STORMWATER ASSESSMENT PROCEDURE TECHNICAL MEMORANDUM

Garrett County, Maryland
North Glade Run Watershed
Stormwater Assessment

AMT Project
15-0097.001
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To: Deborah Carpenter

From: Carlos Cuneo, P.E. and Greg Fox. P.E.

BACKGROUND:

Garrett County retained A. Morton Thomas and Associates, Inc. (AMT) to conduct a stormwater assessment of the North Glade Run (NGR) watershed. One of the goals of the Deep Creek Watershed Management Plan is to "manage stormwater infrastructure to decrease pollution from existing and proposed development to ensure healthy watershed conditions". With that in mind, the goal of this project is to identify areas of the watershed that exhibit stormwater problems and to create an action plan to address the issues and prioritize its implementation.

STORMWATER ASSESSMENT PROCEDURE:

This technical memorandum serves as a reference guide to assess stormwater problems within the NGR watershed and for future watershed assessments. It documents the procedures and decisions undertaken to analyze, evaluate and prioritize stormwater areas with runoff problems. The following sections of the technical memorandum describe the data collected, derived and analyzed, provides a description and significance of the selected criteria, the weighting factors applied to the selected criteria, and the assessment procedures implemented for the geographic information system (GIS) desktop analysis and subsequent engineering screening of the derived problematic areas with regards to stormwater runoff.

WATERSHED DATA COLLECTED:

Garrett County provided an extensive collection of GIS data for the NGR watershed. Data provided included: watershed boundary, 2-ft topographic contours, parcels, road centerlines, wooded forest delineation, Deep Creek Lake boundary, boat docks, address points, development subdivisions, sanitary districts, stormwater structures and ditches, streams, swamps, land use zoning, buildings, paved and unpaved driveways, roads and parking lots, fences, retaining walls, and aerial photography of the watershed for years 2005, 2008, and 2011. Additionally, lake water quality data was provided by the Department of Natural Resources (DNR) in a spreadsheet format and GIS soil data was obtained from the NRCS website.

DATA CREATED AND DERIVED:

AMT created several new GIS coverage and feature data for the watershed from the data provided by the County which provided valuable information to assess potential stormwater problems in the watershed. Multiple coverages were calculated utilizing the 2-ft topographic contours provided. Coverages created include digital elevation model (DEM), triangular irregular networks (TIN), watershed hill shade, flow accumulation, flow direction, flow lengths, drainage patterns, and ground slope. Overlaying the created coverages with feature data provided, new feature data were created including: subwatersheds, hydrologic soil group (HSG), and soil erodibility factor. Additionally, new feature layers were created from

the DNR provided lake water quality data that spatially display the data points. Similarly, the returned "Citizen Input Forms" were linked to the GIS parcel layer to spatially display accepted and denied right-of-entry (ROE) responses, as well as, recorded citizen's concerns. Finally, all pictures taken during the field visits were spatially geo-tagged and loaded to the GIS system for ease of desktop site reconnaissance and assessment.

DATA ANALYSIS:

All the GIS data provided by the County and State agencies, as well as the data created and derived by AMT was compiled into a geodatabase for ease of storage, organization, collaboration, and analysis. Using the subwatershed layer as the geographic boundary to summarize the information, pertinent subwatershed characteristics were extracted and calculated. Recorded data includes; subwatershed drainage area, ground relief statistics (minimum, maximum, mean and standard deviation), impervious cover percentage, agricultural cover percentage, wooded cover percentage, hydrologic soil group percentage (A, B, C, and D), average soil erodibility coefficient, number of citizen's concerns, number and type of stormwater management (SWM) structures, ditch length statistics (sum, density and length relief density), and hotspot area identification.

GIS DESKTOP EVALUATION CRITERIA:

Several GIS provided and derived data were considered in determining subwatersheds for further analysis. In addition, data derived from field observations and citizen's feedback were also considered. Below is a brief description of each of the watershed characteristics evaluated:

- Hydro ID: Identification number for subwatershed. The NGR watershed was subdivided into a total of 78 subwatersheds and given a random identification number;
- Acres: Drainage area of subwatershed in Acres;
- Relief Min: Minimum ground relief of the subwatershed as a percentage;
- Relief Max: Maximum ground relief of the subwatershed as a percentage;
- Relief Range: Range of ground relief, difference between maximum and minimum in percentage;
- Relief Mean: Average ground relief of the subwatershed as a percentage;
- Relief Std: Ground relief standard deviation of the subwatershed;
- ImperPct: Percentage of the subwatershed with impervious surfaces as defined by the GIS paved and unpaved road surface, building, driveway, and parking lot layers.
- AgriPct: Percentage of the subwatershed with agricultural land use as defined by the GIS Zoning layer.
- WoodPct: Percentage of the subwatershed with wooded land use as defined by the GIS Forest Wooded layer.
- HSG A: Percentage of the subwatershed with hydrologic soil group A as defined by the NRCS GIS Soil layer.
- HSG B: Percentage of the subwatershed with hydrologic soil group B as defined by the NRCS GIS Soil layer.

- HSG C: Percentage of the subwatershed with hydrologic soil group C as defined by the NRCS GIS Soil layer.
- HSG D: Percentage of the subwatershed with hydrologic soil group D as defined by the NRCS GIS Soil layer.
- HSG W: Percentage of the subwatershed with hydrologic soil group W, water, as defined by the NRCS GIS Soil layer.
- Soil HSG: An overall numerical value that identifies the prevalent hydrologic soil group of the subwatershed. The value corresponds to the weighted average based on area of the hydrologic soils by assigning a 1 to soil type A, 2 to soil type B, 3 to soil type C, and 4 to soil type D, without considering water areas.
- Soil K: Soil erosion factor identifies the susceptibility of the soil to sheet and rill erosion by water. The K factor ranges from 0.02 to 0.69, the higher the value the more susceptible the soil is to sheet and rill erosion by water.
- SWM No: Indicates the number of stormwater management structures in the subwatershed. The number of structures is evaluated in combination with the type of structures.
- Ditch ft: Total length in feet representing the sum of the lengths of ditches in the subwatershed.
- Ditch FA: Total ditch length in feet divided by the drainage area in acres. This parameter provides information about the subwatershed ditch density.
- Ditch FRA: Total ditch length in feet multiplied by the mean relief in percent and divided by the drainage area in acres. The parameter provides information about the subwatershed ditch density concerning the potential for flashy, high velocity, concentrated flows.
- Complaints: Number of citizen complaints/comments related to rainfall runoff problems as expressed in the returned Citizen Input Form.

The subwatershed parameters described above were evaluated and screened. A screened list of parameters was used to evaluate the subwatersheds susceptibility to stormwater runoff problems. The list included the following parameters: impervious percentage, mean and maximum relief, soil HSG, soil K factor, ditch feet/relief/area, and citizen's concerns. Each parameter was then weighted based on their potential to produce rainfall runoff and sediment load using engineering judgment. Finally, the subwatershed parameter individual scores were summed and the subwatersheds with the highest scores were further evaluated for potential stormwater runoff problems and recommended improvements. Additional criteria used to assess the subwatershed after the initial ranking included drainage area, number and type of SWM facilities, field assessments, and stormwater hotspots.

The screened parameters were given an adjustment weight based on the potential to produce rainfall runoff and/or sediment loads. The weighting factors ranged from 1 to 3, with 3 representing the greatest potential for runoff/sediment. Maximum relief and ditch length/relief/area were given an adjustment weight of 1. Mean relief, hydrologic soil group type, citizen's concerns, and soil K factor were given an adjustment weight of 2. Impervious area percentage was given an adjustment weight of 3.

All subwatersheds were assessed, one parameter at a time. Each individual parameter was evaluated independently and its range of values was examined. Instead of assigning a score based on ranges to every parameter value, a top two-tier scoring system was implemented and used. The top and second tier

break points were initially based on parameter percentile values. Parameters where a higher value increased the potential for stormwater runoff and erosion (all parameters except "Soil HSG") received a top tier break point around the 0.9 percentile value and a second tier break point around the 0.8 percentile value. For "Soil HSG", where a lower value increased the potential for stormwater runoff and erosion, the top tier break point was based around the 0.1 percentile value and the second tier break point was based around the 0.2 percentile value. The calculated tier break points were then compared against each parameter distribution and slightly adjusted to match with natural breaks in the dataset.

Subwatersheds with any parameter values in the top two tiers were identified, selected and scored. Each parameter value within the top tier was given 10 points, with 3 points for those within the second tier. The given score for each subwatershed was calculated as the number of points multiplied by the parameter adjustment weight. The subwatersheds with the resulting highest scores (sum of the scores across all parameters) were selected for detailed assessment and review. Table 1 summarizes the parameters statistics and selected target tier values for top two tiers. Table 2 summarizes the parameter values for the top-scored subwatersheds in the North Glade Run resulting from the GIS desktop analyses.

Table 1. Subwatershed Parameter Statistics and Target Tier Values

Parameter Statistics	Subwatershed Parameter						
	Maximum Relief (%)	Mean Relief (%)	Soil HSG[1]	Soil K Factor	Impervious (%)	Citizen Concern[2]	Ditch F-R-A
Minimum	10.0	4.1	1.217	0.283	0.0	0	0
Maximum	60.0	15.4	3.783	0.397	32.8	5	1313
Average	31.1	9.3	2.372	0.364	6.3	0.2	262
Std. Dev	10.4	3.4	0.552	0.017	5.5	0.7	287
Top Tier Value	40.0	14.5	1.660	0.390	12.8	N/A	823.3
Second Tier Value	33.3	13.5	1.999	0.375	10.2	N/A	450.5

[1] Values smaller or equal to the target tier values were scored, values equal or greater to the target tier values were scored for all other parameters
[2] Parameter scored directly based on the number of stormwater runoff concerns received

Table 2. Preliminary Subwatershed Assessment, Parameter Value and Overall Score

Shed ID	Subwatershed Parameter							Shed Score
	Maximum Relief (%)	Mean Relief (%)	Soil HSG	Soil K Factor	Impervious (%)	Citizen Concern	Ditch F-R-A	
123	35.0	8.3	1.842	0.369	12.8	3	624.6	48
160	43.3	12.5	1.540	0.359	16.4	5	617.5	73
191	60.0	9.1	1.973	0.365	15.6	0	323.2	46
193	50.0	15.0	1.998	0.370	14.9	1	667.1	71
206	46.7	14.5	2.666	0.310	15.2	1	1313.3	72
207	36.7	13.6	1.615	0.369	32.8	0	1003.9	69

GIS DESKTOP EVALUATION SUBWATERSHED SELECTION:

Based on the results of the GIS desktop evaluation, as summarized in Table 2, a brief description of each subwatershed identified in Table 2 is provided below.

Subwatershed ID 123:

Subwatershed 123 is located in Beckman Peninsula across from Harvey Peninsula. The drainage area has approximately 32.6 acres and includes residential houses located along Wooded Ridge Road and White Oak Drive. This portion of Beckman Peninsula was developed before stormwater management regulations; therefore, limited stormwater management measures exist. Most of the runoff is collected by road ditches and routed across the road via culverts to private property before discharging to Deep Creek Lake. The drainage topology is steep, particularly along the eastern boundary of the subwatershed with slopes of as much as 35 percent and an overall subwatershed slope of approximately 8.3 percent. The impervious cover accounts for approximately 13 percent of the drainage area and includes paved roads. The hydrologic soil groups in the area are mainly A and B type, meaning they have good infiltration potential, but are also highly erodible. Three citizen concern forms were received voicing continuous stormwater runoff problems in this area.

Subwatershed ID 160:

Sunwatershed 160 is located in Harvey Peninsula across from Beckman Peninsula. The drainage area has approximately 42.4 acres and includes residential houses located along Oak Way Road and South Shore Road. This portion of Harvey Peninsula was developed before stormwater management regulations and has no stormwater management measures. Stormwater runoff is collected by road ditches and routed across the road via culverts to private property before discharging to Deep Creek Lake. The subwatershed has a high density of drainage ditches per unit area leading to effective collection and concentration of stormwater runoff. The drainage topology is very steep along the entire subwatershed, which has a rectangular shape, with wide sides and a narrow flow path. The subwatershed has slopes of as much as 43 percent and an average slope of 12.5 percent. The impervious cover accounts for approximately 16.4 percent of its drainage area. The hydrologic soil groups in the area are mainly A and B type, meaning they have good infiltration potential, but are also highly erodible. Five citizen concern forms were received voicing continuous stormwater runoff problems in this area.

Subwatershed ID 191:

Subwatershed 191 is located at the tip of Beckman Peninsula with a drainage area of approximately 14.9 acres, the subwatershed includes residential houses located along Beckman Peninsula Road and Bethesda Trail. This portion of Beckman Peninsula was developed before stormwater management regulations and no stormwater management measures exist. Stormwater runoff from the road is collected by road ditches and routed to private property before discharging to Deep Creek Lake. The drainage topology is moderate-to-steep with an overall slope of approximately 9.1 percent, but with a portion of the drainage area that is very steep with slopes of as much as 60 percent. The impervious cover accounts for approximately 15.6 percent of the drainage area and includes paved roads. The hydrologic soil group in the area is mainly B type, meaning it has moderate-to-good infiltration potential, but is also highly erodible. No citizen concern forms were received in this area.

Subwatershed ID 193:

Subwatershed 193 is located along the southern edge of Beckman Peninsula with a drainage area of approximately 26.4 acres. The subwatershed includes residential houses located along White Oak Drive. This portion of the peninsula was developed before stormwater management regulations and has no stormwater management measures. Stormwater runoff is collected by road ditches and routed across the road via culverts to private property before discharging to Deep Creek Lake. The subwatershed has a high density of drainage ditches per unit area leading to effective collection and concentration of stormwater runoff. The drainage topology is very steep along the entire subwatershed, which has a rectangular shape, with wide sides and a narrow flow path. The subwatershed has slopes of as much as 50 percent and an average slope of 15 percent. The impervious cover accounts for approximately 14.9 percent of its drainage area, which includes paved roads. The hydrologic soil group in the area is mainly B type, meaning they have good infiltration potential, but are also highly erodible. One citizen concern form was received voicing continuous stormwater runoff problems in this area.

Subwatershed ID 206:

Subwatershed 206 extends from the North Glade Run watershed ridgeline to Deep Creek Lake and has a drainage area of approximately 76.9 acres. The subwatershed includes residential houses located along Pinnacle Drive, Driftwood Drive, Glen Cove Road and Glen Cove Circle. The subwatershed includes a combination of road ditches and stormwater management measures to try to convey stormwater runoff safely to the lake. The subwatershed has a high density of drainage ditches per unit area leading to effective collection and concentration of stormwater runoff. The drainage topology is very steep along the entire subwatershed, which has a rectangular shape, with wide sides and a narrow flow path. The subwatershed has slopes of as much as 46.7 percent and an average slope of 14.5 percent. The impervious cover accounts for approximately 15.2 percent of its drainage area, which includes paved and unpaved roads. The hydrologic soil groups in the area are mainly C and D type, meaning they have poor infiltration potential, but also have low potential for erosion. One citizen concern form was received voicing continuous stormwater runoff problems in this area.

Subwatershed ID 207:

Subwatershed 207 is located at the tip of Harvey Peninsula with a drainage area of approximately 6.8 acres. The subwatershed is located along Round Beach Circle Drive and includes residential houses and a boat marina. The subwatershed includes a combination of road ditches and stormwater management measures to try to convey stormwater runoff safely to the lake. The subwatershed has a high density of drainage ditches per unit area leading to effective collection and concentration of stormwater runoff. The drainage topology is steep with slopes of as much as 36.7 percent and an average slope of 13.6 percent. The impervious cover accounts for approximately 32.8 percent of its drainage area, which includes buildings, driveways, the marina, and paved and unpaved roads. The hydrologic soil groups in the area are mainly A and B type, meaning they have good infiltration potential, but are also highly erodible. No citizen concern forms were received in this area. In addition, Patterson Boat Company is considered a stormwater hotspot based on the Maryland Department of the Environment (MDE) definition and special stormwater requirements must be in place.

FIELD INVESTIGATIONS:

Based on the results of the GIS desktop evaluation, as summarized in Table 2, a screening and final subwatershed selection process was implemented. The final selection process involved weighing in knowledge gathered from field observations, including the existence of SWM structures, stormwater hotspots (as defined by MDE) and engineering judgment. Through the application of the final selection criteria two subwatersheds previously selected were excluded and three new subwatersheds added. The two excluded subwatersheds are subwatersheds ID 191 and 206. The three subwatershed added are subwatershed 89, 121/213, and 141. The factors that lead to the decision to exclude or include subwatersheds to the final subwatershed selection are discussed below.

Subwatershed ID 191:

Subwatershed 191 was excluded from the final subwatershed selection based on no visual evidence of stormwater runoff problems. Most of the drainage area is moderately sloped, relative to the other selected subwatershed, but the relief values are skewed by a very steep, but stable, portion of the drainage area in the proximity of Patterson Boat Marina. The road ditches do not have large contributing drainage areas and mainly collect road runoff resulting in low volume concentrated flows. Stormwater runoff from the rest of the drainage area is routed to Deep Creek Lake as dispersed overland flow.

Subwatershed ID 206:

Subwatershed 206 was excluded from the final subwatershed selection based on no significant visual evidence of stormwater runoff problems. The drainage area is very steeply sloped, but at the same time it is the subwatershed with the highest value for road ditch density. Most of the roads in the subwatershed have drainage ditches that collect and route stormwater runoff to existing stormwater management facilities or constructed outfalls. Stormwater runoff north of Glendale Road is mostly routed to a detention pond for safe release downstream. The pond discharge and remaining runoff north of Glendale Road is mostly routed to a constructed outfall discharging into Deep Creek Lake north of the bridge. The road ditch along Glendale Road has an intermediate relief culvert near the intersection with Driftwood Drive. This outfall previously caused runoff problems for the homeowners along Driftwood Drive, but stormwater management measures were taken by the homeowners to capture the runoff and safely route it to Deep Creek Lake.

Subwatershed ID 89:

Subwatershed 89 is located at the point of discharge of North Glade Run into Deep Creek Lake and represents the point of entrance of approximately 47 percent of the watershed by area and the greatest point source of stormwater runoff into Deep Creek Lake in the watershed. The stream collects and routes stormwater runoff from the eastern part of the watershed, an area mainly used for agricultural purposes. Field assessments of the subwatershed indicated that the road culvert under North Glade Road is undersized to convey the stormwater runoff from less frequent storm events, like the 10-yr event, and that the road overtops under such events. Additionally, the stream reach downstream of North Glade Road showed signs indicative of a degrading stream. Indicators of active channel widening and incising, such as multiple fallen and undercut trees, were observed along the streambanks. This stream reach, being the main lake influent in the watershed, presents the greatest opportunity to reduce sediment and nutrient loadings into Deep Creek Lake.

Subwatershed ID 121/213:

Subwatersheds 121 and 213, originally considered separately for the desktop analysis, were combined due to Bill's Marina footprint expansion of their boat storage hangers into subwatershed 121. Their combined drainage area is approximately 39.4 acres. The combined subwatersheds were added to the final subwatershed selection because Bill Marina is considered a stormwater hotspot based on the MDE definition and special stormwater requirements must be in place.

Subwatershed ID 141:

Located on the south side of the Lake, Subwatershed 141 includes part of the Sky Valley subdivision with a drainage area of approximately 94.6 acres. Field assessments of the subwatershed identified two point sources of erosion and sediment related to stormwater runoff. One point source problem is related to the cascading culvert outfall located at the intersection of Valley View Drive and Piney Point Drive. Stormwater runoff from the residential houses is routed via roadside ditches to the intersection of Piney Point Drive and Valley View Drive where runoff is collected and then discharged under the road through a culvert down a steep hillside channel to a drainage ditch along Sky Valley Drive to ultimately converge with a tributary stream to Deep Creek Lake. The cascading outfall is actively eroding and incising the channel banks and bottom and tree failure along the channel is evident. The other point source problem is related to the pond located at the intersection of Sky Valley Drive and Bench Road. Field investigations did not find any evidence of outfall protection at the pond outfall which currently freefalls from an approximate height of 3 feet to the receiving stream channel. The existing outfall configuration is actively scouring the channel bottom and vertical banks providing significant sediment loads to Deep Creek Lake.

Following the stormwater assessment procedure outlined in the previous sections for scoring, screening and finalizing the subwatershed selection, Table 3 summarizes the parameter values for the final subwatershed selection within North Glade Run watershed.

Table 3. Stormwater Assessment Procedure, Final Subwatershed Selection and Parameter Values

Shed ID	Subwatershed Parameter						
	Maximum Relief (%)	Mean Relief (%)	Soil HSG	Soil K Factor	Impervious (%)	Citizen Concern	Ditch F-R-A
89	36.7	12.1	2.396	0.358	1.8	1	170.4
121/213	25.0	5.5	2.209	0.369	22.3	0	506.4
123	35.0	8.3	1.842	0.369	12.8	3	624.6
141	45	13.9	2.207	0.375	10.7	0	475.9
160	43.3	12.5	1.540	0.359	16.4	5	617.5
193	50.0	15.0	1.998	0.370	14.9	1	667.1
207	36.7	13.6	1.615	0.369	32.8	0	1003.9

RECOMMENDATIONS:

AMT performed several field investigations throughout the duration of the project to visually assess and evaluate the North Glade Run watershed and to take measurements for the hydrologic analyses and recommended improvements. Field investigations indicated that the watershed, as a whole, is in good

condition from a stormwater runoff point of view. The North Glade Run watershed overall has a relatively low impervious cover percentage. The watershed has an elongated drainage shape with a 3-to-1 ratio between the long and short sides. Topographically and demographically, the watershed could be divided into two regions, western and eastern. The western region is where most of the residential development has occurred along a cove of Deep Creek Lake that divides the watershed through the middle. It is characterized by steep topography all the way to the edge of the lake and single family houses built in a terrace fashion providing views of the lake through the wooded landscape. This region does not have perennial long and wide streams feeding into the lake, but short, narrow and intermittent channels with low baseflow. There are some areas with defined channels, but for the most part stormwater runoff is routed to the lake as overland runoff. It is in this region where most of the stormwater management facilities have been constructed. Waterfront Greens and Glenfield developments have most of the SWM facilities while other developments, built pre-stormwater regulations, have none. The eastern region, east of Waterfront Greens and Sky Valley developments, has more gentle topographic relief and the land is mainly used for agricultural activities.

Even though AMT crews traversed the entire watershed, the focus of the stormwater assessment was in the residential component of the watershed and identifying opportunities to reduce runoff erosion, sediment transport and nutrient loading to Deep Creek Lake. DNR, working with the County, was tasked to perform stream corridor assessments, as well as working with the agricultural component of the watershed. Nonetheless, it should be noted that during our field visits on the eastern region of the watershed we noted several potential sources of sediment and nutrient loading in the agricultural areas. While many fields were properly fenced creating a buffer and keeping livestock out of streams, we noticed several fields with no fences separating livestock from the streams. There were several points along the streams that were identified as livestock stream crossing points. These areas showed wider stream banks with loose soil and gentler channel side slopes. There were also instances where livestock were in the stream bathing. AMT recommends that all agricultural fields have fences on both sides of streams to create a buffer area to filter out nutrients and exclude livestock.

STORMWATER HOTSPOTS:

Pollution source control includes the management of potential “stormwater hotspots” which are certain commercial, industrial, institutional, municipal, and transport-related operations in the watershed. These stormwater hotspots tend to produce higher concentrations of polluted stormwater runoff than other land uses and have a higher risk for spills. Specific on-site operations and maintenance combined with pollution prevention practices can significantly reduce the occurrence of “stormwater hotspot” pollution problems.

Maryland Department of the Environment (MDE) defines “Stormwater Hotspots” as a land use or activity that generates higher concentrations of hydrocarbons, trace metals or toxicants than are found in typical stormwater runoff, based on monitoring studies. The list below provides the land uses or activities classified as stormwater hotspots for the State of Maryland by MDE. Appendix C provides reference documentation for General Permit for Marinas and guidelines from MDE.

- Vehicle salvage yards and recycling facilities*;
- Vehicle service and maintenance facilities;
- Vehicle and equipment cleaning facilities*;
- Fleet storage areas (bus, truck, etc)*;
- Industrial sites (certain SIC codes);
- **Marinas (service and maintenance)***;

- Outdoor liquid container storage;
- Outdoor loading/unloading facilities;
- Public works storage areas;
- Facilities that generate or store hazardous materials*;
- Commercial container nursery;
- Other land uses and activities as designated by an appropriate review authority.

* Stormwater pollution prevention plan implementation is required for these land uses or activities under the EPA NPDES stormwater program.

From a BMP design perspective, if a site is designated as a stormwater hotspot it has important implications for how stormwater is managed. First and foremost, untreated stormwater runoff from stormwater hotspots cannot be allowed to infiltrate into groundwater where it may contaminate water supplies. Second, a greater level of stormwater treatment is needed at stormwater hotspot sites to prevent pollutant washoff after construction. This typically involves preparing and implementing a stormwater pollution prevention plan that involves a series of operational practices at the site that reduces the generation of pollutants by preventing contact with rainfall.

After finalizing the selection of the top subwatersheds susceptible to stormwater runoff problems as it relates to the water quality of Deep Creek Lake, AMT developed individual improvement concept projects for each subwatershed. A brief description of the runoff problems observed in each subwatershed is provided below; detailed concept design information is included in Appendix A, which provides a brief narrative for each proposed concept project along with a plan view of the concept design and standard details. Appendix B provides detailed hydrologic and hydraulic calculation information. The implementation of these projects will depend on the agreement and cooperation of all involved stakeholders.

Subwatershed ID 89:

Subwatershed 89 was not initially identified by the GIS desktop analysis. Nonetheless, the subwatershed was included in the final subwatershed selection based on field observations. Field assessment of the area identified two areas of concern, the culvert under North Glade Rd near its intersection with Beckman Lohr Road and the downstream reach of North Glade Run, just upstream of its confluence with Deep Creek Lake. The road culvert showed signs of overtopping and damage to the headwall and embankment was observed. Hydrologic and hydraulic analyses showed that the existing culvert is undersized and that the road would overtop under the 10-year storm event. The stream reach assessed downstream of North Glade Road showed signs indicative of a degrading stream reach. Active channel widening and incising signs were observed along with multiple fallen and undercut trees. Given the large drainage area tributary to the stream reach, stream restoration presents the greatest opportunity to reduce sediment and nutrient loads to Deep Creek Lake.

Subwatershed ID 121/213:

Subwatershed 121/213 was not initially identified by the GIS desktop analysis. Nonetheless, the subwatershed was included in the final subwatershed selection due to the presence of Bill's Marina, which is considered a stormwater hotspot based on the MDE definition and the requirement that special stormwater practices be in place. Field assessment of the area did observed stormwater runoff problems at the discharge point of the subwatershed into the Lake. Field observations of the downstream channel, just downstream of the culvert under Harvey Peninsula Road, showed signs of bank erosion and the

stream showed some areas with yellow/brown coloring and rainbow sheen indicative of grease, fuel and/or oil discharge. Inclusion in the final selection grouping does not indicate that Bill's Marina is at fault with the special stormwater requirements, but simply serves as a reminder for the County of those special requirements.

Subwatershed ID 123:

In Subwatershed 123 stormwater runoff problems were identified at 606 White Oak Drive. A significant portion of the subwatershed stormwater runoff is collected by ditches along Wooded Ridge Road and White Oak Drive and routed to a low spot at approximately 597 White Oak Drive. Runoff then crosses the road via a culvert and drains to the lake along the side of private property located at 606 White Oak Drive. A natural drainage channel has formed conveying stormwater runoff to Deep Creek Lake. During heavy rainfall events, the property receives highly concentrated flows, which erode and deposit sediment in the front and back yard of the private property. AMT's desktop analysis and field assessments showed the need for peak flow attenuation in this area.

Subwatershed ID 141:

Subwatershed 141 was not initially identified by the GIS desktop analysis. Nonetheless, the subwatershed was included in the final subwatershed selection based on field observations. Field assessment of the area identified two point sources of significant sediment loading to Deep Creek Lake. The first area is located at the corner of Valley View Drive and Piney Point Drive, where stormwater runoff from the upstream residential development is collected and discharged in freefall form through a large diameter CMP outfall. The receiving hillside is very steep and has over 60-ft of vertical drop. The runoff discharge has created a drainage channel that is actively incising and eroding. The second area is the outfall discharge of the pond located near the intersection of Sky Valley Drive and Bench Road. The existing freefall outfall configuration is constantly scouring the channel's bottom and eroding the vertical right bank providing significant sediment loading to Deep Creek Lake. AMT's field assessments showed the need for outfall stabilization in this area.

Subwatershed ID 160:

In Subwatershed 160, stormwater runoff problems were identified at 190, 214, 340, 356, as well as other properties on South Shore Road. Existing ditches route stormwater runoff from Oak Way Road and South Shore Road to an outfall channel located between the private properties at 190 and 214 South Shore Road. A pipe under the road discharges the ditch-conveyed runoff from the north edge of South Shore Road to the lake side of the road. The property owners, who are mainly responsible for the channel maintenance as it runs through their property down to the lake, have lined the outfall channel with flagstone creating a V-shaped channel. Along South Shore Road, several of the culverts installed under driveways have become deformed and/or partially blocked causing the ditches to overflow across the road and onto private properties. AMT's desktop analysis and field assessments showed the need for improved conveyance and peak flow attenuation in this area.

Subwatershed ID 193:

The Subwatershed 193 drainage area is approximately 9 acres and includes residential houses located along Wooded Ridge Road and White Oak Drive. Existing ditches along the northern side of White Oak Drive route stormwater runoff to a couple of culverts crossing White Oak Drive. The outfalls discharge onto private properties on the lake side of White Oak Drive where natural and/or manmade drainage

channels convey the stormwater runoff to Deep Creek Lake. Along White Oak Drive, several of the culverts connecting the ditches under private driveways have become deformed and/or partially blocked causing the ditches to overflow across the road and onto private properties. During heavy rainfall events, some of these properties receive concentrated flows with high flow velocities, which erod and deposit sediment in the front and back yard of the private properties. AMT's desktop analysis and field assessments showed the need for improved conveyance and peak flow attenuation in this area.

Subwatershed ID 207:

Subwatershed 207 was initially identified by the GIS desktop analysis. Field assessment of the area did not observe significant stormwater runoff problems within the subwatershed. Nonetheless, the subwatershed was included in the final subwatershed selection due to the presence of Patterson Boat Company Marina, which is considered a stormwater hotspot based on the MDE definition and special stormwater requirements that must be in place. Their inclusion in the final selection grouping does not indicate that Patterson Boat Company is at fault with the special stormwater requirements, but simply serves as a reminder for the County of those special requirements.

PRIORITIZATION:

Appendix A presents concept design projects that AMT recommends be implemented in North Glade Run watershed to improve stormwater runoff conveyance and reduce sediment and nutrient loadings into Deep Creek Lake, hence enhancing its water quality. It should be noted that most to the rehabilitation concept designs involve private agreements and/or cooperation as many of the recommended improvements occur on private property. Hence, the County will need to partner with the affected property owners to implement the concept projects.

To prioritize and rank the developed concept projects many factors need to be considered and weighted, like cost, stakeholder approval, permitting, ease of construction, expected performance, etc. Not considering the important and constraining factors of cost and right-of-way, AMT prioritized the concept projects based on two factors, sediment/nutrient load reduction and ease of construction, independently. The prioritization does not include the two "stormwater hotspot" subwatersheds. Table 4 presents AMT's ranking order for the two considered prioritization criteria.

Table 4. Concept Design Prioritization Ranking

Ranking	Prioritization Criteria	
	Sediment and Nutrient Load Reduction	Ease of Construction
1	89	123
2	141	193
3	160	160
4	193	89
5	123	141