3 WATERSHED ASSESSMENT METHODS

This section discusses tools and methods used for many of the watershed assessment studies presented later in this report. It should be noted that Section 2 also made use of the GIS tools discussed herein.

3.1 Geographic Information Systems (GIS) Methods

Much of the data for the RSWMP was taken from both State and County Geographic Information System (GIS) files. This database allows the user to create maps of the data and to calculate areas within the watershed that have mappable characteristics, such as soils or land use. The data are provided as layer files including information such as land use, geology, well locations, soils and other data. The GIS ArcView system allows the layer files to be overlain and combined to analyze geographic information. The layer files were created by digitizing mapped data such as a soils map or by analyzing other data such as using aerial photographs to determined land use.

Monmouth County's existing GIS data provided the basis for the watershed characterization. The GIS base data was derived from a series of aerial photography flights from April 2003. These were processed and developed using standard photogrammetric processes by the firm Buchart-Horn Basco Associates of York, Pa. The data has a +/- one foot horizontal and vertical accuracy and was checked for Quality Assurance/Quality Control (QA/QC) by the firm Civil Solutions, Hammonton, NJ.

The use of two-foot contour lines, spot elevations, stream centerlines and water body polygons provided the Monmouth County Office of GIS with the ability to generate high resolution digital elevation models commonly known as DEM's. Once the DEM's were processed, they could be run through a series of processes to develop vector data. The output dataset used most frequently is the sub-watershed boundary. It was subject to many changes. In August, 2005 staff from NJDA and NJDEP ground-truthed the sub-watershed boundaries and provided suggestions as to boundary adjustments based on stormwater infrastructure, which may have modified natural drainage patterns. Sub-watershed boundaries provided key functions during the course of the study, including base mapping, land use characterization and flow direction.

In 2004 Tom Kellers, then chairman of the Wreck Pond Brook Regional Stormwater Management Planning Committee, asked the Monmouth County Office of GIS to participate in the Regional Stormwater Management Plan for the Wreck Pond Brook Watershed. Around the same time, ESRI, of Redlands, California, and the University of Texas, Center for Research in Water Resources (CRWR), were collaborating on the first version of ArcHydro. ArcHydro is a data model developed to work within the ArcGIS environment. ArcHydro has an associated set of GIS tools that populate the attributes of the features in the data framework, interconnect features in different data layers and support hydrologic analysis. ArcHydro provided standardized format for collecting hydrologic data and placing it in a GIS format.

The County determined that ArcHydro would be a useful tool in development of the RSWMPs as well as for other uses within the County planning department. However, there was very little mapped data for the watersheds within the county. The staff at Monmouth County GIS began developing GIS datasets for the regional plan using the ArcHydro tools. Once acceptable datasets were developed, the ArcHydro data model was incorporated into the Regional Stormwater Management Planning process.

The Wreck Pond Brook Watershed delineation began by determining suitable locations for stream gauges. Once stream gauge locations were determined the process of defining and identifying features began. Section 3.3, following, discusses the gauge locations. The gauge locations provided the subwatershed boundaries. MCOOGIS then synthesized existing data or collected and digitized new data to provide GIS layers with data on a subwatershed basis. ArcHydro also provided the tools for the creation of a schematic of the watershed that was used to diagram the connection between each sub-watershed area and its local drainage system.

The information discussed above, along with other existing data from the MCOOGIS provided much of the data for the study. In addition, data layers from the New Jersey GIS database were included such as the landscape maps for endangered species and public well locations. Technical studies conducted as part of the RSWMP planning process also were converted to digital GIS layers. Table 11 lists many of the GIS layers used in or developed for this project.

3.2 Measurement of Rainfall

Initial development of the WPB RSWMP included the purchase and installation of a weather station. The purpose of the weather station was to provide rainfall and weather data specific to the WPB watershed for the purpose of plan and model development. As such, following a grant award from the NJDEP, Monmouth County teamed with the South Jersey Resource Conservation and Development Council, Inc. (SJRCD) to install a weather station within the watershed.

SJRCD, a non-profit organization that maintains numerous weather stations located throughout Southern New Jersey, assisted the County with installation of the weather station in Wall Township. In May, 2005, the station was installed and began collecting data. The station is sited on the grounds of the Wall Township Municipal Complex, strategically located in the central region of the watershed.

The Wall Township Weather Station is part of the SJRCD's RISE system. RISE is an acronym for "Resource Information Serving Everyone." The system was created to address the need for high quality weather data for the management of irrigation practices, and consists of twenty (20) stations in eight (8) counties.

Table 11: GIS LAYERS	
GIS File	**Data Source**
Land Use (2006)	MCGIS
Road Edges	MCGIS
Building Outlines	MCGIS
Municipal Boundaries	MCGIS
Parcels (Tax Maps)	MCGIS
Contours (2')	MCGIS
WPB Watershed Boundary	MCGIS
WPB Watershed Catchments	MCGIS
Streams	MCGIS
Lakes	MCGIS
Endangered Species	NJDEP GIS/Landscape Maps
Wetlands	NJDEP GIS Wetlands Layer
Topography	USGS Quadrangle Maps and MCOOGIS
Geology	NJDEP GIS
Well Locations	NJDEP GIS
Zoning	MCGIS and Najarian Associates
Farm and Recreation Lands	MCGIS and RCE
Sampling Locations for Pond, tributary, watershed and sediment cores	Najarian Associates, Monmouth County, Monmouth University, Rutgers Cooperative Extension

The station provides the following weather related information: temperature, wind speed, wind direction, relative humidity, solar radiation and precipitation. The precipitation information is supplied in six (6) minute intervals, as well as daily and monthly totals.

SJRCD inspects and maintains all of the Campbell Scientific CM10 weather stations including the Wall Township gauge on a regular basis. Collected data from the station is relayed back to SJRCD at regular intervals via cell phone, where the data is collected and posted to the RISE system website. Weather data can then be downloaded from the website by subscribers for their use.

3.3 Stream Gaging and County Water Quality Stations

The Wreck Pond Book watershed measures approximately 12 square miles and is bisected by several major highways. As discussed previously, the watershed includes a variety of land uses, two primary streams, a smaller tributary and numerous ponds. In order to investigate the impact of watershed characteristics on stormwater quantity and quality, the watershed was subdivided into smaller study areas. A stream gage was located at the downstream end of each subwatershed.

The gages were placed in consideration of several factors including areas with relatively homogeneous characteristics such as land use and the natural sub-watershed boundaries. "Natural" watershed break points were sought which would allow hydraulic measurements. These "control points" are typically a road crossing, culvert, bridge or dam. Once a generalized gaging location was selected, exact locations were refined based on the "measurability" of the flow at the selected locations. Stream cross sections should be fairly uniform and prismatic with well defined banks and floodplain. The stream channel upstream and downstream of the gage location ideally should be similar to the cross section at the gage location so that hydraulic modeling of the stream channel can be performed. The gage location site must also be characterized by a free-flowing water and flow should not be affected by tides or "backwater".

Lastly, safety of the investigators must be considered. Data loggers used by the investigators require manual downloading to a Palm™ type device. This necessitates safe access to the logger for extended time periods while data is retrieved Table 12 and Figure 10 summarizes the gage and sampling stations, which are described in detail in Appendix A.

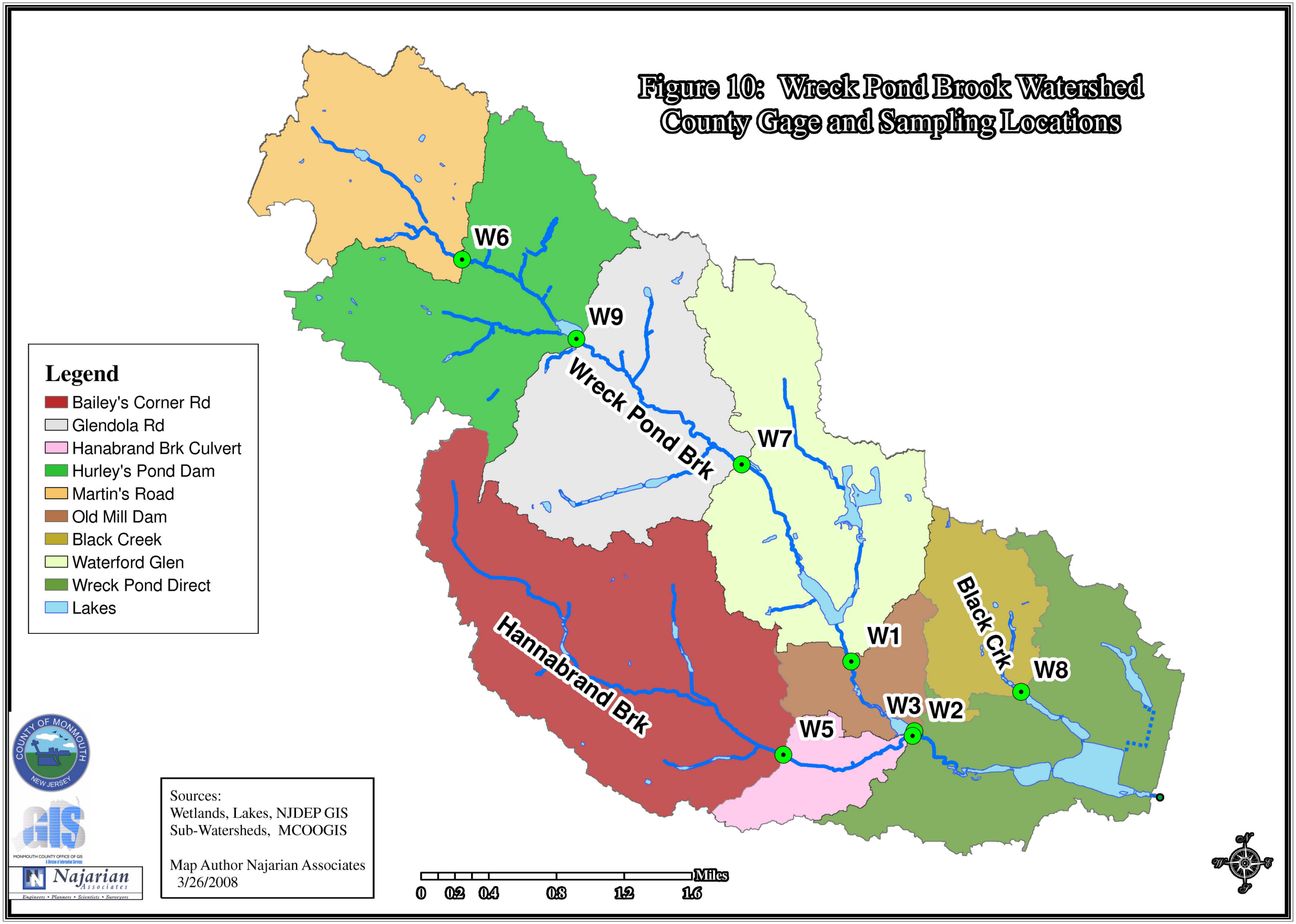

Figure 10: Wreck Pond Brook Watershed
County Gage and Sampling Locations
Legend
Bailey's Corner Rd
Glendola Rd
Hanabrand Brk Culvert
Hurley's Pond Dam
Martin's Road
Old Mill Dam
Black Creek
Waterford Glen
Wreck Pond Direct
Lakes
W6
W9
W7
W1
W3
W2
W8
W5
Wreck Pond Brk
Hannabrand Brk
Black Crk
Sources:
Wetlands, Lakes, NJDEP GIS
Sub-Watersheds, MCOOGIS
Map Author Najarian Associates
3/26/2008
Miles
0 0.2 0.4 0.8 1.2 1.6
COUNTY OF MONMOUTH
NEW JERSEY
Najarian Associates

Table 12: County Gauge and Sampling Stations		
Station #	**Subwatershed**	**Location**
Wreck Pond Brook		
W6	Martins Road	Just west of Garden State Parkway, upstream side of Martins Road culvert
W9	Hurley's Pond Dam	Downstream Side of Allenwood Road Culvert, Near Intersection of Hurley Pond Road and Allenwood Road
W7	Glendola Road	Downstream Side of Glendola Road Culvert, Adjacent to Taylor Pond
W1	Waterford Glen	Wreck Pond Brook, Stream Location Behind Waterford Glen Assisted Living Facility, Off of Route 35
W3	Old Mill Dam Culvert	Wreck Pond Brook, Downstream Side of Old Mill Road Culvert, Across Street of Old Mill Restaurant
Hannabrand Brook		
W5	Bailey's Corner Road	Hannabrand Brook, Downstream Side of Bailey's Corner Road Culvert, Just South of Pump Station
W2	Hannabrand Brook Culvert	Hannabrand Brook, Upstream Side of Old Mill Road Culvert, Adjacent to Old Mill Restaurant
Black Creek		
W8	Spring Lake Golf Club	North Branch of Wreck Pond Brook, Downstream Side of Route 71 Culvert, Southeast of Golf Course

4 STREAM ASSESSMENTS

In addition to the overall watershed assessments provided in Section 2, an in-field stream assessment was deemed necessary for the development of this Plan. All stream assessments within the watershed were performed by the Freehold Soil Conservation District (District). The assessments were performed between March 2005 and May 2006. The District utilized the United States Department of Agriculture Stream Visual Assessment Protocol methodology (SVAP) to execute the stream assessments.

4.1 Assessment Methodology

The SVAP method was developed by the Department of Agriculture as a first level assessment protocol to evaluate the aquatic ecosystems associated with streams. The SVAP method is the first step of a four-part assessment protocol to assess these ecosystems. This first level assessment provides information on basic health of the stream, specifically associated with the physical condition within the assessment area. The results of these assessments can then be used by stakeholders and planners to decide to conduct further ecological assessments, or develop design alternatives for stream restoration.

The method does not require specialized training, and can be implemented successfully with little biological, hydraulic or aquatic expertise. Essential to the method, however, are the use of reference sites. A reference site is a stream reach that has been least impacted by impairments and provides a standard for comparison during the assessment process. They represent the best condition attainable within a particular watershed or region.

The SVAP method uses a National Stream Assessment template. However, the SVAP method was designed to allow modification to the national template to better reflect conditions within a specific watershed. In this case, slight modifications to the national version included changes to the “assessment elements” and the “element scoring” by FSCD. Table 13 lists the assessment elements and their respective score ranges used during this assessment:

The information above was input into the Reach Assessment Score Sheet, which is located in Appendix B of this report. In addition to a scoring system, each element has condition categories, which include a small narrative describing what the stream reach should exhibit to warrant a specific scoring. The four condition categories include Optimal, Sub-Optimal, Marginal and Poor. For instance, in order for a reach to receive an Optimal score (score of 16 – 20) for channel flow status, the reach must exhibit the following: “Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.”

Table 13: Stream Assessment Scoring	
Assessment Element	**Scoring Range (Poor to Optimal)**
Pool Substrate Characterization	0 – 20
Pool Variability	0 – 20
Sediment Deposition	0 – 20
Channel Flow Status	0 – 20
Channel Alteration	0 – 20
Channel Sinuosity	0 – 20
Bank Stability – Left Bank	0 – 10
Bank Stability – Right Bank	0 – 10
Bank Vegetative Protection – Left Bank	0 – 10
Bank Vegetative Protection – Right Bank	0 – 10
Riparian Vegetative Zone Width – Left Bank	0 – 10
Riparian Vegetative Zone Width – Right Bank	0 – 10

FSCD performed all assessments by walking each stream and assessing individual reaches, recording the assessments and scores on individual Reach Assessment Score Sheets. Reaches were divided into manageable lengths, and each length received an assessment and score. In addition to the Reach Assessment Score Sheet, FSCD took photographs off all reaches assessed and recorded additional data on a Reach Assessment Data Sheet. The Data Sheet included information such as: channel width, buffer widths, bank slope descriptions, bank vegetation cover percentage, water clarity, debris, etc.

4.2 Data Collection and Management

During the assessment period, data sheets, scores, GPS coordinates of reaches and photographs were input into a controlled Microsoft Access database. Using information within the FSCD database, Najarian Associates developed a stream shapefile that can be imported into a GIS graphics program. This shapefile was then color coded according to the score ranges, and used to develop Figure 11 of this report. Figure 11 depicts each stream reach and its location within the watershed, and the color of the reach corresponds to the appropriate score range. Reaches not assessed by FSCD due to various circumstances are color coded on the figure as well.

4.3 Conclusions of Stream Assessment Study

As depicted in Figure 11, the majority of stream reaches fall under the Sub-Optimal category. These are spread throughout the watershed and exhibit no distinct pattern. The majority of Optimal reaches are located within the Waterford Glen sub-watershed. The small amount of Marginal reaches are located in the headwaters regions of the

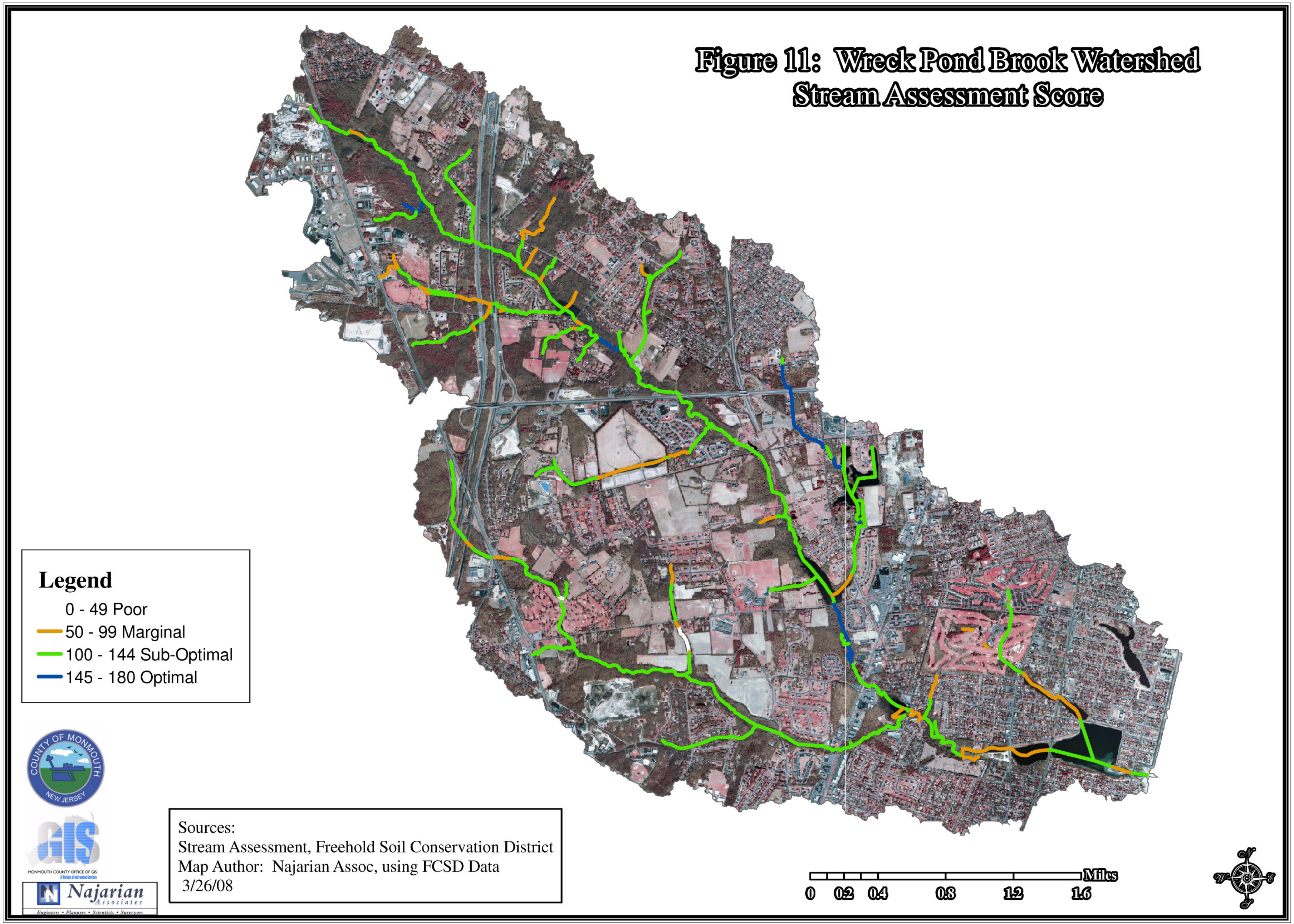
Figure 11: Wreck Pond Brook Watershed
Stream Assessment Score
Legend
0 - 49 Poor
50 - 99 Marginal
100 - 144 Sub-Optimal
145 - 180 Optimal
Sources:
Stream Assessment, Freehold Soil Conservation District
Map Author: Najarian Assoc, using FCSD Data
3/26/08
Miles
0 0.2 0.4 0.8 1.2 1.6
COUNTY OF MONMOUTH
NEW JERSEY
GIS
Najarian
Associates

Hannabrand Brook, by the Garden State Parkway and Route 34, and the Wreck Pond Brook, located within the Hurley's Pond sub-watershed.

Overall, the data collected by FSCD provide information to focus stream restoration and remediation efforts and BMP implementation. Additionally, specific score results within the assessments may provide evidence of other physical or biological impairments within specific parts of the watershed. For example, reaches with poor bank stability scores may be indicative of high stormwater runoff flows, causing stream bank erosion.

5 AGRICULTURAL AND RECREATION LAND SURVEY

Rutgers Cooperative Extension (RCE) has characterized the agricultural and recreational lands in the watershed, and analyzed their potential for contribution to fecal coliform and nutrient loading to Wreck Pond. Education, outreach, and recommendations for best management practices are outcomes of the characterization process. This section of the report details methodologies and provides results of the agricultural and recreational land use survey and water quality monitoring.

5.1 Identification of Farm and Recreation Parcels

Through the use of the Monmouth County GIS system, feature classes for streams, road centerlines, watershed boundaries, land use and land cover, and municipal tax records, as well as aerial photography were obtained. Examination of the tax records provided records that were labeled “3a” or “3b” with respect to farmland. These records indicate farm house and qualified farm properties. To become a qualified farm, a parcel must be actively involved in agriculture on at least five acres of the property. The Wall Township municipal Tax Atlas information used was from the year 2005, although online data from more recent years was consulted for comparison. All qualified farms found during the survey are depicted on Figure 12.

In addition, 1997 land use and land cover feature classes were analyzed to assess farm properties. The feature classes were queried under the 1997 label field and the 1997 SCS description field, and a feature class was made out of all agricultural and recreational lands in the Wreck Pond Brook watershed (Figure 12). Both sets of data were selected for land parcels within 500 feet of any water body in the Wreck Pond Brook watershed. This group was identified for potential water quality impacts. The sum of this information generated data tables with owner information for each parcel on the tax map.

Tables 14 and 15 summarize the agricultural and recreational lands in the watershed.

5.2 Agricultural Surveys

An agricultural land use survey was constructed to assess the characteristics of these parcels, and determine which were still in use as farmland. The survey was confidential, and employed the use of an identification number to make participants more comfortable answering questions. There were twenty questions on land use of the property, overall knowledge of best management practices, and willingness to let RCE tour the property and discuss management of manure and fertilizer and chemical applications with the owners. A full survey is provided in Appendix C.

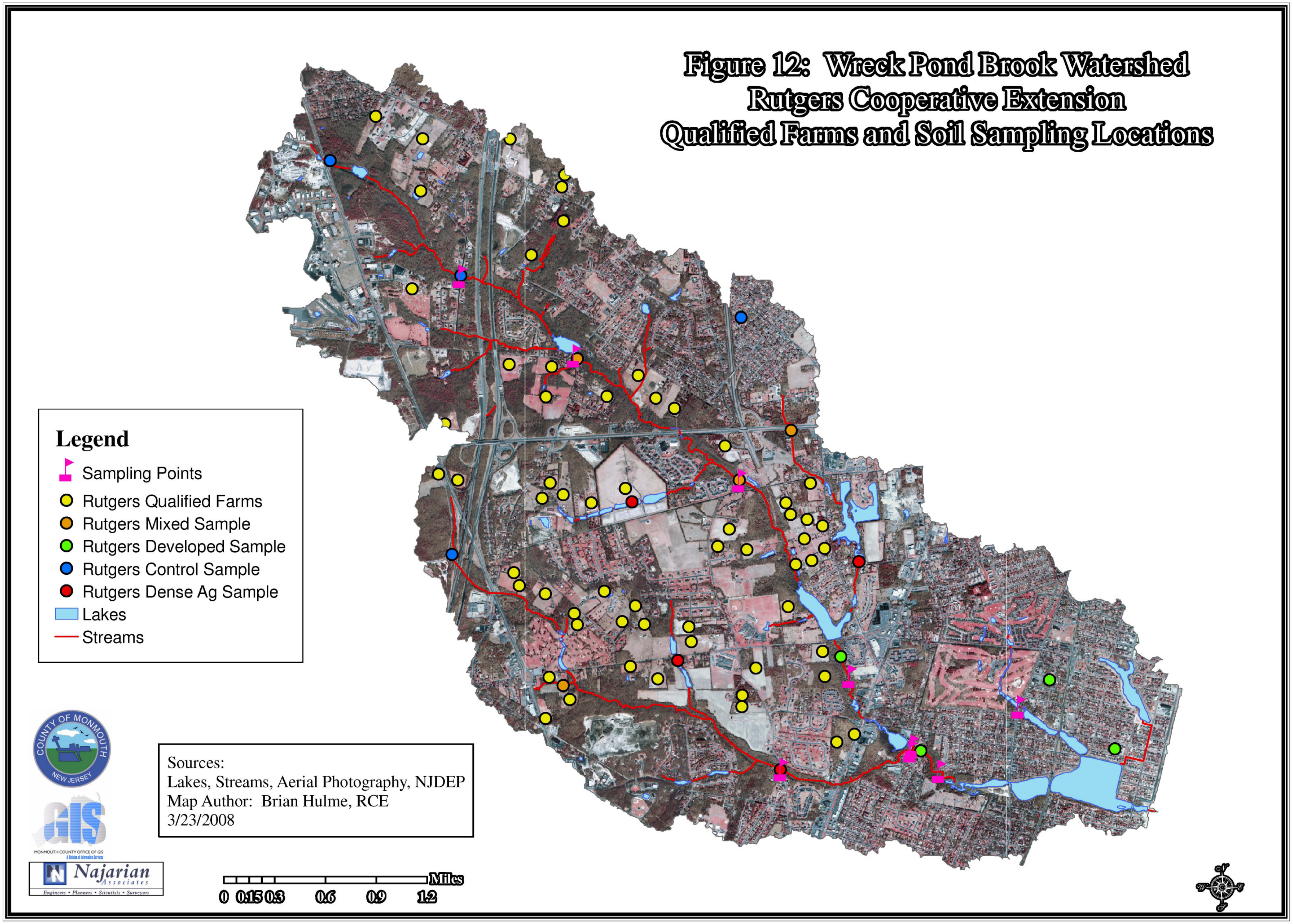
Figure 12: Wreck Pond Brook Watershed
Rutgers Cooperative Extension
Qualified Farms and Soil Sampling Locations
Legend
Sampling Points
Rutgers Qualified Farms
Rutgers Mixed Sample
Rutgers Developed Sample
Rutgers Control Sample
Rutgers Dense Ag Sample
Lakes
Streams
Sources:
Lakes, Streams, Aerial Photography, NJDEP
Map Author: Brian Hulme, RCE
3/23/2008
Miles
0 0.15 0.3 0.6 0.9 1.2

Table 14 - 2005 Wreck Pond Agriculturally Assessed Land				
LU - 2005	**Assessed Size (acres)**	**Area Actively Farmed (acres)**	**Hydrologic Soil Group**	**Dist. To Stream (ft.)**
Crop/Nursery	6.50	1.97	B, C/D	adjacent
Pasture	7.41	3.00	A, B/D	655
Crop	20.50	20.00	A, B/D	1265
Nursery	6.68	6.29	A, B/D, C/D	395
Pasture	44.60	43.63	A,B,B/D,C,C/D	220
Crop	5.58	2.54	B	680
Crop	15.76	0.00	A, B/D	adjacent
Crop	254.70	11.25	B	380
Crop	21.40	11.17	B	160
Crop	6.50	6.51	B	35
Crop	47.60	24.90	B, B/D	30
Crop	6.50	3.15	B	300
Nursery	14.53	9.09	B	adjacent
Crop	35.00	32.00	B, D	adjacent
Crop	10.00	6.23	B, B/D	240
Crop	5.40	5.24	B	540
Crop	41.58	27.47	B, A	adjacent
Crop	15.70	6.71	B	adjacent
Crop	90.00	68.38	B, A	adjacent
Crop	10.70	10.70	B, D	70
Crop	12.00	6.98	B, B/D	145
Pasture	17.20	10.79	B	520
Pasture	11.63	6.94	B	35
Pasture	6.64	3.34	A	210
Pasture	33.94	10.91	A, B	adjacent
Pasture	8.00	6.60	B	1191
Pasture	21.51	38.00	B	adjacent
Crop	22.38	7.38	B	adjacent
Pasture	5.00	2.26	B	1815
Crop	15.96	6.32	B	645
Crop	42.06	26.79	B	530
Crop	11.81		B	100
Crop	8.19		B	adjacent
Crop	9.00	2.92	B	1015
Crop	10.00	27.50	B, B/D, D	adjacent
Crop	26.44	19.94	B, B/D, C	1645
Crop	5.72	0.58	B/D	1070
Crop	5.00	5.00	B, B/D, D	adjacent
Crop	16.41	0.00	B	345
Crop	5.70		D	adjacent
Crop	5.34	8.53	B, B/D	210
Crop	10.00	5.16	B	45
Crop	12.70	10.47	B, B/D, D	adjacent
Crop	6.72	3.92	B	450
Pasture	8.24	2.71	B	380
Crop	10.44	3.24	B, B/D	adjacent
Crop	5.16	4.73	B	155
Crop	8.67	6.82	B	260
Total	***1028.50***	***528.06***		

Table 15- Wreck Pond Brook Watershed Athletic/Recreational Fields						
Code	Name	LU	Size (acres)	Impervious (acres)	Hydro Grp	Dist to Stream (ft.)
A1	Wall Stadium	Rec Land	18	5.1	Urban	1545
A2	Quail Ridge GC	Golf Course	38.1		A , B	380
A3	Wall Park	Landscap.	1.7		B	1150
A4	Wall Elem. School	Ath. Field	9.8		B/C	955
A5	Wall BOE	Rec Land	11.87		Urban	adjacent
B1	Wall Park	Rec Land	0.8		B/D	170
B2	Wall Mun. Complex	Rec Land	36.1		B	adjacent
B3	Bel-Aire GC	Golf Course	78.1		B/D	adjacent
B4	Wall BOE	Rec Land	40.82		B	335
C1	Misc. Park	Rec Land	1		B	255
C2	Wall High School	Rec Land	1.86	0.97	B	472
C3	Spring Lake Heights School	Rec Land	2.76	0.56	B/D	3520
D1	Allenwood School	Rec Land	6.7	0.6	A	730
D2	Allenwood School	Rec Land	9.42	0.12	B	845
D3	Wall Intermediate School	Ath. Field	10.25		B, B/D	610
D4	South Manor Tennis	Rec Land	0.28	0.28	B/D	420
D5	Tarpon Townhouses	Rec Land	0.78	0.18	A	470
E1	Old Mill School	Rec Land	1.82		D, A	adjacent
E2	Spring Lake Heights Park	Rec Land	1.91	0.84	A	240
E3	Fairway Mews GC	Golf Course	111	(50/50 house mix) 50	B	adjacent
E4	Spring Lake GC	Golf Course	142		B, A	adjacent
E5	Junior Junction Preschool	Ath. Field	3.87		Urban	960
E6	Spring Lake Park	Rec Land	2.7		Urban	360
E7	Misc. Park	Rec Land	0.31	0.31	Urban	adjacent
E8	St. Catherines School	Rec Land	1.42	0.42	Urban	300
Total:			***533.37***	***59.38***		

A total of 49 property owners, all in Wall Township, were identified with "qualified" agricultural properties within 500 feet of a Wreck Pond Brook tributary. The survey was sent to landowners in August 2005. Out of the 49 surveys sent, three never reached their intended recipients, indicating either a database address error or a change in land use. Nineteen of the forty-six recipients returned the mail survey. Out of the 27 remaining property owners, correct phone numbers were found for about 50% (14), with the remaining numbers unlisted or disconnected. A follow up phone survey was performed on these 14 owners, with 7 not responding to the phone call, 6 refusing to answer the questions, and one owner answering a brief phone version of the survey. This indicates that 41% of the recipients answered the survey on the first attempt to contact them, while another 28% were contacted a second time by phone. In total, 20 property owners have responded to date, yielding a 43% overall response rate.

All 20 respondents answered that their land was currently in use as agricultural property and had been for the past 5 years. There are challenges involved with interpreting the results of any survey. Some respondents accidentally skipped the questions on the back of the first page, lowering some of the response rates. One respondent answered yes and no for several questions, which, in analysis was recorded as "Not sure". An equal 44% percent of respondents indicated that there either was or was not a drainage or stream running through the property, while 11% said they didn't know. Seventy eight percent of respondents owned and farmed between 5 and 20 acres, with a few (5%) farming 0-5 acres, and the remaining 17% farming between 20 and 50 acres. No respondents farmed more than 50 acres.

Table 16 provides a summary of the uses of farmland by respondents, in percent. Respondents were allowed to choose as many answers as applied, so totals exceed 100%.

Table 16: Uses of Agricultural Land

Use	Percent of respondents
Crop/Vegetable	67%
Orchard/Vineyard	22%
Livestock/Animal	22%
Ornamental/Nursery	39%
Other	17%

Note: More than one response possible so does not add to 100%

Table 16 shows the percentage of respondents engaged in various categories of farming. Of respondents, 37% said there were domestic animals or livestock on their property, while 63% did not. Table 17 shows the breakdown of the 219 livestock identified in the survey, although one owner failed to specify the number of horses on the property. Only 21% of respondents reported using manure as a nutrient addition on their farm fields, however only 74% of respondents answered this question.

Only five respondents (29%) of the nineteen mail surveys indicated that they had manure on site. The five respondents used such manure management practices as storing manure away from water, using a flat concrete pad closed on three sides, and composting manure on site. As far as respondents performing cropland application, 33% had soil tested for proper application, and 66% only applied manure as necessary, once a year.

Table 17: Animals on Agricultural Lands		
Animal	**Total Animals**	**Number of Owners**
Chickens	70	2
Cows	12	1
Cats/Dogs	3	3
Horses*	78	2
Mini Donkeys	7	2
Pigs	4	1
Rabbits	40	1
Sheep	5	1
Total	219	13
**One respondent did supply number of horses, may be higher*		

Table 18 shows the total of all agriculturally assessed land in the Wreck Pond Watershed as of 2005. They are broken down into agricultural land use, total size and the area of those total sizes actively used for agricultural purposes.

Recreational lands were also surveyed. Table 19 is a summary of all recreational land in the Wreck Pond Watershed as of 2005. This table breaks the recreational land into land use, size and amount of impervious surfaces within each parcel. The majority of recreational and athletic fields are municipal schools or parks.

Table 18: Use of Agriculturally Assessed Land as of 2005.		
Land Use	**Size (acres)**	**Area Actively Farmed (acres)**
Pasture	164.17	128.18
Crop	836.62	382.53
Nursery	27.71	17.35
Total	***1208.5***	***528.06***

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Table 19 Use of Recreational/Athletic Land of 2005		
Land Use	**Size (acres)**	**Impervious (acres)**
Recreational	140.25	9.38
Golf Course	369.2	50
Athletic Field	23.92	0
Total	***533.37***	***59.38***

5.3 Farm Tours

Based on the data obtained from the agricultural survey (see Appendix C) key agricultural land that may have an environmental impact on the Wreck Pond Watershed was inspected. The information gathered included the acreage of land actively farmed, the type, amount, and rate of fertilizers, herbicides and pesticides applied and the manure storage practices. The information was acquired and documented through personal interviews with the farm owners/managers. Soil samples were collected and were analyzed at the Rutgers University Soil Testing Lab and photographs.

A total of seven farms were visited and assessed. These farms were diverse in size and animals raised or crops grown. The inspections, while few in number, are believed to have given an accurate representation of typical practices at agricultural operations in the watershed. It was found through grower testimony that the quantities of fertilizers applied did not exceed what the crops can readily absorb, meaning, nutrients (Nitrogen, Phosphorous and Potassium) applied to the fields are not likely to run-off during storm events into the surrounding rivers and streams. The results from the nutrient monitoring (Appendix C) support this assumption.

However, of the four farms which raised animals, three of those farms may be impacting the watershed in a negative way in regards to manure management. It was observed that although the quantity of manure produced was relatively low, and the land was not directly adjacent to the stream, some microorganisms may reach the small tributaries of the Wreck Pond Watershed during large storm events. Table 20 describes the possible sources of contamination.

Table 20: Manure Management of Farms in Wreck Pond Watershed

Farm	Animals Raised	Appropriate Manure Management Practices?
1	18 head of steer	Yes
2	7 miniature donkeys	No
3	~ 20 chickens, 4 pigs	No
4	~ 10 sheep, ~ 20 chickens and turkeys	No

5.4 Water Quality Monitoring

Water quality measurements and a nutrient concentration study were performed. Samples were taken once a week for one year from November 2005 through November 2006 at the eight County sampling points along the upper and lower portions of the watershed on both the Wreck Pond Brook and Hannabrand Brook. Nitrate and Ammonia were collected along with conventional water quality parameters using a YSI

6600 probe, and orthophosphate data was collected with an optical calorimeter kit, initially ChemMetrics, and more recently by Hach. This differs from the collection of other water quality data discussed later in this study which was collected in the field and sent to a laboratory for analysis.

A full year, November 2005 – November 2006, of calibrated water quality measurements were made once a week at each of the eight County watershed sampling sites (Table 12 and Figure 10), with nine water quality parameters tested.

Table 21 summarizes the calibrated water quality results collected with ranges and median values. The number of observations is for all stations. The numbers vary by parameter as not every parameter had an accurate reading each week.

Table 21: RCE Water Quality Results

Parameter	Units	Range (Min & Max Observed)	# of Observations	Median Values
Temperature	ºC	2.92 - 30.34	318	16.53
Specific Conductivity	mS/cm	0.090 - 16.20	301	0.179
Dissolved Oxygen	mg/L	3.47 - 27.87[a]	214	10.39
pH	pH	5.18 - 7.48	318	6.35
Ammonia	NH_3 mg/L	0.00 - 0.040	310	0.00
Nitrate	NO_3 mg/L	0.02 - 15.79[b]	318	0.62
Turbidity	NTU	0.00 - 308.3	318	5.4
Chlorophyll	µg/L	0.0 – 16.5[c]	310	2.8
Ortho-Phosphate	PO_4^{-3} mg/L	0.05 - 1.50	223	0.27

[a]Max DO levels out of range
[b]Max nitrate levels higher than other watershed monitoring
[c]Two out-of-range values removed (48 in April and 82 in Oct)

It should be noted, that when comparing this water quality data to data collected by other partners, some readings for DO, nitrate, TSS and ortho-phosphate collected by RCE were out of acceptable ranges. This may be due to the fact that these measurements were collected via the water quality meters, while other partner data was analyzed with different methods, including laboratory analyses for nutrients and analyzed by different state certified laboratories.

pH data collected in this element is lower than those obtained by the County or by NA for the Borough study. The few very high DO readings taken by RCE were not seen in the NA monitoring or within the typical range of DO data and so are considered to be anomalous, out of range data. Similarly, comparison of nitrate data suggests that the above-standard RCE data are likely anomalies.

The table above combines all of the data for the watershed. Figures in Appendix C provide a breakdown by station. For example, as in other data collected, pH is lowest at W6.

Low pH and high turbidity were seen that did not conform to standards. Analysis of turbidity versus rainfall did not show a consistent pattern. Although nitrate was found above the drinking water standard of 10 mg/l which is a groundwater standard. It is more likely that this is a meter problem, than an accurate reading. In any event, the elevated nitrate concentrations were transient.

5.5 Macroinvertebrate Sampling

In addition to chemical and physical parameters, biological samples of macroinvertebrates were also taken at all Wreck sites once a month in June, July and August, 2006. Samples were taken using the EPA Rapid Bioassessment Protocols for Multiple Habitat Benthic Macroinvertebrate Sampling.

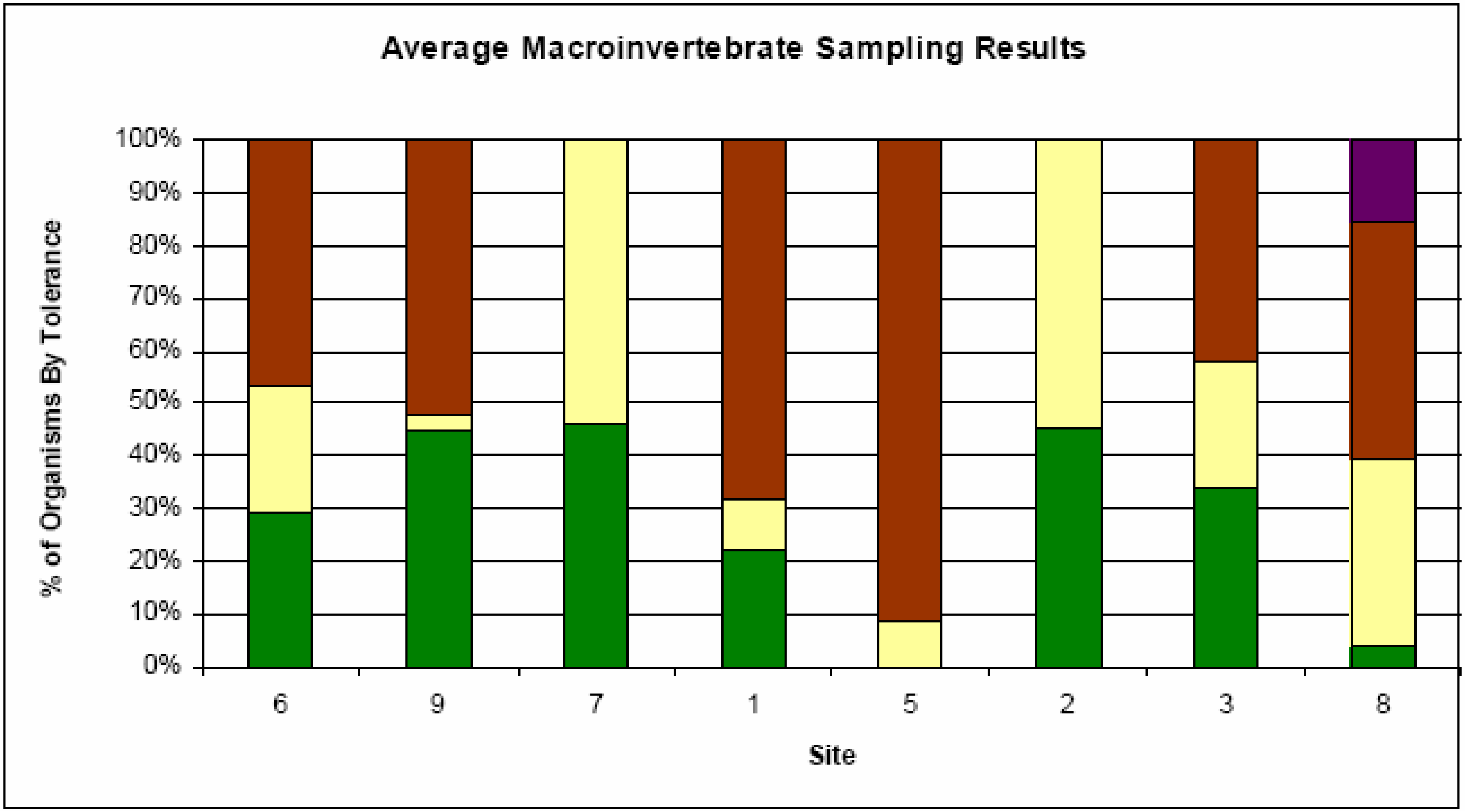
The results of the macroinvertebrate samples show a large variation between samples taken from the upper portion of the watershed and the lower portion of the watershed. Figure 13 shows the percentages of extremely intolerant organisms (purple), sensitive organisms (green), somewhat sensitive organisms (yellow) or tolerant organisms (red). In general, the sites from the upper portion of the watershed had a higher percentage of sensitive organisms. The sites from the lower portion of the watershed contained a lower percentage of sensitive organisms. Since the chemical monitoring results have shown no major nutrient loading problems, the macroinvertebrate results lead to the conclusion that the lower portion of the watershed may be experiencing higher negative effects from erosion and sedimentation.

The percentage of dominant organisms found at each site was compared to the percentage of sensitive organisms at those sites. The sites with the higher percentage of sensitive organisms also had a higher biodiversity, and the sites with a lower percentage of sensitive organisms had a lower biodiversity. Site W5 in particular should be noted as no sensitive organisms were found there.

5.6 Soil Sampling

A soils investigation also was conducted. The purpose of the soil sampling program was to determine the soil conditions existing naturally in the Wreck Pond watershed compared to the soil conditions found in representative agricultural operations as well as developed areas. The location of the soil samples was associated with the location of the stream water quality sample Wreck sites. In order to assess the general nutrient and fertility levels in the watershed, the area was first divided into four separate categories:

A. Agricultural (Ag) lands



. Legend: Purple: Extremely Intolerant;
Green: Sensitive
Yellow: Somewhat Sensitive;
Red: Tolerant

Figure 13: Wreck Pond Watershed

Average Macroinvertebrate Tolerance from RCE Sampling at Watershed Sites

B. Between Ag lands and native lands
C. Native land/control
D. Development

Agricultural lands were defined as dense agricultural areas that were farmland assessed. Native lands with indigenous vegetation areas such as forest and meadow regions with little agriculture or development served as control areas. Development areas were covered with residential housing, businesses and schools. Most stream segments included a range of these various categories within their contributing area.

Soil samples were taken in proximity to the stream water quality sample sites, and were collected either just above the stream bank, or at the farm site or home site. Samples were collected within each of the four categories. The selected soil areas in the stream site program were randomly sub-sampled ten times within a 25 foot line. The selected soil areas in the farm site program were randomly sub-sampled ten times within a one to two acre block. The selected soil areas in the home site or business program were randomly sub-sampled ten times within the half-acre of property. Sampling sites are shown on Figure 12.

Composite samples were selected and taken to the soil lab for analysis. Soil analysis consisted of levels of soil acidity as measured by pH, cation exchange capacity, macronutrient levels of phosphorus, potassium, magnesium and calcium and micronutrient levels of zinc, copper, manganese, boron and iron. Additionally, special tests were run on soil organic matter as measured by percentage of organic matter and organic carbon. Inorganic nitrogen was measured in the form of nitrate-N and ammonium-N.

The results of the stream bank soil tests revealed that all four land-use categories had macronutrient levels of phosphorus, potassium, magnesium and calcium that were either below optimum or optimum, rarely above. As for micronutrients, zinc, copper, manganese boron and iron were all either low or adequate, with the exception being iron. Iron levels were consistently high. However, these high iron readings are expected in the Wreck Pond Brook Watershed which has high levels of naturally occurring iron in soils and groundwater. The agricultural and developed stream banks showed a slightly higher level of organic matter and carbon, as well as nitrate-N and ammonium-N, than the native land control and mixed stream bank samples.

The results of the agricultural land soil tests revealed that more often than the stream bank samples, one or more macronutrients were above optimum levels, approximately 36 out of 48 samples. The micronutrients were normal, with the exception of iron, for the same reasons as described above. Organic matter, organic carbon, nitrate-N and ammonium-N had a wide range of results, depending on the field tested.

The results of the recreational and homeowner land soil tests were similar to those of the agricultural land results. The macronutrients occasionally reached above optimal levels 20 out of 32 samples, especially in phosphorus. Iron was the only high micronutrient, again for naturally occurring reasons. The organic matter, organic carbon, nitrate-N and ammonium-N showed no obvious distinction between the stream bank results or the agricultural land results.

5.7 Conclusions Agricultural and Recreational Land Survey

The study results did not find a significant impact from either the agricultural or recreational lands on the overall health of the Wreck Pond Brook Watershed. The water quality data found few instances in which water quality standards were not met. As noted, pH was most often in violation but this is likely due to naturally occurring low pH for the area. Other standard violations may be anomalies from use of water quality meters.

An area in obvious need of remediation is Site W5. Field observations make it apparent that it is being impacted by heavy soil erosion. This soil erosion is believed to be originating from a point source directly upstream. This issue is not related to agricultural or recreational lands.

The recommended action by the RCE to maintain surface water quality and further reduce what little impact agricultural or recreational lands are having on the watershed involves public education. The RCE have always recommended that prior to any planting or fertilizing that soil tests be done to first gauge the amount of nutrients already available in the land. If farmers, landscapers and homeowners follow the recommendations provided in their soil results, little nutrient run-off will take place. This policy benefits growers and landscapers in that given the high price of fertilizers, needless applications will greatly reduce costs. In addition to fertilizing practices, manure management also needs to be addressed. While it has been observed through farm tours that the majority of large, commercial Confined Animal Feeding Operations (CAFOs) appear to be complying with existing regulations in terms of manure management, smaller lands that may only have a few farm animals, do not fall into this category. These small “hobby farms” are difficult to identify and regulate.

Owner education appears to be the most effective option. To further this goal, an information packet was also handed out containing runoff and erosion BMPs from the USDA – Natural Resource Conservation Service (NRCS). The Monmouth County Agricultural Agent, William Sciarappa, Ph.D., will provide individual BMP recommendations to all those who store manure, if current storage methods appear to be inappropriate. These recommendations will help assure that those managing the farm lands are adhering to the appropriate Stormwater Management Regulations and USDA – NRCS measures, as well as preventing soil erosion and nutrient and pathogen runoff from their lands.

The RCE plans to increase their efforts in educating growers, landscapers and homeowners on the negative impacts over fertilizing has not only on their land, but the health of the entire watershed. Public informational programs are planned for any and all stakeholders to reiterate the importance of reducing stormwater runoff and erosion, as well as easily implementable low-cost Best Management Practices. On-farm demonstrations of manure management facilities and commercial practices have been conducted previously in the county and more are planned to take place in the near future to be better engage smaller operations such as seen in the Wreck Pond Watershed.

6 MICROBIAL SOURCE TRACKING

Finding the source of fecal pollution is complex because it is rare to find pollution in the Wreck Pond watershed flowing in clearly defined channels. In this watershed, fecal pollution enters the waterbody in various ways and rapidly becomes mixed. Microbial Source Tracking studies aim to deconvolute this intricate system, find the source of contamination, and then effect remediation.

A Microbial Source Tracking Study was conducted by Monmouth University in 2005 to characterize and differentiate between potential sources of bacterial contaminants contributing to the Wreck Pond watershed (Monmouth University Final Report Sept 2007) using Antibiotic Resistance Analysis (ARA) methodologies. This section summarizes that report.

ARA is a phenotypic library-based MST technique developed as a method for microbial source tracking based on the assumption that bacteria from the intestines of humans and domestic animals will have different antibiotic profiles. The antibiotic profiles should differ because hosts exposed to different antibiotics or differing amounts of the same or similar antibiotics will develop varying resistance to those antibiotics. When bacteria are grown in the presence of several different antibiotics, certain patterns of resistance are created and ARA profiles can be developed for each source. Individual profiles for bacteria present in animal species can be compiled to form a library of antibiotic resistance profiles. These profiles then can be compared with fecal pollution from unknown sources in water samples to determine the source of contamination.

Results from MST studies can be used to develop area-specific stormwater management measures to improve water quality and control the sources of pollutants that adversely affect beneficial uses of the waterbodies that comprise Wreck Pond watershed.

6.1 ARA Profile Library Creation for Known Sources

The Monmouth University MST study developed a large database of ARA profiles for potential sources of fecal pollution including farm animals, wild animals, waterfowl, humans and pets. The human source was collected from raw sewage influent to treatment plants, while known samples of the other sources were collected either directly from the animals or their droppings. Bacterial samples were grown in the presence of the various antibiotics and a library of resistance patterns was developed.

6.2 Water Sampling

Water samples were collected from 12 stations in the watershed including Wreck Pond, Old Mill Pond, Osborn Pond, Albert Pond, and the three tributary streams as shown in Table 22. Temperature, salinity, DO and pH were also measured at each station. Seven sampling events were conduced during the summer of 2005. Table 23 summarizes the ambient water quality data collected. These data show measurable salinity at stations 1, 2 and 3. DO is found below standard at several stations. In particular, the minimum DO at Station 3 within Wreck Pond as 1.7 mg/l, suggesting very low DO and highly stressed conditions. This was only noted on one occasion. DO of around 3.4-3.7 mg/l was found at several other stations, which is below standard and can impair aquatic life.

6.3 ARA Results

The overall results of the study led to the conclusion that fecal pollution in the watershed is from mixed sources. Monmouth's final report documents the fact that waterfowl, other wildlife, farm animals and humans may be sources at all of the stations. Pets were found to be of less importance throughout the watershed.

The possibility of human sources of bacteria is of concern within the watershed since a host of pathogens are associated with fecal contamination. There are no known point sources to Wreck Pond or its tributaries. In addition, there are no known septic systems within the watershed. However, there may be illicit or historic septic systems that still contribute to pollution.

Another potential source of human bacteria is cross-connection of sewer and stormwater lines or leaking sewer lines which could be a source of human contamination. The infrastructure within Spring Lake is old. However, some of the sewer mains were previously studied and areas of concern were identified and re-lined according to the Spring Lake Department of Public Works. In the time since those studies, other systems of the pipes may have been compromised. Further, connections from homes to the sewer lines may have leaks, but are not routinely impacted.

In summary, the overall conclusion of the Monmouth University report is that several sources of fecal bacteria are present in the watershed. The report suggests BMPs that may serve to reduce loadings, some of which are included in Book 2 of this Plan.

Table 22: Monmouth University Water Quality Sample Locations		
WRECK POND WATERSHED STATIONS	**STATION NAME**	**STATION LOCATION**
Station 1	Wreck Pond West of Oceanfront Floodgate	Salt pond area west of ocean floodgate south of the municipal parking lot adjacent to Brown Avenue Latitude: 40°08.317' N; Longitude: 74°01.641'W
Station 2	Wreck Pond at Second Avenue	Wreck Pond shoreline at the intersection of Second Avenue and Ocean Road Latitude: 40°08.524' N; Longitude: 74°01.782'W
Station 3	Wreck Pond	Northern shore of Wreck Pond south of Ocean Road crossing Latitude: 40°08.588' N; Longitude: 74°02.059'W
Station 4	Black Creek (N. Branch) at Ocean Road	Eastern shore of Black Creek at the intersection of Ocean Road and Fourth Avenue Latitude: 40°08.603' N; Longitude: 74°02.010'W
Station 5	Black Creek (N. Branch) East of Route 71	Stream channel of Black Creek east of Route 71 across from the Spring Lake Golf Club Latitude: 40°08.827' N; Longitude: 74°02.455'W
Station 6	Wreck Pond Brook West of Route 71	Southern shore of Wreck Pond Brook west of Route 71 adjacent to Jimmy Byrne property Latitude: 40°08.428' N; Longitude: 74°02.579'W
Station 7	Wreck Pond Brook at Old Mill Road	Northern shore of Wreck Pond Brook east of Old Mill Road at the intersection of Old Mill Road and Butternut Road Latitude: 40°08.609' N; Longitude: 74°03.189'W
Station 8	Old Mill Pond	Northeast shore of Old Mill Pond at the Old Mill Inn restaurant boat ramp Latitude: 40°08.699' N; Longitude: 74°03.261'W
Station 9	Osborn Pond	Osborn Pond at foot of Mill Pond Court Latitude: 40°09.350' N; Longitude: 74°03.572'W
Station 10	Albert Pond	Albert Pond at intersection of Oxford Lane and private road Latitude: 40°09.719' N; Longitude: 74°03.516'W
Station 11	Wreck Pond Brook at Allenwood Road	Stream channel east of Allenwood Road crossing just downstream from Hurley Pond Latitude: 40°10.652' N; Longitude: 74°05.421'W
Station 12	Hannabrand Brook At Allaire Road	Eastern stream bank of Hannabrand Brook on south side of Allaire Road across from Bel-Aire County Golf Course Latitude: 40°09.032' N; Longitude: 74°05.483'W

Table 23: Summer Water Quality Data – Monmouth University					
Date	**Time**	**Temp (^oC)**	**Salinity (ppt)**	**DO (mg/l)**	**pH**
Station 1	Minimum	17.1	12.30	4.8	7.6
	Maximum	26.8	29.60	8.8	8.5
	Mean	23.0	23.63	7.5	7.9
Station 2	Minimum	21.0	7.40	3.9	7.1
	Maximum	26.1	24.90	9.7	8.1
	Mean	24.1	17.36	7.2	7.7
Station 3	Minimum	21.4	0.00	1.7	7.1
	Maximum	28.5	22.30	11.2	8.8
	Mean	25.7	6.85	7.5	7.9
Station 4	Minimum	20.9	0.00	3.4	6.6
	Maximum	29.0	0.00	9.2	7.9
	Mean	24.9	0.00	5.7	7.3
Station 5	Minimum	20.0	0.00	3.6	6.5
	Maximum	25.5	0.00	8.8	6.9
	Mean	23.2	0.00	6.0	6.7
Station 6	Minimum	20.9	0.00	5.6	6.4
	Maximum	27.9	0.00	13.6	6.9
	Mean	23.3	0.00	8.5	6.6
Station 7	Minimum	17.7	0.00	7.7	6.3
	Maximum	20.4	0.00	10.8	6.6
	Mean	19.0	0.00	8.8	6.4
Station 8	Minimum	20.7	0.00	3.5	6.2
	Maximum	26.1	0.00	10.3	6.8
	Mean	23.3	0.00	6.8	6.5
Station 9	Minimum	18.6	0.00	5.1	6.1
	Maximum	23.5	0.00	9.0	6.9
	Mean	20.6	0.00	7.3	6.4
Station 10	Minimum	22.5	0.00	3.5	6.7
	Maximum	25.5	0.00	11.2	7.5
	Mean	24.1	0.00	5.9	7.0
Station 11	Minimum	19.3	0.00	5.0	6.2
	Maximum	25.4	0.00	7.6	9.9
	Mean	23.4	0.00	6.6	7.1
Station 12	Minimum	19.2	0.00	4.4	6.1
	Maximum	23.8	0.00	10.3	7.3
	Mean	22.6	0.00	7.7	6.5