



URBAN STORMWATER BMP DATABASE **HISTORIC BMP RECORD REVIEW AND UPDATE**

SCOPE OF WORK

Background and Purpose

The Anne Arundel County National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit, issued by the Maryland Department of Environment (MDE), requires that the County maintain an urban stormwater best management practices (BMP) database that identifies all existing stormwater facilities within the County along with specific design, construction, and inspection information. This information is to be documented in database format with accompanying GIS coverages.

The County has developed and maintains an urban stormwater (BMP) database that documents certain aspects of individual stormwater management facilities and practices. Over the years the required database structure, and data to be captured, have changed as changes in NPDES MS4 Permit reporting and tracking requirements have occurred. The two most recent changes occurred in August of 2014 and in March 2015.

In August 2014, MDE issued the guidance document: “Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated – Guidance for National Pollutant Discharge Elimination System Stormwater Permits.” This document provided a roadmap for NPDES MS4 Phase I jurisdictions to determine their impervious acre baseline, the 20% impervious area management requirement, and to determine pollutant load credits for restoration project implementation. At the time of issuance, the stormwater facility database reporting requirements detailed in Appendix B of the August 2014 MDE guidance document took precedence over any prior issued guidance (e.g., Attachment A to the NPDES MS4 Phase I Permits).

In March 2015, MDE issued a geodatabase design and user’s guide for the NPDES MS4 Phase I Permit program (MDE 2015). The geodatabase was designed for the purpose of NPDES MS4 Phase I permittee annual data reporting, and establishes a reporting structure for submittal of local jurisdictional program data and for showing compliance with permit requirements. The geodatabase design includes specific requirements for documentation of urban stormwater BMPs, some of which carry over from the August 2014 guidance requirements.

These most recent stormwater BMP reporting requirements include data fields not previously identified or captured for prior approved BMP records in the County database. Furthermore, some previously required data fields were not completed for some BMP records. To review the historic BMP records and to research, correct, and complete the required fields for each existing record, the County is soliciting contractual support. This work effort applies to all BMPs included in the County’s existing Urban Stormwater BMP database as of June 30, 2015. There are approximately 14,000 records. Given the volume of data to be reviewed the County will pursue this effort in a phased manner.

In summary, the major components of this work effort are to

- review the existing stormwater BMP database records;
- research, correct, and populate the required database fields for existing records;
- as necessary, create new records for existing legacy BMPs (e.g., stacked ESD records) that do not have a separate record; and
- develop GIS coverages associated with this database.

The ultimate objective of this work effort is to produce a complete and accurate geodatabase of the existing urban stormwater BMPs. The resulting geodatabase will be used for multiple purposes. Such purposes include modeling nutrient and sediment load reductions associated with stormwater management measures throughout the County; determining the acres of impervious area managed by stormwater facilities and practices; and to serve as the platform from which stormwater facility inspections and maintenance efforts are scheduled and recorded, and from which stormwater facilities are identified for potential retrofit. Thus, the accuracy of the data must be sufficient for these purposes.

To assist in developing a technical and cost proposal, the County will provide the consultant with a copy of the master Urban Stormwater BMP Database. This database includes the entirety of the County's Urban Stormwater BMP records through June 30, 2015.

Timeline

This work effort will be accomplished as a progressive award. The County anticipates the completion of the first phase of the project within 12 months of Notice to Proceed. The work phases are described below:

Phase 1: This phase of the work effort will focus on stormwater management facility records associated with BMPs constructed starting in 2002. There are approximately 8,900 BMP records for this time period.

- 1) BMPs constructed from 2002 onward are most likely to be designed for water quality treatment. From this grouping of records, the priority for research is:
 - a) BMPs with inspection dates between June 30, 2012 and June 30, 2015 (1286 records).
 - b) BMPs with inspection dates unknown or prior to July 1, 2012 (7260 records).
 - c) BMPs with inspection dates since July 1, 2015 (352 records).
- 2) BMPs constructed after 2010 will most likely include facilities, or groups of facilities, that meet the criteria of ESD to the MEP (~ 5000 records).

Phase 2: This phase of the work effort will focus on those stormwater facility records associated with BMPs constructed prior to 2002. There are approximately 5,100 BMP records for this time period.

- 1) BMPs constructed between 1985 and 2002 may or may not include water quality management measures. From this grouping of records, the priority for research is:
 - a) BMPs with inspection dates between June 30, 2012 and June 30, 2015 (733 records).
 - b) BMPs with inspection dates since July 1, 2015 (195 records).
 - c) BMPs with inspection dates unknown or prior to June 30, 2012 (2900 records).
- 2) BMPs constructed prior to 1985 or with unknown built dates (1261 records).

When preparing the technical and cost proposal, please address each phase as a separate cost item.

Fee

The cost of the proposed work will be based upon actual cost plus a fixed fee.

Project Tasks

Task 1 Project Initiation, Coordination, and Quality Assurance Project Plan

Subtask 1.1 Project Initiation

Within two weeks of receiving the Notice to Proceed, the consultant will meet with the County Project Manager and designated staff to discuss project coordination efforts, the proposed work plan, and the schedule of activities. The meeting is anticipated to last no longer than two hours.

At the project initiation meeting, the County will provide the consultant with the most current Urban Stormwater BMP Database, with data records compiled through the end of County Fiscal Year 2015 (end date June 30, 2015). Additionally, the County will provide the consultant with information regarding the pertinent data sources for the required fields.

Results of the project initiation meeting will include a documented meeting summary and a project work plan and schedule.

Subtask 1.2 Project Coordination

Project coordination with County staff will be important throughout the course of the project. The consultant will attend and will, with assistance from the County Project Manager, lead in planning and organizing up to four (4) two (2) hour project coordination sessions for each phase of the project. These sessions will bring together the management team of County staff from within the Department of Public Works, and will ensure that the end products are usable and meet the permit requirements.

The consultant shall prepare an agenda for these meetings and email it to the County Project Manager for input two working days prior to the meeting date. Additionally, the consultant shall prepare meeting minutes describing work accomplished as well as action to be achieved in in the next quarter of work. The meeting minutes will be reviewed first by the Project Manager and then distributed by the consultant to the members of the management team. The meeting minutes shall be provided to the Project Manager within 5 working days of the meeting.

Subtask 1.3 Quality Assurance Project Plan and Standard Operating Procedures

A Quality Assurance Project Plan (QAPP) will be developed to document the standard procedures to be undertaken during this project, as well as the quality assurance and quality controls measures that will be employed. This document will serve as the Standard Operating Procedures and QAPP for the entirety of this project. The QAPP will include but not be limited to documentation of methods, data sources, meta data requirements, reporting and deliverable formats, quality assurance and quality control procedures, and schedule for task completion.

Task 1 Deliverables

The consultant will provide a draft and final memorandum documenting the project initiation meeting.

The consultant will develop and deliver the draft and final project work plan and schedule.

The consultant, with assistance from the County Project Manager, shall be the lead in the preparation of schedules, agendas, and meeting minute summaries of up to 4 coordination meetings per each phase of the project.

The consultant shall develop and finalize the detailed QAPP based on the comments from the initiation meeting. This deliverable shall be provided as an electronic copy in Word and PDF format.

Task 2 Urban Stormwater BMP Data Review and Update

Given the volume of data to be reviewed, the County will pursue this effort in the phased manner described above. When preparing the technical and cost proposal, please address each of these phases as separate cost items.

Subtask 2.1 Assemble Data

Stormwater BMP Facility Data

The consultant shall use all available data sources to research, correct, and populate the required database fields and develop a complete georeferenced inventory of all constructed and in-place publicly and privately owned and maintained stormwater BMPs located within the County. To assist with this effort, the County will provide electronic copies of the following databases and information. All databases will be current through June 30, 2015.

- County-wide Urban Stormwater BMP geodatabase
- County-wide BMP drainage area shapefiles
- Countywide impervious surfaces geodatabase
- LIDAR
- DEM
- County-wide Capital Improvement Program Restoration Project Dataset
- NPDES MS4 Geodatabase Design and User's Guide (MDE 2015 or most recent version)
- "Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated – Guidance for National Pollutant Discharge Elimination System Stormwater Permits (MDE 2014 or most recent version)

In some, but not all County watershed areas, the Urban Stormwater BMP data were reviewed to identify necessary information for purposes of nutrient load modeling for certain watershed studies. As part of this effort, some but not all stormwater BMP information has been researched and certain corresponding fields updated (i.e., missing data for BMP type, location, and drainage area). To provide information associated with that effort, Anne Arundel County will provide electronic copies of the following technical memoranda associated with these watershed studies:

- Technical memoranda for Urban Stormwater BMP data review and updates associated with the following County watershed studies:
 - West and Rhode River Watersheds,
 - Little Patuxent River Watershed

- o Patapsco Tidal River and Bodkin Creek Watersheds.

Data Sources for Records Review

The consultant should note that certain components of data review and research will require the consultant to be physically located at the County offices to access and assemble County-held data. Such work components include researching County grading and building permits and associated approved grading plans and/or as-built plans for each stormwater BMP record. The County will coordinate with the consultant to plan and make provisions to accommodate this review and research, including but not limited to providing office space and limited computer network access.

The County will provide the consultant with files or sharing access (from the County office premises) to various data sources for purposes of records research and review. These data sources will aid the consultants in identifying accurate and correct data for BMP records. The following is a list and brief description of the primary data sources:

Scanned Grading and Building Permits: The Office of Inspection and Permits has scanned a number of grading and building permits to backup and replace the paper copies. This source of information shall be utilized to fill data gaps and/or resolve contradictions and duplications that may be discovered. The plans, plats, computations, and other permit related documentation is stored in a directory, and is identified by the grading permit, subdivision or project name. This data resource is a valuable search tool for obtaining additional information for records within the Urban Stormwater BMP Database. It should be noted that projects that were not issued grading and building permits through the Office of Inspection and Permits will not be found in this directory. The search keywords to use for retrieving permit related documentation are the grading permit number or the subdivision name listed in the Urban Stormwater BMP Database. This document search can only be done at the WPRP premises at the County office.

Department of Public Works As-Built Drawings: As-Built plans are generally available for all subdivisions and developments containing public infrastructure and requiring an As-Built plan completion for bond release purposes. This source of information shall be utilized to fill data gaps and/or resolve contradictions and duplications that may be discovered. DPW maintains a desktop enterprise tool used internally within the County office to view pertinent GIS layers and As-Built plans. The County can provide the consultant with an OIT GIS “As-Built Viewer Help” document to assist in this research. DPW also hosts a publically available website for querying and viewing as-built drawings.

File Room Plans: Hardcopy SWM plans and computations are housed at three locations within the County. These are the file room at Inspection and Permits (e.g., hard copy grading and building permits, approved stormwater plans), As-Built plans awaiting scanning at the DPW/MGI records desk, and the Soil Conservation District office (e.g., MD-378 ponds). Additionally, hard copy grading and/or building permit files associated with a limited number of public stormwater BMP facilities may be housed in the DPW Bureau of Highways Infrastructure Management Division. All locations are within the Heritage Office Complex and access to these records will be arranged through the WPRP project manager.

Iron Mountain: Older hard copy records of grading or building permits, stormwater management plans and computations, and other information pertinent to this work effort may not be housed within County offices. These documents and information may have been archived off-site. Should this information be needed to complete the research, record review, and data field updates the retrieval of these data will be arranged through the WPRP project manager.

Various supporting GIS layers: The County maintains various GIS layers that can support the search for a BMP location. Layers denoted with © are only available through a shared access computer at the County offices. Examples of the available support layers are:

- County Street Centerline File
- Parcel map and GIS property query ©
- Consolidated property file table
- Aerial photographs
- Microsoft Live Local Pictometry ©
- Digital storm and sewer 40 scale operating maps ©
- LIDAR DEM and drain line at 1000 pixel resolution or finer if needed for drainage area delineation purposes.

Additional GIS layers (e.g., address points, streams, closed storm drain system) can also be made available as needed.

Subtask 2.2 Data Review for Accuracy and Completeness

Existing stormwater BMP data and GIS coverage will be reviewed for purposes of pollutant load reduction calculation, impervious area management credit, and potential for retrofit. The consultant will be required to review and identify inaccurate or missing information for each of the fields identified in Appendix B of the of the August 2014 MDE guidance (MDE 2014). Additionally, the consultant should be aware that in certain instances multiple stormwater BMP facilities were entered into the existing database as a single record. Therefore, these records should be designated for further research to identify the individual facilities and to create complete records for each. This work to be completed under Task 2.3

As examples for this task, for those database fields listed below the following minimum data are required. Please note that the information below is not an exhaustive list of the data fields to be researched for each BMP record.

Location: Because MDE requires all BMPs to be spatially located in a GIS point shapefile and associated table, Maryland grid coordinates (Northing and Easting in NAD 83 feet) shall be reported for each facility. Please note that although MDE requires data submittal in NAD 83 meters, the County standard is NAD 83 feet and the location coordinates should adhere to County standards.

The spatial accuracy may vary based on available information with a preferred hierarchy as specified below:

- Riser structure as applicable and identifiable, confirmed using County 2014 aerial photography and/or field verification as needed.
- Actual centroid of the facility based on record drawings and confirmed using County 2014 aerial photography.
- Centroid of the property
- Geocoded by a street address, the entire address including street number must be available.
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Many records contained in the stormwater BMP database may have inaccurate or unknown spatial locations, or have multiple facilities “stacked” in one location. These records should be tagged such that spatial locations and disaggregation, as appropriate, can be addressed in Task 2.3.

Watershed: All BMP records shall be attributed with the Maryland 8-digit hydrologic unit code. The USGS 12-digit hydrologic unit code will be automatically assigned in the geodatabase.

BMP Class: All BMP records must be classified as either E, S, or A. The definition of these classifications is found in Appendix B of the August 2014 MDE guidance document (MDE 2014).

Structure Type: All BMP records must be assigned a 4-letter structure type code as identified in Appendix B of the August 2014 MDE guidance (MDE 2014). The County requests that two fields be developed to address this MDE database requirement. The first field will identify the structure type using the codes or descriptors found on the as-built plants or other verifiable record. The second field will translate that structure type into the required 4-letter structure type code from Appendix B (MDE 2014). A translation table will be provided by the County.

WQv and/or PE: All BMP records must have documentation of the required and achieved WQv or, if the BMP is part of an Environmental Site Design (ESD) development, the BMP must have documentation of the required and achieved PE for the site.

Drainage Area: All BMPs shall be attributed with a drainage area. The drainage area for many of the records can be found in the existing BMP database. For records with null or zero values, the consultant must research all available sources to identify the drainage area. Sources in preferred priority order include As-Built plans found on CountyView, the scanned grading and building permits on the County server, hard copy grading and building permit files held by the County (either in County offices or stored in archives), and DPW file room plans. Should these sources not provide a drainage area associated with the original BMP design, the consultant will tag the record for drainage area delineation as per Task 2.4.

(Permit) Approval Date (Permit Issuance Date): All BMPs shall have an approval date that represents the date of the corresponding grading or building permit approval. For existing records without approval dates or with incorrect approval dates (e.g., 1/1/1900), the consultant will research available sources including the scanned grading and building permits on the County server, the file room plans, archived records, and As-built plans on CountyView to identify the correct dates.

Completion Date (aka Built Date per MDE): All BMPs shall have a completion date that represents the date of As-Built completion. For existing records without completion dates, the consultant will research available sources including the scanned grading and building permits on the County server, the file room plans, archived records, and As-built plans on CountyView to identify the correct dates.

Note that the existing County database already includes a field for “Built Date” which represents the date the stormwater facility was put into the ground; it does not reflect the date of As-built plan completion. MDE requires a field to document the date of As-built plan completion.

Storm ID: As noted earlier in this task description, each existing stormwater BMP record will ultimately have a corresponding STORM ID in the database. Should the consultant identify multiple BMPs represented by a single BMP entry (i.e., multiple BMPs associated with a single STORM ID), the records should be flagged for correction as part of Task 2.3.

Subtask 2.3 Research, Update, and Complete Data Fields

Following review of existing stormwater BMP facility records and identification of incorrect and/or missing data, the consultant will research, compile, and confirm/update all fields for each stormwater BMP facility record and confirm or identify the correct spatial locations of each facility. The consultant is reminded that certain components of data research will require the consultant to be physically located at the County offices to access County-held data. With respect to the stormwater BMP facility spatial location, the consultant is referred to the MDE geodatabase structure guidance (MDE 2015) for information on point and polygon coverage attributes.

During the course of BMP research, multiple BMPs may be found to be represented by a single entry in the database. These records should have been flagged in Task 2.2 and are to be corrected in this task. Correction is made by creating a new BMP point for each of the BMPs, and placing it appropriately within a GIS context. A new Storm ID is to be created by adding a sequential letter to the end of the original point's Storm ID. These data can then be captured in a new field (i.e., *NewSTORMID*) that is included in the draft revised database.

The consultant may identify duplicate records within the stormwater BMP facility database and should make every effort to identify and tag potential duplicate records. Duplicate records may be identified through examining attributes and spatial locations. Duplicate records should not be removed from the draft revised database, but should be reviewed with the County project team to determine if they are indeed duplicates or representative of the evolution of a facility (i.e., original facility and retrofit of original facility). Notation of potential duplicate records shall be made in a new, appropriately named field in the geodatabase.

All hard copy source data utilized to review, verify, and update facility records should be set aside for future scanning purposes. Scanning will be accomplished by the County. The consultant is responsible only for aggregating these hard copy sources by Permit or project number.

Subtask 2.4 Verify or Correct BMP Location

The stormwater BMP facility dataset contains records with unknown or inaccurate spatial location (e.g., spatial location is the centroid of the County). For each record researched, the location (coordinates) in the current Urban BMP database shall be visually checked using the GIS and verified or corrected based on the retrieved research documents and/or a site visit as necessary. The geodatabase should then be updated to reflect that the location of the BMP has been verified or corrected.

With respect to spatial verification of each BMP, the consultant should include a "note" to specifically identify how the BMP was spatially verified and include general information about that BMP as appropriate. The consultant will make specific notation regarding what and how those data were modified by adding a new field labeled "Location Source" to the BMP feature class with domain values of:

- UBMP Database – verified
- Georeferenced plan
- Plan Coordinates
- Orthophoto
- GPS

Subtask 2.5. Delineate BMP Drainage Areas

To properly account for impervious area management and nutrient/sediment load reductions associated with stormwater BMP facilities, and to comply with NPDES MS4 Permit requirements, drainage areas must be delineated for all stormwater BMP facilities. In this task, the consultant will capture (digitize polygon) the drainage area(s) shown on the plans in a polygon feature class related to the BMP point feature class. The resulting drainage area value should match the value for the drainage area on the plans (i.e., a QC check) or the difference in values should be less than 1%. If there is a difference between the drainage area value on the plans and the drainage area shown on the plans, and that difference is greater than 1%, the consultant should also delineate the drainage area using ArcHydro or another County pre-approved method.

Drainage areas that are also delineated using ArcHydro or other County pre-approved method, should be saved in a separate feature class. Thus, it should be recognized that some stormwater BMP facilities will have two (2) drainage area polygons, one (1) that matches the original plans and stormwater reports for the facility, and one (1) that is derived from ArcHydro or other pre-approved method.

Drainage area delineations are addressed differently depending on the BMP structure type, the original data source, and the accuracy of the BMP's spatial location. In addition to delineating the drainage area and completing the required database field, the consultant will provide documentation of the method used to create and populate the drainage area field in the BMP Feature class attributes.

For BMPs with no measurable water quality benefit (e.g., pre-treatment BMPs), drainage areas are not to be created. The Delineate field for these BMPs will be marked as "No WQ – No DA."

Drainage area polygons for stormwater BMPs facilities and restoration projects associated with the **Capital Improvement Program** were previously developed and provided to the consultant in Task 2.1 These drainage area polygons should require no modifications.

It is anticipated that there will be overlapping/nested drainage areas where multiple BMPs have been established through the land development process. The County desires that the drainage areas be topologically correct; thus, once the drainage areas are created or compiled for each BMP in the final dataset a topology will be established to identify overlapping drainage areas. The consultant and County will work together to define the rules governing treatment of overlapping/nested drainage areas, but some basic assumptions are provided here. For example, each BMP facility should have a discreet drainage area for which it is assumed to provide exclusive treatment. It is also assumed that overlapping drainage area polygons will be assigned to the BMP point that topographically best reflects the likely flow path to that point or matches best with the existing closed storm drain coverage. In most cases, the County believes that the BMP point closest to an individual drainage area polygon will be attributed to that polygon, but the consultant will verify that relationship.

Following completion of this step, the consultant will attribute the drainage area to each BMP by current County impervious and pervious areas. The resulting acreage of impervious area within the stormwater BMP facility drainage area can then be identified.

Subtask 2.6 Determine BMP WQv

Within the County's urban stormwater BMP facility database, WQv is reported to be the most common field with missing data. Historically, this field was not required to be submitted in design plans during the County plan review process; however, the County is now required to report these data for each BMP facility record. Moreover, stormwater BMP facilities with missing WQv data cannot be utilized for impervious area management credit or nutrient/sediment load reduction calculations; in essence, these BMPs are not being used for addressing NPDES MS4 Permit or Bay TMDL Stormwater WLA compliance. Because these data are not always available for historic BMPs, yet the information is critical to the County's impervious area accounting as well as TMDL Stormwater WLA compliance, a new method for populating the missing records must be developed.

The Maryland Department of the Environment outlines the method for calculating WQv in the Unified Stormwater Sizing Criteria found in Chapter 2 of the Maryland Stormwater Design Manual, Volume 1 (MDE 2000, MDE 2009). WQv represents the storage needed to capture and treat the runoff from 90% of the average annual rainfall measured in acre-feet. The equation is as follows:

$$WQv = [(P) (Rv) (A)] / 12$$

P = rainfall depth in inches and is equal to 1.0” in the Eastern Rainfall Zone $R_v = 0.05 + 0.009(I)$
 I = percent impervious cover A = area in acres

The only unknown variables required to calculate the required WQ_v are percent impervious cover and the drainage area. Through the delineation process outlined in Task 2.5, a drainage area for each BMP is developed and the associated impervious area within that drainage area is documented. The consultant will utilize this information to determine an estimate of required WQ_v for each stormwater BMP facility.

It is recognized that some facilities may not be designed to manage 100% of the required WQ_v . To determine the percentage of WQ_v managed by a facility, the designed storage capacity of the facility must be determined. If this information is not readily available from the previously reviewed plans and/or stormwater report, the consultant should estimate the capacity based on the facility dimensions.

In determining WQ_v for each record using the drainage area delineation data from Task 2.4, the County acknowledges that potential for error exists. This drainage area may not be an exact match of the drainage area as per the original facility design. For example, the current elevation model being used for delineation may not reflect conditions as present during the design and construction of a BMP. This could cause a slight mismatch in drainage area boundaries. The impervious surface layer utilized in the facility design analysis may not represent the current conditions within the drainage area. It is possible the percent imperviousness within the drainage area has changed since the design of the BMP. To gain a better understanding of the accuracy of this method a subset of BMPs with recorded WQ_v will be used to test the calculation methodology prior to completing this task. Comparing the recorded WQ_v to the calculated WQ_v will provide the County with a level of confidence in the proposed methodology and allow the County, in consultation with the consultant, to identify any needed adjustments to the methodology.

Task 2 Deliverables

Phase 1:

- Final QAPP with all SOPs utilized in Phase 1 of this work effort.
- Proposed Geodatabase design

Interim Deliverables:

- Technical Memorandum and geodatabase submission at 10% completion
- Technical Memorandum and geodatabase submission at 60% completion

Final Deliverables:

- Updated/Verified/Completed Master Urban Stormwater BMP database
- Final Urban Stormwater BMP shapefiles with features and metadata
- Technical report documenting research procedures taken and methodology used for data field review/update.
- Hard copy data sources (e.g., as-built plans, stormwater reports, drawings) used for database review and update, compiled by Permit or Project Number and delivered to County for scanning purposes.

Phase 2:

- Final QAPP with all SOPs utilized in Phase 2 of this work effort.

Interim Deliverables:

- Technical Memorandum and geodatabase submission at 10% completion
- Technical Memorandum and geodatabase submission at 60% completion

Final Deliverables:

- Updated/Verified/Completed Master Urban Stormwater BMP database
- Final Urban Stormwater BMP shapefiles with features and metadata
- Technical report documenting research procedures taken and methodology used for data field review/update.
- Hard copy data sources (e.g., as-built plans, stormwater reports, drawings) used for database review and update, compiled by Permit or Project Number and delivered to County for scanning purposes.

References

MDE. 2015. National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4), Geodatabase Design and User's Guide. Version 1.1. Prepared for U.S. EPA Chesapeake Bay Restoration and Protection Funding (CBRAP). Prepared by Maryland Department of the Environment, Baltimore, Maryland and Maryland Environmental Service, Millersville, MD.

MDE. 2014. Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated. Guidance for National Pollutant Discharge Elimination System Stormwater Permits. Maryland Department of the Environment, Baltimore, MD.

www.mde.state.md.us/programs/Water/StormwaterManagementProgram/Documents/NPDES%20MS4%20Guidance%20August%2018%202014.pdf

MDE. 2000. 2000 Maryland Stormwater Design Manual. Volume I: Stormwater Management Criteria. Chapter 2: Unified Stormwater Sizing Criteria. Maryland Department of the Environment, Water Management Administration, Baltimore, MD

www.mde.state.md.us/programs/Water/StormwaterManagementProgram/MarylandStormwaterDesignManual/Documents/www.mde.state.md.us/assets/document/chapter2.pdf