections to Sewer

Under Maryland's nutrient management cap strategy, MDE is considering allowing increases in the annual nitrogen wasteload allocations of wastewater treatment plants when OSDS are converted to sewered connections. Maryland's 2006 TMDL Implementation Guidance for Local Governments (MDE, 2006) presents this as a way to accommodate new development and envisions that developers would fund the connection of OSDS to wastewater treatment plants that have been upgraded to Enhanced Nutrient Removal levels. While this could very well be a common scenario, county and local governments could have a variety of incentives for seeking the hookup of OSDS, among them public health issues and local water-quality improvement. Such hookups should also generate credits, so any program for granting credits for septic hookups should not necessarily be restricted to developers.

The TMDL guidance document goes on to state that "the pound loadings involved in septic connections are not particularly large, current estimates are that about one new residential unit could be justified for every two units that are connected" (p. 4-20). It also states that uncertainty should be accounted for in calculating the credits, and that some of the reduction should be applied to existing impairments.

Another section of the TMDL Guidance presents a calculation of a statewide average annual nitrogen load delivered to surface water per OSDS (p. 5-13). The calculation is based on the following assumptions:

- 9.5 lbs/yr/person/household nitrogen delivered to the septic drain field
- 2.6 people/household or equivalent dwelling unit (EDU)
- 40% loss of nitrogen during transport from the septic field to the surface water (a 0.60 delivery factor)

Hence, MDE has calculated the statewide average annual nitrogen load to surface water per OSDS as:

$$2.6 \times 9.5 \times 0.6 = 14.8 \text{ lbs}$$

Based on the analysis of the Anne Arundel County septic loading rates presented above, this number may be low. The Base Case, as described in Table 10, is probably the one that comes closest to estimating actual conditions. It assumes 2.6 people per household, the Anne Arundel County average (and also coincidentally equal to the statewide average used in the TMDL Guidance document calculation); a per capita wastewater flow rate of 78 gpd (also consistent with MDE assumptions); and a septic effluent concentration of 40 mg/L, a number provided by MDE as typical in Maryland. Table 11 presents the calculated countywide average annual nitrogen load per Anne Arundel County OSDS for the Base Case, as well as the other cases. The annual average nitrogen load delivered to surface waters is 30.5 pounds, more than twice the 14.8 lbs calculated by the TMDL Guidance document. Further, if an Anne Arundel County OSDS were connected to sewer and the flow treated at an ENR facility, the annual load to surface waters from the EDU would drop to 2.9 pounds per year, a reduction of 27.6 pounds.

TABLE 11
Average Total Nitrogen Load Delivered Per Septic System, Compared to Denitrifying Systems and Load When Connected to Sewer
Anne Arundel County Septic Evaluation Study

	Base Case	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**
TN (lb/yr)	1,241,400	775,837	1,553,565	458,585	959,002	639,335
Delivered Load to Receiving Waters per Septic System (lb/yr)	30.5	19.1	38.2	11.3	23.6	15.7
Delivered Load per OSDS converted to denitrification (lb/yr)	15.3	9.6	15.3	5.7	11.9	7.9
Load per OSDS connected to sewer (lb/yr)	2.9	1.8	2.9	2.9	2.9	2.9
Load Reduction beyond tributary strategy requirement, per system connected to sewer (lb/yr)	12.4	7.8	12.4	2.7	8.9	5.0

Assuming the 27.6 pounds per year result is accurate, the question becomes how much of this load reduction should the wastewater treatment plant receive as a credit to be used to increase its annual nitrogen load limit, and how many new EDUs could then be built in the facilities service area? One EDU per two septic hookups, as proposed by the TMDL Guidance, is unnecessarily low.

The last row of Table 11 contains the results of a calculation that assumes that part of the reduction goes to meeting tributary strategy requirements for OSDS nitrogen load reductions. This is based on Maryland's tributary strategies call for upgrading all OSDS to denitrifying ones with average effluent nitrogen concentrations of 20 mg/L. This results in a delivered load of 15.3 pounds per year per system with the assumptions in the Base Case. The reduction from 30.5 to 15.3 pounds per year is dedicated to achieving tributary strategy goals. Under this approach, the amount subject to credit is then the difference between 15.3 and 2.9 pounds per year, or the 12.4 pounds shown in the last line of the table.

This analysis also suggests that extending sewer lines and connecting OSDS may be a substantially more cost-effective method of reducing septic nitrogen loads to surface waters than the OSDS conversion to denitrifying systems that is called for by the Tributary Strategies. This illustrates the possible value in allowing the use of Restoration Fund grant money to extend sewer lines and connecting OSDS. This is among the many policy questions that should be addressed by the state and Anne Arundel County as the OSDS program is implemented. At the same time, additional work is needed to provide a sound scientific basis for establishing a OSDS hookup credit. Improving the understanding of delivery ratios, in particular, is of great importance.

References

Maryland Department of the Environment, 2006. *Maryland's 2006 TMDL Implementation Guidance for Local Governments*. Baltimore, Md. Available at: http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/TMDL_implementation_2006_guidance_document.asp. Last accessed August 10, 2006.

Stearns & Wheler. *Development of Wastewater Treatment Alternatives and Cost Estimates to Meet Projected 2030 Flows*. Draft Memorandum. July 12, 2006.

U.S. Environmental Protection Agency, *Water Quality Functions of Riparian Forest Buffer Systems in the Chesapeake Bay Watershed*. Prepared by the Nutrient Subcommittee of the Chesapeake Bay Program. EPA 903-R-95-004. August 1995.

Attachment A – Inventory of OSDS, by Watershed, Sewer Service Area, Planned Sewer Service Type, and Health Department Problem Area

Inventory and Existing Total Nitrogen Load of OSDS, by Watershed, Sewer Service Area, Planned Sewer Service Type including Health Department Problem Area Inventory

Watershed	SSA	Sewer_Type	Number of OSDS	TN Existing - All OSDS (lb/yr)	Number of OSDS within HDPA
Bodkin Creek	Bodkin Pt-Pinehurst	Existing Service	6	225	1
		No Public Service	114	2,787	114
		Planned Service	11	217	11
		Resource Conservation Area	9	178	7
	Bodkin Pt-Pinehurst Total		*140*	*3,408*	*133*
	Cox Creek	Existing Service	9	67	
		Planned Service	1	12	
	Cox Creek Total		*10*	*79*	
	Rural	No Public Service	2,752	57,010	974
		Resource Conservation Area	191	7,318	50
	Rural Total		*2,943*	*64,328*	*1,024*
Bodkin Creek Total			3,093	67,815	1,157
Herring Bay	Broadwater	Existing Service	23	853	
		Planned Service	145	5,155	121
		Resource Conservation Area	21	1,377	6
	Broadwater Total		*189*	*7,385*	*127*
	Rose Haven	Existing Service	4	186	
	Rose Haven Total		*4*	*186*	
	Rural	No Public Service	722	19,181	174
		Resource Conservation Area	125	6,640	59
	Rural Total		*847*	*25,822*	*233*
	(blank)	(blank)	1	12	
	(blank) Total		*1*	*12*	
Herring Bay Total			1,041	33,406	360
Little Patuxent	Baltimore City	Future Service	190	3,683	122
	Baltimore City Total		*190*	*3,683*	*122*
	Ft. George Meade	No Public Service	1	79	
	Ft. George Meade Total		*1*	*79*	
	Maryland City	Existing Service	2	87	
		Future Service	24	519	
		No Public Service	2	158	
		Other	6	408	
		Planned Service	108	4,165	19
	Maryland City Total		*142*	*5,338*	*19*
	Patuxent	Existing Service	72	2,187	
		No Public Service	1	7	
		Other	1	48	
		Planned Service	186	6,329	
	Patuxent Total		*260*	*8,571*	

Inventory and Existing Total Nitrogen Load of OSDS, by Watershed, Sewer Service Area, Planned Sewer Service Type including Health Department Problem Area Inventory

Watershed	SSA	Sewer_Type	Number of OSDS	TN Existing - All OSDS (lb/yr)	Number of OSDS within HDPA
	Piney Orchard	Existing Service	9	131	
		Planned Service	8	294	
	Piney Orchard Total		*17*	*426*	
	Rural	No Public Service	183	6,802	
	Rural Total		*183*	*6,802*	
Little Patuxent Total			793	24,899	141
Magothy River	Broadneck	Existing Service	357	8,174	1
		Future Service	2,878	52,255	202
		No Public Service	6	119	6
		Park	1	12	
		Planned Service	1,522	22,480	10
		Resource Conservation Area	41	1,452	15
	Broadneck Total		*4,805*	*84,492*	*234*
	Cox Creek	Existing Service	11	442	
		Future Service	1,023	19,053	500
		No Public Service	30	710	30
		Planned Service	21	851	
		Resource Conservation Area	29	1,749	
	Cox Creek Total		*1,118*	*22,804*	*530*
	Rural	Future Service	9	141	9
		No Public Service	3,572	66,118	1,028
		Resource Conservation Area	122	4,962	
	Rural Total		*3,703*	*71,221*	*1,037*
Magothy River Total			9,626	178,517	1,801
Middle Patuxent	Rural	No Public Service	2,155	59,574	
		Resource Conservation Area	51	3,865	
	Rural Total		*2,206*	*63,439*	
Middle Patuxent Total			2,206	63,439	
Patapsco Non-tidal	Baltimore City	Existing Service	131	3,537	
		Future Service	264	4,629	
		No Public Service	59	1,244	
		Park	7	153	
		Planned Service	645	14,257	
		Resource Conservation Area	8	645	
	Baltimore City Total		*1,114*	*24,465*	
	Cox Creek	Future Service	3	206	
	Cox Creek Total		*3*	*206*	
	Patuxent	Existing Service	1	12	
		Planned Service	2	87	
	Patuxent Total		*3*	*99*	

Inventory and Existing Total Nitrogen Load of OSDS, by Watershed, Sewer Service Area, Planned Sewer Service Type including Health Department Problem Area Inventory

Watershed	SSA	Sewer_Type	Number of OSDS	TN Existing - All OSDS (lb/yr)	Number of OSDS within HDPA
Patapsco Non-tidal Total			1,120	24,770	
Patapsco Tidal	Baltimore City	Existing Service	14	239	
		No Public Service	6	456	
		Other	1	79	
		Park	1	79	
		Planned Service	37	603	
		Resource Conservation Area	1	127	
	Baltimore City Total		*60*	*1,583*	
	Broadneck	Future Service	29	420	
		Planned Service	150	1,398	
	Broadneck Total		*179*	*1,818*	
	Cox Creek	Existing Service	283	6,308	3
		Future Service	447	9,204	41
		No Public Service	8	966	
		Planned Service	523	12,224	34
		Resource Conservation Area	88	5,874	75
	Cox Creek Total		*1,352*	*34,576*	*153*
	Rural	No Public Service	459	9,130	265
		Resource Conservation Area	113	2,852	13
	Rural Total		*572*	*11,982*	*278*
Patapsco Tidal Total			2,163	49,959	431
Rhode River	Mayo-Glebe Heights	Existing Service	14	510	
		Planned Service	15	357	
		Resource Conservation Area	5	633	
	Mayo-Glebe Heights Total		*34*	*1,501*	
	Rural	No Public Service	371	9,512	
		Planned Service	1	7	
		Resource Conservation Area	24	1,437	
	Rural Total		*396*	*10,956*	
Rhode River Total			430	12,457	
Severn River	Annapolis	Existing Service	125	3,841	
		Future Service	680	19,267	
		No Public Service	10	411	
		Planned Service	18	1,263	
		Resource Conservation Area	30	1,448	
	Annapolis Total		*863*	*26,231*	
	Baltimore City	Existing Service	5	52	
		Future Service	4	49	
		Planned Service	73	760	
	Baltimore City Total		*82*	*861*	

Inventory and Existing Total Nitrogen Load of OSDS, by Watershed, Sewer Service Area, Planned Sewer Service Type including Health Department Problem Area Inventory

Watershed	SSA	Sewer_Type	Number of OSDS	TN Existing - All OSDS (lb/yr)	Number of OSDS within HDPA
	Broadneck	Existing Service	170	3,854	
		Future Service	1.492	27,126	7
		No Public Service	1,566	29,237	181
		Planned Service	1,499	20,406	8
		Resource Conservation Area	240	7,165	14
	Broadneck Total		*4,967*	*87,788*	*210*
	Cox Creek	Existing Service	13	126	
		Future Service	8	89	
		Planned Service	9	215	
	Cox Creek Total		*30*	*430*	
	Patuxent	Existing Service	166	3,331	14
		Future Service	30	472	
		No Public Service	2	25	
		Other	4	116	
		Planned Service	326	6,083	
	Patuxent Total		*528*	*10,027*	*14*
	Rural	No Public Service	5,303	108,866	867
		Other	2	92	
		Park	11	470	
		Planned Service	1	7	
		Resource Conservation Area	134	4,247	66
	Rural Total		*5,451*	*113,682*	*933*
	(blank)	(blank)	5	329	
	(blank) Total		*5*	*329*	
Severn River Total			11,926	239,348	1,157
South River	Annapolis	Existing Service	344	10,277	
		Future Service	1,235	24,243	578
		No Public Service	305	5,972	58
		Planned Service	234	8,562	25
		Resource Conservation Area	218	6,233	4
	Annapolis Total		*2,336*	*55,286*	*665*
	Mayo-Glebe Heights	Existing Service	11	443	
		Planned Service	41	519	
		Resource Conservation Area	18	783	
	Mayo-Glebe Heights Total		*70*	*1,746*	
	Patuxent	Existing Service	1	79	
		Planned Service	10	257	
	Patuxent Total		*11*	*336*	
	Rural	Existing Service	1	12	
		No Public Service	3,620	67,631	55

Inventory and Existing Total Nitrogen Load of OSDS, by Watershed, Sewer Service Area, Planned Sewer Service Type including Health Department Problem Area Inventory

Watershed	SSA	Sewer_Type	Number of OSDS	TN Existing - All OSDS (lb/yr)	Number of OSDS within HDPA
		Other	4	317	
		Resource Conservation Area	29	2,343	
	Rural Total		*3,654*	*70,304*	*55*
	(blank)	No Public Service	1	20	
		(blank)	12	148	
	(blank) Total		*13*	*168*	
South River Total			6,084	127,840	720
Upper Patuxent	Ft. George Meade	Park	1	48	
	Ft. George Meade Total		*1*	*48*	
	Maryland City	Existing Service	8	433	
		No Public Service	1	79	
		Park	1	12	
		Planned Service	8	185	
	Maryland City Total		*18*	*709*	
	Patuxent	Existing Service	70	4,540	
		No Public Service	1	7	
		Planned Service	19	1,304	
	Patuxent Total		*90*	*5,852*	
	Rural	No Public Service	1,603	35,292	
		Resource Conservation Area	3	166	
	Rural Total		*1,606*	*35,459*	
Upper Patuxent Total			1,715	42,067	
West River	Broadwater	Existing Service	28	1,026	1
		Planned Service	63	1,663	
		Resource Conservation Area	11	752	
	Broadwater Total		*102*	*3,440*	*1*
	Rural	No Public Service	180	6,259	
		Resource Conservation Area	69	3,930	
	Rural Total		*249*	*10,189*	
West River Total			351	13,630	1
(blank)	Annapolis	Future Service	1	20	1
		Resource Conservation Area	1	20	1
	Annapolis Total		*2*	*40*	*2*
	Broadneck	Future Service	5	91	
		No Public Service	1	20	
	Broadneck Total		*6*	*111*	
	Rural	No Public Service	3	59	1
		Resource Conservation Area	2	206	2
	Rural Total		*5*	*265*	*3*
	(blank)	Resource Conservation Area	1	12	
		(blank)	120	2,425	
	(blank) Total		*121*	*2,437*	
(blank) Total			134	2,853	5
Grand Total			40,682	881,000	5,773

Attachment B – Evaluation Criteria Weights Assigned by Anne Arundel County Staff

Evaluation Criteria and Weights

6/15/2006

		Participant											
	Evaluation Criteria	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Average**	**Average Normalized**
1	Distance from Health Dept. Problem Areas (ft)	100	100	100	80	100	75	100	100	100	80	93.5	100
3	*Distance to Water (ft)*	50	100	100	100	100	100	70	100	100	80	90	96.3
2	*Distance from Chesapeake Critical Area (ft)*	100	80	70	90	70	50	100	50	100	100	81	86.6
7	*Depth to Groundwater (ft)*	30	50	50	20	80	10	70	100	100	80	59	63.1
5	*Distance from Bogs (ft)*	50	80	100	70	0	10	10	80	100	60	56	59.9
6	*Slope (%)*	50	80	20	60	40	25	50	50	75	40	49	52.4
8	*Low-end of Range of Soil Percolation Rates (in/hr)*	20	50	50	40	20	25	100	50	50	60	46.5	49.7
10	*Distance from Well Head Protection Areas (ft)*	80	50	30	40	60	80	50	50	0	20	46	49.2
9	*High-end of Range of Soil Percolation Rates (in/hr)*	20	50	50	40	20	25	10	50	100	60	42.5	45.5
	Distance to Wetlands						100					100	100
	Density of Systems						100					100	100

Criteria weights are from 0 to 100, 100 is most important. Scores do not have to add up to 100. Use relative values to assign relative importance. For example, assign all 100, if all equally important or 50 if half as important as a 100.

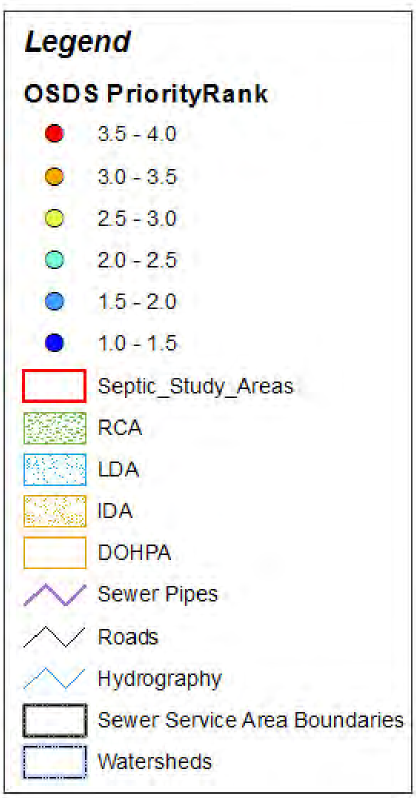
Attachment C – Sensitivity Analysis for Four Prioritization Schemes

The following pages show a sensitivity analysis comparing the total priority score computed for OSDS in seven different areas of Anne Arundel County based on 3, 4, 6 or 8 evaluation criteria, as listed in the following table.

TABLE C-1
Combinations of Evaluation Criteria Presented in Sensitivity Analysis
Anne Arundel County Septic Evaluation Study

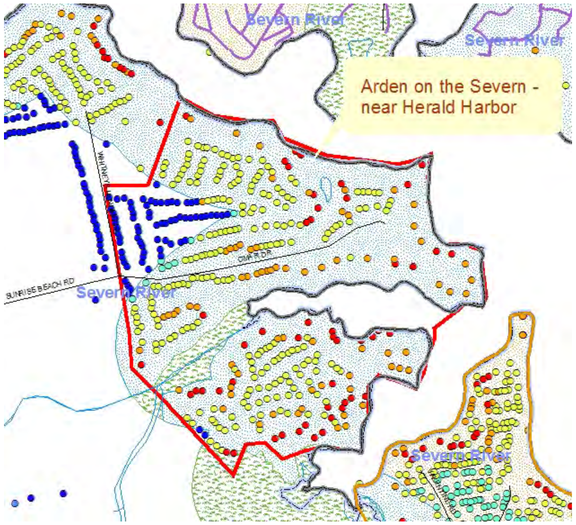
	Evaluation Criteria	Approach No. 4: Three Criteria	Approach No. 3: Four Criteria	Approach No. 2: Six Criteria	Approach No. 1: Eight Criteria
1	Distance from Health Dept. OSDS Problem Areas (ft)		√	√	√
2	Distance to (Surface) Water (ft)	√	√	√	√
3	Distance from Chesapeake Critical Area (ft)	√	√	√	√
4	Depth to Groundwater (ft)				√
5	Distance from Bogs (ft)			√	√
6	Slope (%)	√	√	√	√
7	Soil Percolation Rates (in/hr)				√
8	Distance from Well Head Protection Areas (ft)			√	√

The following legend applies to all the figures.

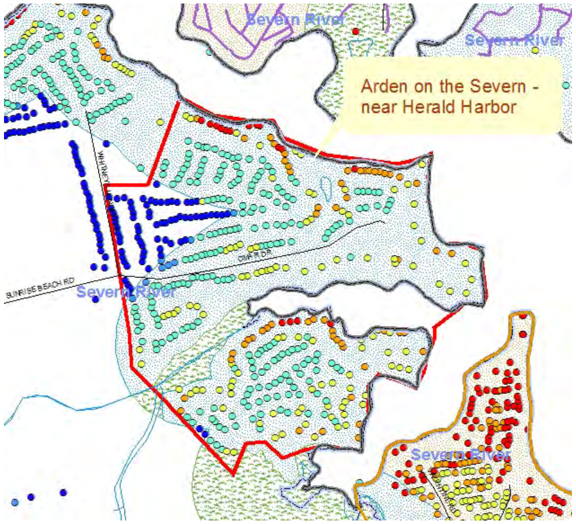


The following observations can be made based on review of the following figures:

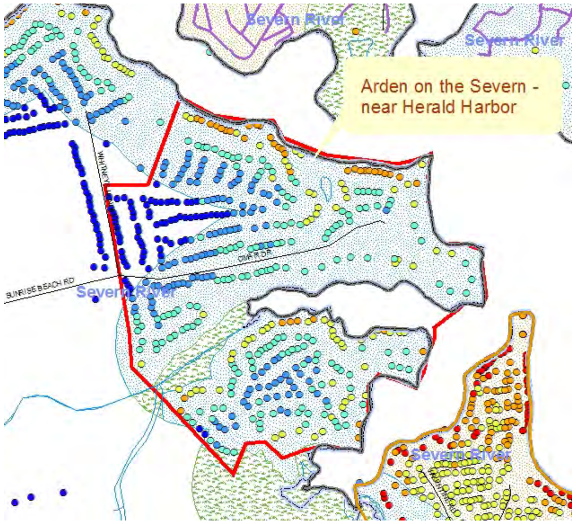
1. Adding more evaluation criteria results in fewer OSDS being placed in higher priority categories; there are progressively fewer red, orange and green dots on the figures with four, six and eight evaluation criteria. In other words, adding evaluation criteria may capture more factors, but it also inherently dilutes the influence of some of the more important factors. There are two approaches to remedying this, either lower the criteria weight for the additional criteria or remove them altogether.
2. Comparing the approaches with 3 and 4 evaluation criteria shows the influence of being in a Department of Health Problem Area (DOHPA) and whether that DOHPA is near the water. For example,
    a. Looking at Shore Acres where there's a DOHPA on the water indicates that adjacent OSDS with similar distance to water and therefore likelihood of TN delivery get different priority ranking if DOHPA are included.
    b. Looking at Gingerville where there's a DOHPA away from the water indicates that priorities for systems in the critical area and close to water but not in the DOHPA get downgraded, even though their proximity to water indicates that they are more likely to be a source of TN.
    c. Looking at Riverdale, Severn Run and Chartwell where there are no DOHPA again indicates that addition of the DOHPA criteria tends to downgrade the priority for OSDS in the critical area and near water. This is largely due to the dilution effect of simply adding more criteria, listed in item 1.
3. Comparing all four approaches indicates that none of them necessarily will give high priorities to all OSDS in areas that have been anecdotally identified as potential problem areas, such as Chartwell and Terrace Gardens on Mill Creek.



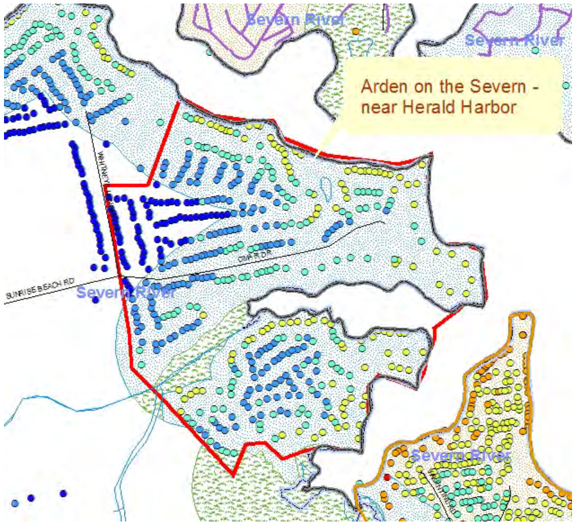
Three Evaluation Criteria



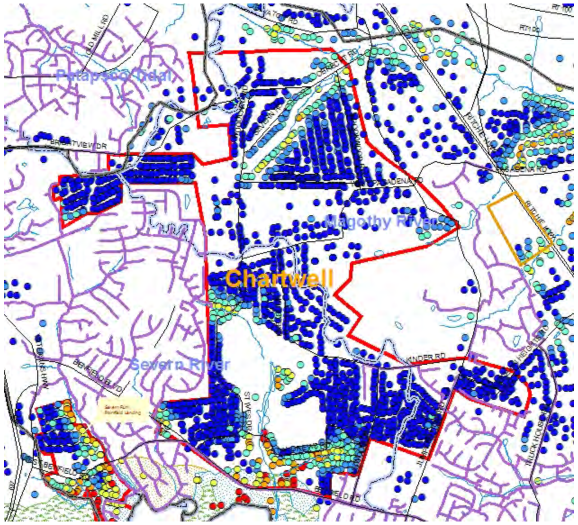
Four Evaluation Criteria



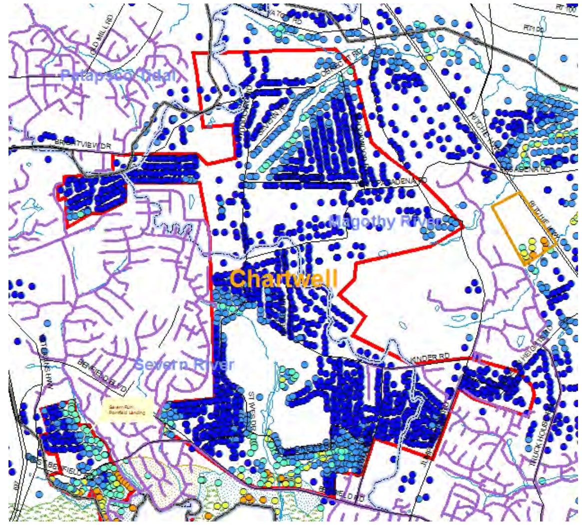
Six Evaluation Criteria



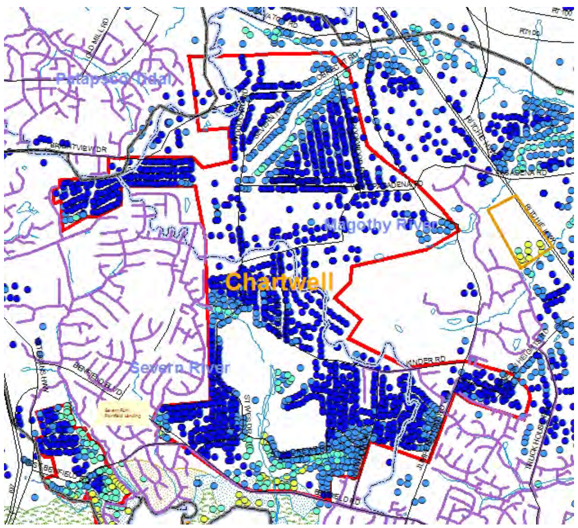
Eight Evaluation Criteria



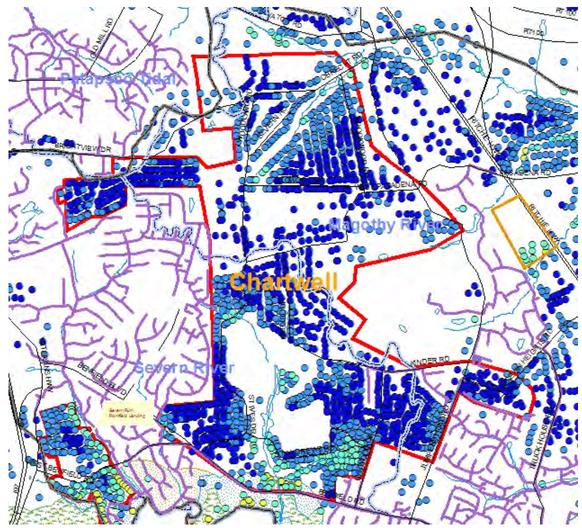
Three Evaluation Criteria



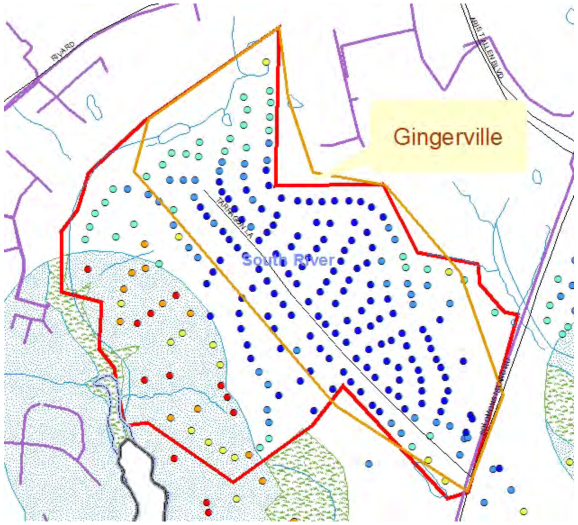
Four Evaluation Criteria



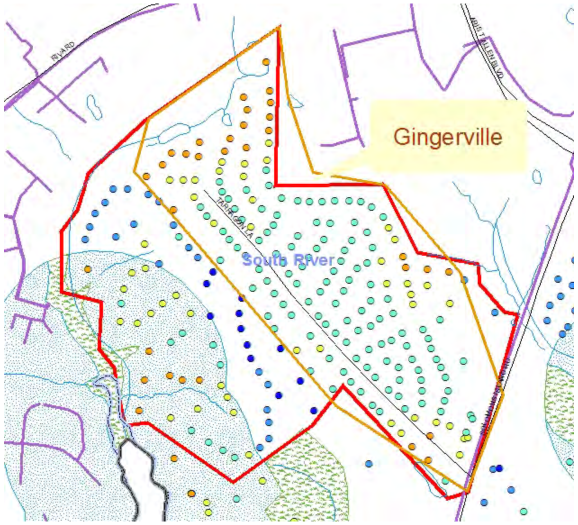
Six Evaluation Criteria



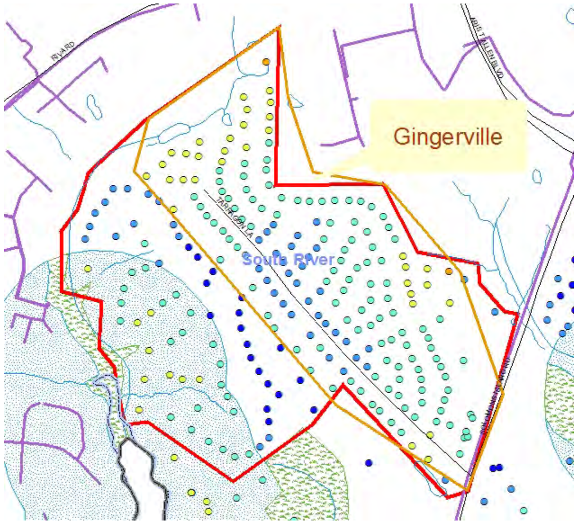
Eight Evaluation Criteria



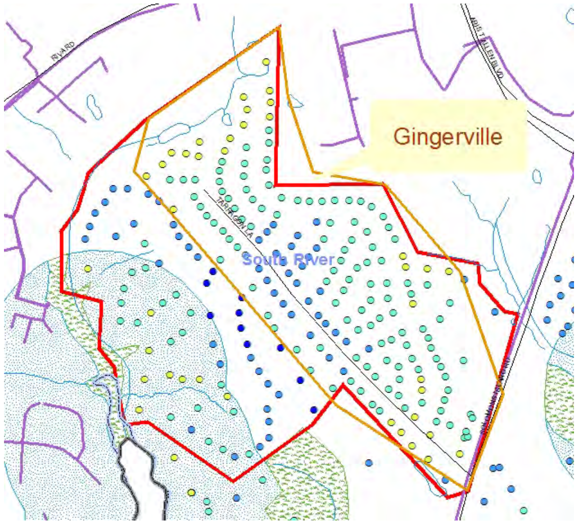
Three Evaluation Criteria



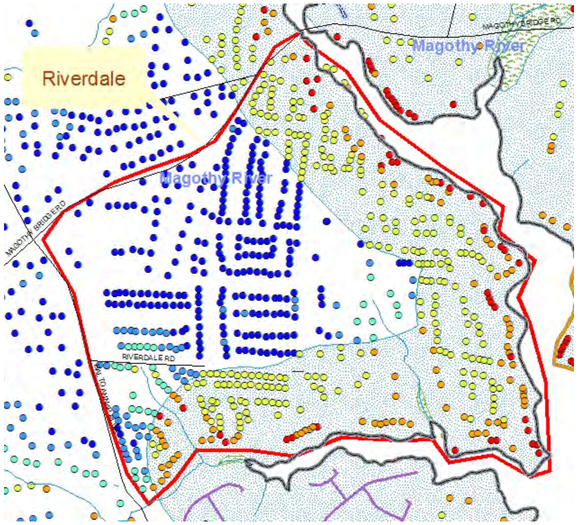
Four Evaluation Criteria



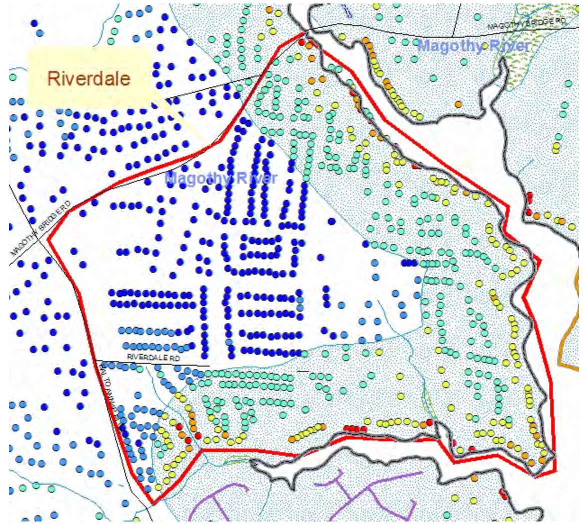
Six Evaluation Criteria



Eight Evaluation Criteria



Three Evaluation Criteria



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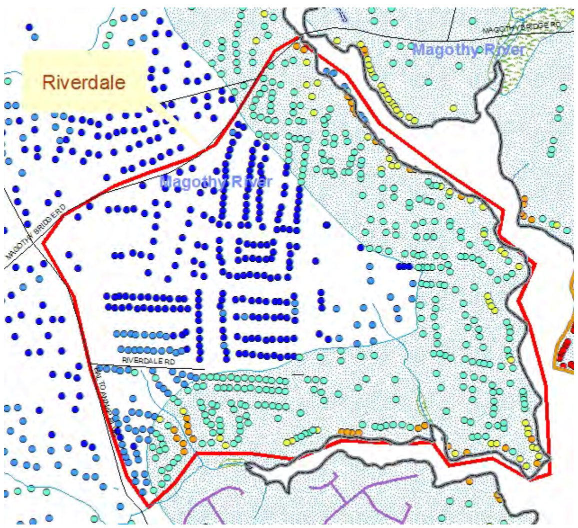

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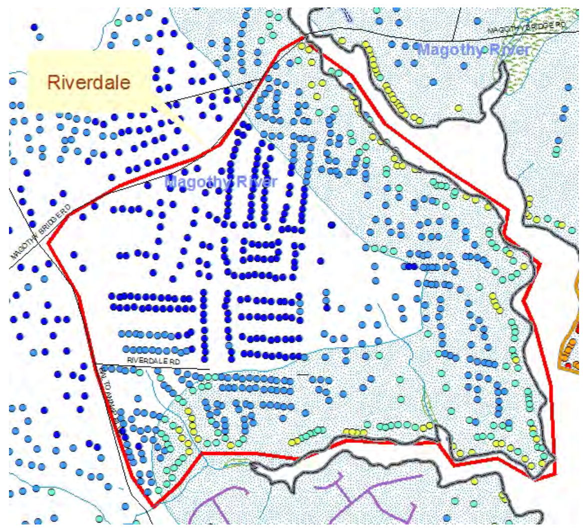

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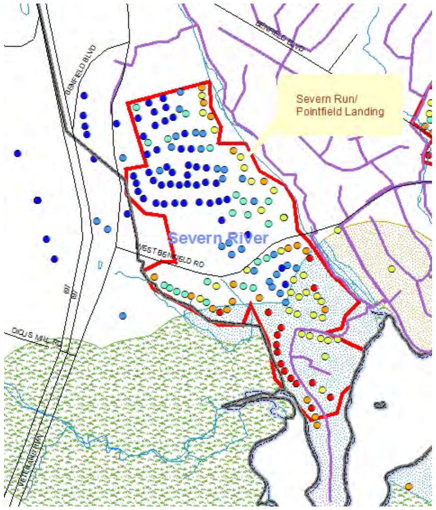

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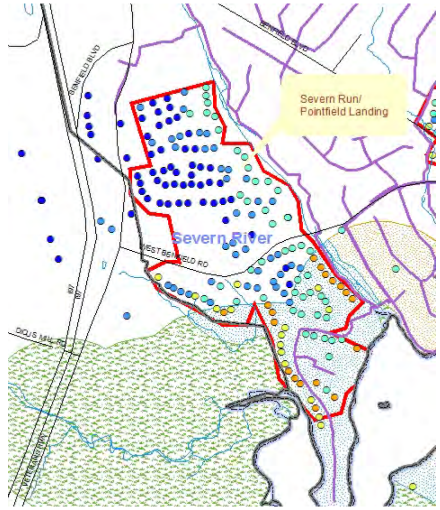

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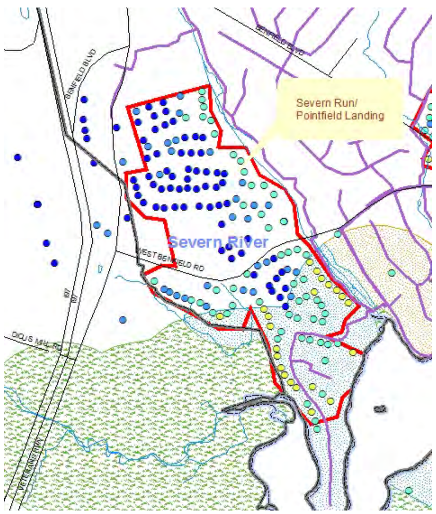

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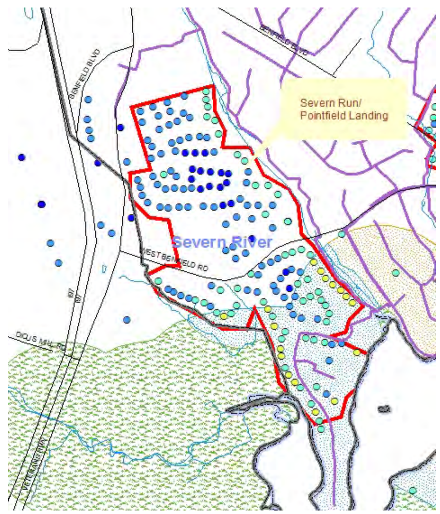

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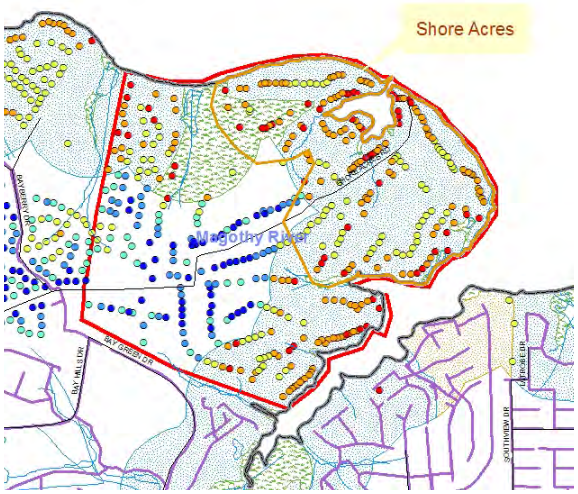

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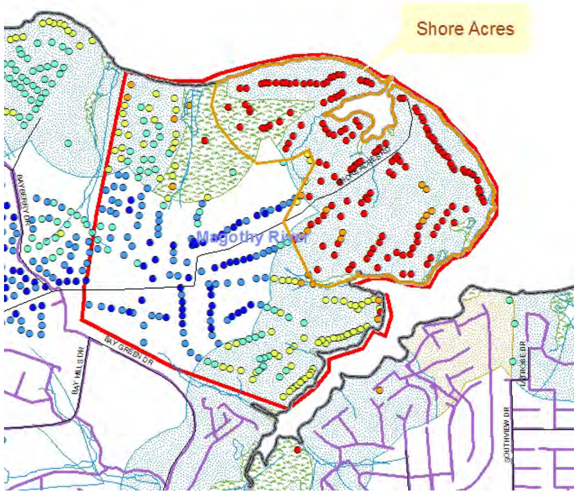

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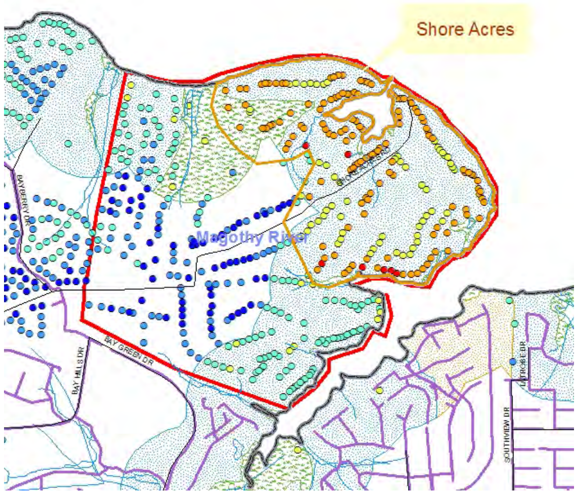

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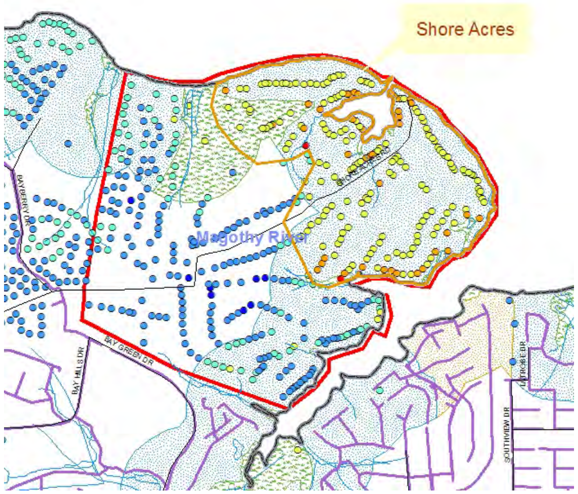

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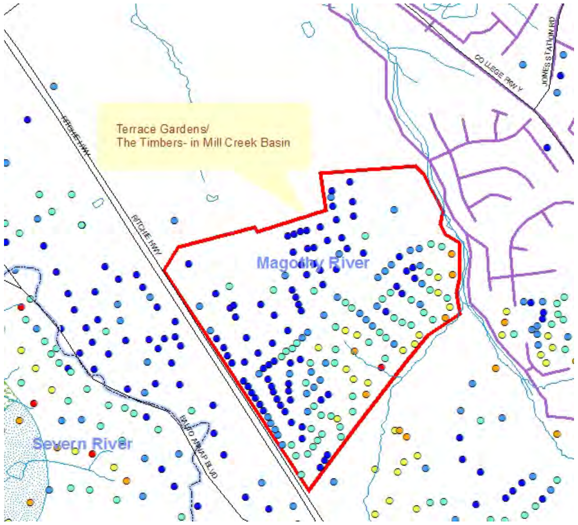

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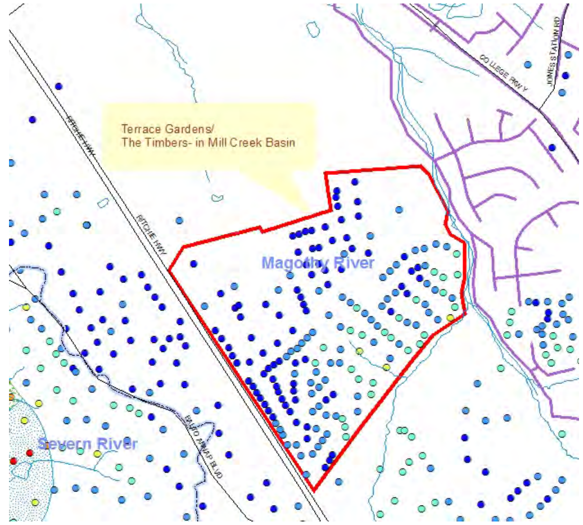

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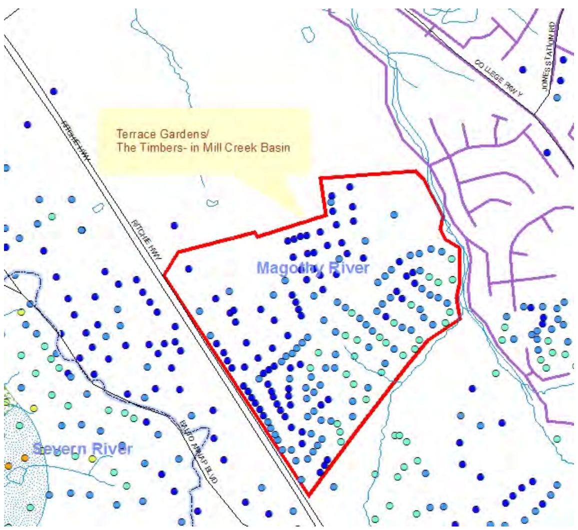
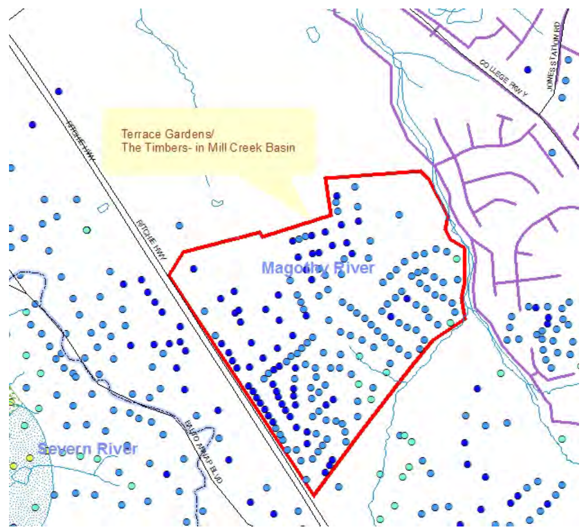


Six Evaluation Criteria



Eight Evaluation Criteria

Attachment D – Prioritization Results Using Eight Evaluation Criteria

As discussed previously, four different prioritization schemes were considered to rank each of the 40,684 OSDS in the Anne Arundel County OSDS database. This attachment presents the results of using the approach based on all eight criteria. Each of the OSDS in the County database was scored against each of the eight evaluation criteria, and those scores were weighted based on the criteria weights assigned by County staff. This resulted in a single prioritization score being assigned to each OSDS countywide.

Figure D-1 shows the priority rank of OSDS spatially throughout the County.

As shown earlier in Table 3, about 40 percent of all OSDS are in areas of existing, planned, or future sewer service. Table D-1 below shows the breakdown of OSDS by priority category, based on planned sewer service type. Looking at OSDS with scores over 2.5 illustrates that about 15.9 percent are in this higher-priority ranking. However, only 4.2 percent of OSDS in this higher priority are in areas of existing, planned, or future sewer service.

Table D-2 shows a further breakdown based on proximity to the existing sewer system, for those OSDS in areas of existing, planned, or future sewer service.

TABLE D-1
Priority OSDS Categorized by Planned Sewer Service Type
Anne Arundel County Septic Evaluation Study

Priority Score Category	Existing Service	Planned Service	Future Service	No Public Service	Resource Conservation Area	Park	Other	Grand Total
1.0-1.5	472	2440	1471	4219	14	4	3	8623
1.5-2.0	854	2376	3690	10049	175	9	9	17162
2.0-2.5	421	545	1888	4827	619	8	6	8314
2.5-3.0	128	173	1020	2882	579	1		4783
3.0-3.5	6	86	206	936	137			1371
3.5-4.0		56	47	128	60			291
Grand Total	1881	5676	8322	23041	1584	22	18	40544

TABLE D-2
Priority OSDS Categorized by Proximity to the Existing Sewer System (Distance in ft), within Areas of Planned Sewer Service
Anne Arundel County Septic Evaluation Study

	Existing Service					Existing Service Total	Planned Service						Planned Service Total	Future Service						Future Service Total	Grand Total
Priority Score Category	0-500 ft	500-1000 ft	1000-1500 ft	1500-2000 ft	2000-5000 ft		0-500 ft	500-1000 ft	1000-1500 ft	1500-2000 ft	2000-5000 ft	>5000 ft		0-500 ft	500-1000 ft	1000-1500 ft	1500-2000 ft	2000-5000 ft	>5000 ft		
1.0-1.5	414	56	2			472	686	767	330	218	433	6	2440	85	180	166	209	772	59	686	4383
1.5-2.0	756	85	8	3	2	854	701	764	407	174	296	34	2376	167	390	496	643	1759	235	701	6920
2.0-2.5	382	38	1			421	195	187	82	28	46	7	545	71	282	327	125	809	274	195	2854
2.5-3.0	113	15				128	63	64	25	1	19	1	173	30	100	132	131	474	153	63	1321
3.0-3.5	5	1				6	26	34	15	11			86	4	24	50	77	49	2	26	298
3.5-4.0							1	24	24	7			56	1	1	19	15	11		1	103
Grand Total	1670	195	11	3	2	1881	1672	1840	883	439	794	48	5676	358	977	1190	1200	3874	723	8322	15879

Table D-3 shows the breakdown of OSDS by priority category, based on density. About 15.9 percent of all OSDS have priority scores over 2.5. However, 4,283 OSDS that are in this higher priority (11 percent of all systems) are in areas of density of at least 0.5 OSDS per acre, and 1,618 are in areas of higher density of at least 1 OSDS per acre.

TABLE D-3
Priority OSDS Categorized by Density
Anne Arundel County Septic Evaluation Study

	Density (Acres/Septic System)					
	>5	**2 to 5**	**1 to 2**	**0.5 to 1**	**0.25-0.5**	
	Density (OSDS/Acre)					
Priority Score Category	**0-0.2**	**0.2-0.5**	**0.5-1**	**1-2**	**2-4**	**Grand Total**
1.0-1.5	2013	2836	2394	1380		8623
1.5-2.0	4169	6036	4475	1999	483	17162
2.0-2.5	1739	2224	2900	1450	1	8314
2.5-3.0	574	962	1887	1312	48	4783
3.0-3.5	100	369	689	213		1371
3.5-4.0	46	111	89	45		291
Grand Total	12538	12434	8641	6399	532	40544

Attachment E – Data Sources

GIS Data Source and Processing for Septic Study

Layer Name	Source	Source Date	Processing Information
Septic Data	DPW	6/13/2006	Original data received in a Microsoft Access database format; converted to a shape file based on the x-coord, and y-coord information in the septic data table
Sewer Pipes	DPW	10/13/2004	Original data received in shapefile format, no additional processing was necessary
Sewer Service Area Boundaries	DPW	2/7/2005	Original data received in shapefile format, no additional processing was necessary
Sewer Service Timing Categories	DPW	1/28/2005	Original data received in shapefile format, no additional processing was necessary
Health Department OSDS Problem Areas	Health Dept	5/10/2006	Original data received in shapefile format, no additional processing was necessary
Critical Area	OECR	5/13/2006	Original data received in shapefile format, no additional processing was necessary
Surface Water	OECR	5/13/2006	Merge all surface water features (major steams, streams, open waters, and Severn River updated streams/reaches) into one polyline shape file
Watershed Boundaries	OECR	12/13/2005	Original data received in shapefile format, no additional processing was necessary
Wetland	Maryland DNR	7/5/2006	Two data sets: A. Maryland Wetland Inventory (1:4800, DOQQ tiles); B. Wetland of Special State Concern (WSSC)
BOGs	OECR	5/13/2006	Original data received in shapefile format, no additional processing was necessary

GIS Data Source and Processing for Septic Study

Layer Name	Source	Source Date	Processing Information
Soil Percolation Rate	NRCS	6/2/2006	Original soil polygon data received in shapefile format; soil percolation rate information were summarized by CH2M HILL from NRCS published documents
Depth to Ground Water	NRCS	6/2/2006	Original soil polygon data received in shapefile format; depth to ground water information were summarized by CH2M HILL from NRCS published documents
2-M DEM	DPW	5/10/2006	Original data received in ArcInfo GRID format; resampled to 15-feet GRID for slope computation; original data were used for spot elevation
Slope	N/A	5/30/2006	Computed from the 15-feet GRID using ArcGIS Spatial Analyst slope function
Well Head Protection Areas	DPW	5/10/2006	Original data received in shapefile format, including SCON and CON data from different projects; all SCON and 10 yr CON data sets were merged into one WHPA shapefile with an attribute identify the WHPA types
Aquifer Recharge Area	DPW	8/2/2006	Original data received in shapefile format, merged together with WHPA shapefile with an attribute identify WHPA types or recharge zone

Attachment F – Frequency Distribution of OSDS by Evaluation Criteria

Inside or Outside Health Department OSDS Problem Areas

Inside or Outside Health Dept. Problem Areas	*Frequency*	*Cumulative %*
Yes	5773	14.19%
No	34910	100.00%
More	0	100.00%

Distance to Surface Water (ft)

Distance to Water (ft)	*Frequency*	*Cumulative %*
0	0	0.00%
100	3517	8.64%
200	5207	21.44%
300	4732	33.08%
400	4906	45.13%
500	3986	54.93%
600	3643	63.89%
700	2977	71.20%
800	2334	76.94%
900	2206	82.36%
1000	1679	86.49%
5000	5494	100.00%
More	2	100.00%

Inside or Outside Chesapeake Critical Area

Inside or Outside Chesapeake Critical Area	*Frequency*	*Cumulative %*
Outside	27,498	68%
IDA	1,007	70%
LDA	10,785	97%
RCA	1,393	100%
More	-	100%

Depth to Groundwater (ft)

Depth to Groundwater (ft)	*Frequency*	*Cumulative %*
NA	14543	35.75%
1	872	37.89%
2	1085	40.56%
3	9628	64.22%
4	779	66.14%
5	13776	100.00%
6	0	100.00%

NA = Not Available

Distance from Bogs

Distance from Bogs (ft)	*Frequency*	*Cumulative %*
Inside Bogs	8	0.02%
100	102	0.27%
300	708	2.01%
1,000	885	4.19%
More	38980	100.00%

Ground Slope

Slope (%)	*Frequency*	*Cumulative %*
0	50	0%
12	31843	78%
15	2475	84%
25	3869	94%
More	2444	100%

Soil Percolation Rates

Soil Percolation Rates (in/hr)	*Frequency*	*Cumulative %*
-	349	1%
0.50	1123	4%
1.00	12	4%
2.00	3617	13%
More	35580	100%

Inside or Outside Well Head Protection Areas (WHPA): Semi-Confined and Confined, and Aquifer Recharge Areas

Inside or Outside WHPA	*Frequency*	*Cumulative %*
Outside	16,684	41%
In Recharge Area	20,717	92%
<= 100' of 10-Yr Confined WHPA	1,823	96%
<= 100' of 10-Yr Semi-Confined WHPA	1,459	100%
More	-	100%

Priority Scores, Normalized to a Range from 1 to 5

Priority Scores	*Frequency*	*Cumulative %*
1.0	4,929	12%
1.5	8,259	32%
2.0	5,547	46%
2.5	5,698	60%
3.0	7,527	79%
3.5	4,389	89%
4.0	2,633	96%
4.5	1,124	99%
5.0	578	100%
More	0	100%

Priority Scores, Normalized to a Range from 1 to 100

Priority Scores	*Frequency*	*Cumulative %*
-	-	0%
10	-	0%
20	4,929	12%
30	8,259	32%
40	5,547	46%
50	5,698	60%
60	7,527	79%
70	4,389	89%
80	2,633	96%
90	1,124	99%
100	578	100%
More	-	100%

Distance from Existing Sewer System

Distance from Existing Sewer System (ft)	*Frequency*	*Cumulative %*
-	0	0%
500	3925	10%
1,000	3591	18%
1,500	3044	26%
2,000	2636	32%
2,500	2378	38%
3,000	2145	44%
3,500	1839	48%
4,000	1600	52%
4,500	1327	55%
5,000	1279	58%
5,500	1239	61%
6,000	1224	64%
6,500	1109	67%
7,000	1143	70%
7,500	1361	73%
8,000	1200	76%
8,500	1177	79%
9,000	1014	82%
9,500	823	84%
10,000	760	86%
More	5867	100%

Density

Density (Septic/ Acre)	*Density (Acres/Septic System)*	*Frequency*	*Cumulative %*
-	-	-	0%
0-0.2	>5	8,656	21%
0.2-0.5	2-5	12,571	52%
0.5-1	1-2	12,495	83%
1-2	0.5-1	6,429	99%
2-4	0.25-0.5	532	100%
More	More	-	100%