FHWA-NJ-2012-010

DRAINAGE INFORMATION ANALYSIS AND MAPPING SYSTEM

FINAL REPORT

October 2012

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In cooperation with

New Jersey
Department of Transportation
Division of Research and Technology
and
U.S. Department of Transportation
Federal Highway Administration

DISCLAIMER STATEMENT

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. FHWA-NJ-2012-010	**2. Government Accession No.**	**3. Recipient's Catalog No.**

4. Title and Subtitle Drainage Information Analysis and Mapping	**5. Report Date** October, 31, 2012
	6. Performing Organization Code
7. Author(s) J. Meegoda, T. Juliano, C. Tang, S. Liu, L. Potts, C. Bell, T. Marhaba, A. Borgaonkar and Q. Guo	**8. Performing Organization Report No.**
9. Performing Organization Name and Address Department of Civil and Environmental Engineering New Jersey Institute of Technology University Heights, Newark, NJ 07102-1982	**10. Work Unit No.**
	11. Contract or Grant No. NJDOT 2010 – 01
12. Sponsoring Agency Name and Address N.J. Department of Transportation 1035 Parkway Avenue P.O. Box 600 Trenton, NJ 08625-0600 Federal Highway Administration U.S. Department of Transportation Washington, D.C.	**13. Type of Report and Period Covered** Final Report January 2010 – Oct. 2012
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract The primary objective of this research is to develop a Drainage Information Analysis and Mapping System (DIAMS), with online inspection data submission, which will comply with the necessary requirements, mandated by both the Governmental Accounting Standards Board (GASB-34) and the federal storm water regulations. The DIAMS project will serve as a vehicle for evaluating underground drainage infrastructure assets which includes locating and cataloging pipes, storm-water devices (e.g., manufactured treatment devices), outfalls, and other structures, (e.g., manholes and catch basins), as well as, collecting inspection and rehabilitation/replacement/repair data. The DIAMS has an electronic documentation system that performs quality checks on the submitted inspection data and stores the approved data in a comprehensive information management system for updating, analysis, classification and mapping. The DIAMS utilizes a two layer front and back end management tool comprised of MS Access for data submission and SQL database for data storage that is accessed through a graphical user interface (GUI). The GUI is structured into four modules: Data Uploading, Asset Identification, System Administration, and Financial Analysis. The Data Uploading module includes the conversion of user input field data into comprehensive information format, review of input data, quality assurance and quality control checking, and appending the data to the system database. Users can locate assets needing immediate repair by road/milepost based upon their condition state. The Asset Identification module stores all the receiving storm water data such as the quality/quantity of water and discharge to watersheds, while also being able to develop general property reports. The module also gives users an assessed condition state, which allows them to select the best treatment technique. The System Administration module allows individual flexibility through editing keywords. The Financial Analysis module analyzes the selected data and provides optimal recommendations to inspect, rehabilitate, replace, repair or do nothing at both project and network levels. Financial analyses are derived from a sequential process including defining networks, confirming input data sets, and optimizing for budget allocation preferences. At the project level this is achieved by comparing inspection and/or rehabilitation/replacement/repair costs via an updatable user cost, currently based on the 2011 NJDOT Engineer's Estimate – Maintenance Drainage Repair Contract, with risks and costs associated with failure. At the network level, the associated costs are optimized to meet annual maintenance budget allocations by prioritizing assets needing inspection and rehabilitation/replacement/repair. When all input data have been appended into the module, DIAMS can generate financial summaries and work orders.

17. Key Words Pipes, condition assessment, reliability, user cost, inspection, repair, rehabilitation, financial analysis	**18. Distribution Statement** No Restrictions.

19. Security Classification (of this report) Unclassified	**20. Security Classification (of this page)** Unclassified	**21. No of Pages** 30	**22. Price**

ACKNOWLEDGMENTS

The authors wish to acknowledge the efforts of the NJDOT former project manager Ms. Stefanie Potapa, current project manager Mr. Paul Thomas, NJDOT Research Customers Ms. Nancy Ciaruffoli and Mr. Alkesh Desai of NJDOT, NJDOT Manager of the Bureau of Research Ms. Camille Crichton-Sumners and Mr. Hadi Pezeshki of FHWA.

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INTRODUCTION

According to the American Society for Civil Engineers more than 1.6 trillion dollars are needed to update the nation's mostly aging infrastructure through various bonds and public funds. It can be convincingly argued that it would be more cost effective over the long term to spend a good portion of this investment by taking a proactive course in managing the maintenance processes of the infrastructure rather than waiting and being forced to merely react to disruptive incidences. The importance of a proactive maintenance management policy becomes more pronounced when considering vital systems. This importance emanates from the fact that an unexpected failure of a component of one of these complex systems usually creates disruptions, which could have cascading effects leading not only to havoc and its consequences of inconveniencies, but also to major economic effects requiring colossal expenditure to contain the damages incurred from such premature and unexpected failures.

At present, various maintenance treatments are employed by infrastructure agencies to slow deterioration and restore the condition of highway pavements, bridges, culverts and other physical assets. However, budget constraints and other factors have often led to delaying or eliminating the application of these treatments. Such decisions usually have adverse influence on the condition and performance of the particular infrastructure leading to reduced levels of service, faster deterioration rates, and eventually to the need for costly rehabilitation or replacement. Some analytical tools are currently available to address the consequences of delayed application of maintenance treatments for pavements, bridges, pipes and other assets. However, a comprehensive framework for using these tools to demonstrate the potential savings and performance enhancement resulting from applying maintenance treatments at the right time is not readily available. In addition, Phase II of the Governmental Accounting Standards Board, Statement No. 34 (GASB 34) requires public agencies to maintain or improve the overall condition state of their infrastructure systems with annual funding, where the minimum amount needed is provided by a comprehensive asset management system. Hence, the integrated Drainage Identification, Analysis and Mapping System (DIAMS) and subsequent developments should help concerned agencies and asset owners to better assess the benefits of maintenance actions and their role in enhancing the level of service of infrastructure systems. Also, incorporating the expected outcomes of the DIAMS in asset management systems would provide a means for optimizing the allocation of resources.

State DOTs have found that funds made available to maintain infrastructure are insufficient in meeting GASB-34 requirements. Hence the need exists for adopting an optimal strategy that requires accurate information on the present state of infrastructure to be able to predict future performance. The modified approach lays out the requirements towards an efficient drainage infrastructure maintenance and management system. It requires the state DOTs to:

1. Maintain an up-to-date inventory of eligible infrastructure assets.
2. Perform condition assessments of eligible infrastructure assets at least every three years.
3. Summarize the results, noting any factors that may influence trends in the

information
4. Estimate the annual cost of maintenance for infrastructure assets, at or above the established condition level.
5. Ensure that the result of the three most recent condition assessments meet or exceed the established condition level.
6. Compare the estimated maintenance cost of infrastructure assets at or above the established condition level based on amounts spent during each of the past five reporting periods.

To maintain a prescribed level of service within budgetary costs represents substantial expenses for the lifetime of the specific asset. Although it is difficult to make a reliable prediction of structural deterioration and behavior, consequences of delayed application of maintenance treatments play a significant role in the lifetime expenses of the considered infrastructure.

Many experts stand in agreement that a significant portion of the US infrastructure is in the “accelerated damaged” zone. With no serious effort set to rehabilitate our aging infrastructure, this stage of potential deterioration will eventually create the need for colossal investments required to recover them, with increasing risk to the safety of public transportation. The DIAMS was developed to support this disposition and to be a sustainable system with a specific focus on prioritizing maintenance activities subject to operational and budgetary constraints. The following sections describe a proactive data maintenance system.

The need for identifying and mapping drainage infrastructures comes from the fact that transportation agencies develop extensive transportation networks that cross and also drain to natural water bodies. Hence, DOTs are responsible for a large inventory of pipes and other structures. Drainage infrastructure assets often go unnoticed, since they are usually below ground, until a problem arises such as flooding, roadway settlement and even collapse.

A loss of pipe integrity could result in temporary roadway closure and considerable rehabilitation/replacement/repair costs or even worse. In addition, the total collapse of a drainage pipe could pose a major safety risk to motorists, such as the catastrophic failure that occurred on I-88 near Unadilla, NY on June 28, 2006. The New York State Police photograph shown in Figure 1 illustrates the damage to I-88 resulting from a drainage pipe collapse. Two truck drivers were killed when their rigs fell into the washout caused by heavy rainfall. Due to the collapse of I-88 the New York State Thruway (I-90) was closed in both directions from Schenectady to Syracuse. The washout of all four lanes and center median was a result of a failed 30-foot diameter pipe just beyond the Exit 10 interchange. (Albany Times-Union) Failures of this magnitude typically lead to catastrophic accidents, which may involve the loss of life and property. Hence a drainage information analysis and mapping system is necessary for timely maintenance of drainage assets.

Figure 1. Collapse of a Culvert Crossing I-88 on June 28, 2006

Currently, underground infrastructure asset accounting is based on a linear depreciation rate. To ensure long-term durability of pipes, compliance with required federal accounting requirements, state departments of transportation (DOTs) are exploring ways to implement pipe inspection and management programs. This has been a requirement stipulated by the Governmental Accounting Standards Bureau, in the Basic Financial Statements and Management's Discussion and Analysis for State and Local Governments (i.e. GASB-34 Standard, 1999). GASB-34 requires the governing authorities to declare the present worth of infrastructure assets and to provide useful information on maintenance cost and future replacement cost. It also requires reporting of infrastructure assets as a depreciated cost, scheduled based on the historical cost or a discounted replacement cost. In the "GASB-34 Modified Approach" reporting the present cost of preserving eligible infrastructure is allowed in lieu of reporting depreciation or replacement costs.

Many state and local agencies have yet to implement a pipe management plan based on the `Modified GASB Approach'. Collecting and interpreting data in order to assess the present Condition State with respect to deterioration requires accessibility to underground infrastructure, and the ability to perform a proper condition assessment. Hence, the above is a justification for implementing a preventive maintenance program, which incorporates user costs associated with drainage asset failures, such as due to flooding, roadway collapses and ensuing traffic delays and expensive repairs. In many cases indirect costs can easily exceed direct costs, and ignoring them can lead to less than optimal decisions.

The service life of a drainage asset may differ from its design life, and it depends largely on the supporting soil, local environment, and corrosive and abrasive properties of the transported fluid and solids. Recognizing the effects of these factors on the deterioration of pipes and taking actions to maintain the serviceability conditions can prolong service life, which may prevent premature replacement of structures and pipes, and thereby prevent costly failures. There is a widely recognized problem of rehabilitating older, deteriorated pipes and structures throughout New Jersey. NJDOT Maintenance has identified many existing pipes with significant deterioration and section losses at inverts, both alongside and under roadways. These structures pose a great risk factor to transportation systems and users if failure were to occur due to age and deterioration from corrosion and abrasion (Meegoda *et al.,* 2004).

SUMMARY OF LITERATURE REVIEW

The primary objective of literature review was to gather information on NJDOT drainage infrastructure and maintenance operations. Several keyword searches were conducted using the New Jersey Institute of Technology and Rutgers University public library databases, the Internet, and libraries of ASTM, AASTHO and of other DOTs. Information discovered during these searches cover technology citations, guidelines, methodologies. In addition, searches on published studies on pipe durability and hydraulic characteristics for various pipe material compositions, coatings, and environmental conditions provided guidance on our approach toward constructing a computerized data analysis methodology for the asset management module of DAIMS for NJDOT.

The need for identifying drainage infrastructures comes from the fact that transportation agencies develop extensive transportation networks that crisscross natural surface water features. Transportation networks therefore have a structural symbiosis with manmade drainage structures in order to mitigate flooding disasters and traffic hazards. A significant number of drainage structures are required to conduct the distribution and pathways of surface water. Hence, DOTs are responsible for a far greater inventory of culverts than bridges and other structures, and thus the investment in and importance of drainage infrastructures are enormous. Drainage infrastructures often go unnoticed as they are usually substructures, masked by ground cover, submerged, or placed in a remote location until a problem arises such as flooding, roadway settlement and even collapse.

It is in the best interest for departments of transportation to carry out comprehensive drainage infrastructure inspection on a regular basis to ensure that drainage systems are functioning properly and the report of such inspection are to be properly documented in order to determine whether a system requires repair, rehabilitation, or replacement.

Presently, there is no standard or consistent methodology to inventory, inspect, and evaluate culverts in the field. In order to ensure a successful drainage infrastructure inspection program, established standard guidelines must be put into place so that all data collected by inspectors are consistent. Visual inspection is the most common method of culvert inspection; however, some DOTs and road authorities also make use of video cameras. Typically, visual inspections lack consistency because they are carried out by multiple inspectors with differing biases. An all-inclusive database with facility to furnish data at the blink of an eye and generate condition summary reports would go a long way in saving NJDOT a lot of time, money, and resources in maintaining its drainage infrastructure. A storm-water information management system would serve in the form of a database for storm-water system with culverts/pipes and MTDs inventories and assist with recording locations, tracking condition and performance assessments, scheduling inspection and maintenance activities, and selecting and budgeting rehabilitation and replacement jobs.

It was also identified that information available from several past successful projects completed by NJIT would be very useful in putting together the basic structure of NJDOT's Drainage Identification, Analysis and Mapping System (DIAMS). For several years in the making, the foundation for the DIAMS Project came about from various frameworks. This included a comprehensive corrugated steel culvert pipe (CSCP) preventive maintenance study, a four-level condition state assessment based on the Caltrans system, an automated real-time culvert monitoring study, NJDOT Culvert Information Management System (CIMS) and literature of existing technology and test methods to provide both NJDOT and NJ's first inclusive drainage infrastructure identification, mapping, and capital investment technology system.

The Federal Highway Administration (FHWA, 1995) developed a comprehensive Culvert Inspection Manual that describes, in detail, inspection procedures, guidelines and inspection frequency, and requires that inspections be performed once in every 3 years (Arnoult, 1986). NCHRP Synthesis 303 on Assessment and Rehabilitation of Existing Culverts (NCHRP Synthesis 303, 2002) also documents the methods for inventorying, inspecting, and cleaning culverts and reported the following examples:

1. There is a need to establish a standard set of guidelines, under which all inspectors will inspect and consistently collect data.
2. New York State DOT and Connecticut DOT have comprehensive culvert inventory and inspection manuals that describe their culvert management program.
3. Some agencies cleanse their large diameter culverts between 2 – 3 year intervals.
4. There is need for a regular inspection schedule, similar to that provided in the National Bridge Inspection Standard (Gallivan, 2002). However, regular cycles are not followed by transportation agencies.

Culvert or pipe breakdowns and failures could lead to flooding if roads and embankments are not maintained properly; therefore, the safety of the public is one of the upmost concerns (Perrin and Dwiwedi, 2005). For the last several years, NJDOT has been actively engaged in identifying and cataloging culvert and pipe locations as well as inspection and condition information (NJDOT, 2010). NJDOT has recognized the benefits of enhanced data collection and a wide distribution of information and software applications would be highly valuable, not only interdepartmentally, but also to the New Jersey Department of Environmental Protection (NJDEP), FHWA, USEPA, American Association of State Highway and Transportation Officials (AASHTO), U.S. Army

Corps of Engineers, all state DOTs, counties, cities and both public and private engineering and design firms. In addition, to complying with NJDEP storm-water regulations, NJDOT is also required to report all discharges from culverts, which may potentially enter into New Jersey rivers and streams (NJDOT, 2010).

It is also imperative to update guidelines and procedures, to perform inspections and analyses of existing drainage infrastructures, including culverts, pipes, outfalls and Manufactured Treatment Devices (MTDs). These structures must be periodically inspected and evaluated to ensure satisfactory compliance with the requirements governed by structural, geotechnical and hydraulic standards and performance criteria (AASHTO, 2009). In addition, they must also meet changing and growing needs due to urbanization and other factors. Therefore, regularly scheduled and updated inspections, analyses, and condition rating guidelines are critical, as is a comprehensive management system to serve as a data warehouse of structure assets and to provide coordination of inspection, maintenance, rehabilitation, and replacement activities (Meegoda et al., 2005).

OBJECTIVES

The objectives of this research were to a) identify and catalog drainage infrastructure and b) provide a means of determining the optimum allocation of current maintenance budgets by identifying drainage infrastructure that are to be inspected, repaired, rehabilitated or replaced, and to comply with GASB-34 requirements. Also this system should be capable of making project level decisions to repair, rehabilitate, replace, or do nothing for a given drainage infrastructure.

Assessing the user's cost or financial risk associated with failure is the most challenging issue in effective management for assets. One of the key aspects of this research was to forecast and develop inspection, cleaning and repair methods using the geographical information system and financial formulas to implement the best plan forward for the safety of our roads.

DRAINAGE INFORMATION ANALYSIS AND MAPPING SYSTEM (DIAMS)

The DIAMS is a two-layer information management system that consists of separate Structured Query Language (SQL) databases for pipes, inlet/outlet structures, outfalls, and manufactured storm-water treatment devices (MTDs). The 'front-end' of DIAMS is programmed on an Access 2003 application database with user-interfaces and queries for data review and manipulation. The 'back-end' consists of several database tables and related photo/movie files and reports. All database files are integrated into an effective data management system. Data supplied by contractors are saved as media files in different formats. DAIMS requires that the data be reorganized from these media before uploading them into the databases. In order to facilitate the data uploading processes, DIAMS currently uploads digital video files and stores them separately due to their size. Users can review, modify, save and delete database records in DIAMS to keep the system data up-to-date. Database records can be conveniently displayed with forms and reports with links to photos and videos.

The use of DIAMS starts with recording cleaning and inspection information of the pipes. Vendors would upload field inspection data including condition states into DIAMS via an online submission system. The estimations for the cost of pipes are integrated into DIAMS. Condition state values and cost estimates are used to compute the remaining worth of each asset in the system. The financial data analysis module allows users to make better-informed management decisions.

The DIAMS home screen is shown in Figure 2. It illustrates the four separate DIAMS modules: asset identification, data upload, financial analysis and system administration.

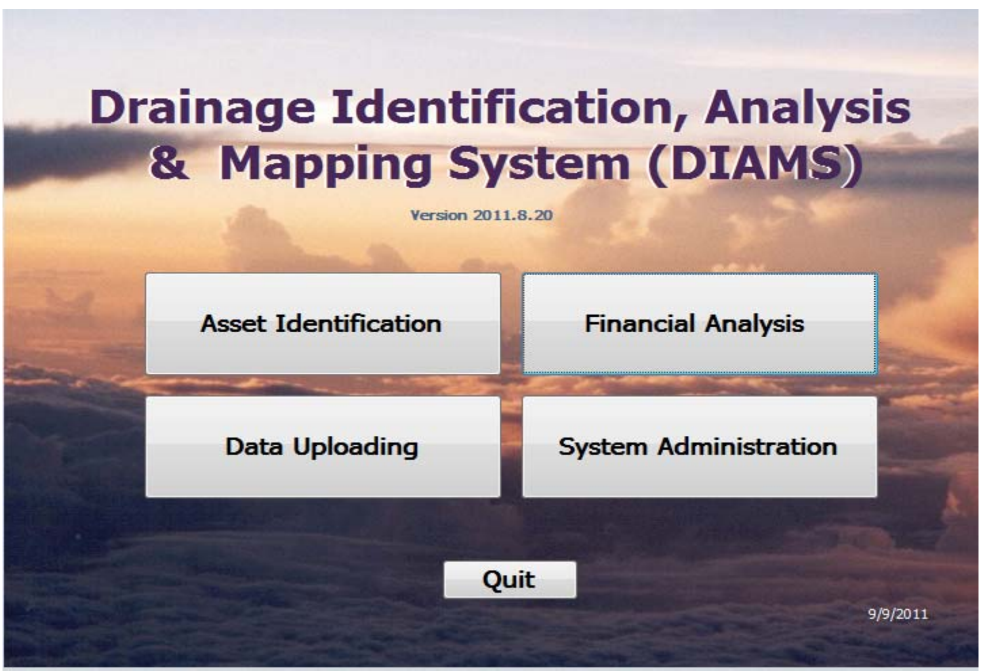


Figure 2. DIAMS Home Screen

The data upload module has various sub-nodes to ensure that the contractor-supplied field data uploaded to the database is unified and consistent. The asset identification module accesses the key attributes of the various physical components, and assigns functionality attributes to the inventory of drainage infrastructure. The system administration module supports low-level data reviews and editing, and the financial analysis compares maintenance and repair costs to design and extension of drainage network. The substructures of each module are shown schematically in Figure 3.

Figure 3 provides a schematic diagram of the operational details of the DIAM system with substructures of each module in Figure 2. This system is an outgrowth of the Culvert Information Management System (CIMS), which was developed under a previous NJDOT research project (Meegoda et al., 2009). The CIMS MSAccess database was updated to the new DIAM SQL database format and is included in the DIAM system, which consists of four functional layers:

1. Asset Layer – includes static and dynamic data obtained from Asset Inventory as well as Vendor Uploads
2. Application Layer – includes processed data as well as additionally provided external data, e.g., unit costs
3. Analysis Layer – includes ODBC and various optimization schemes with access to financial resource data
4. User Layer – includes outputs to reports, to the SLD, and eventually to the enterprise Data Warehouse

DIAMs Data Collection

One of the most critical factors in determining asset evaluation is the inspection and accumulation of field data through vendor inspections. For the past several years NJDOT has performed infrastructure inspections using analog videos and have saved the relevant information in VHS videotapes. The more recent inspections utilize digital photography, which accumulates a large amount of data that is difficult to process manually. Digital videos can be processed using a suitable image-processing scheme or simply by watching them to identify the critical sections and comparing them with historical information to identify Condition State.

The condition states, which are ranked zero to five, are as follows. The description for zero is an unknown condition and implications are to be addressed according to situation type. The description for one is excellent condition and no structural defects. The description for two is good condition and no likelihood of immediate collapse or potential for deterioration. The description for three is average and collapse is unlikely in the near future but further deterioration likely to happen. The description for four is poor and collapse is likely in the foreseeable future. Finally, the description for five is failed, and the structure has collapsed or collapse is imminently close. The above information and associated financial information will be used in making the required pipe management decisions. Pipes in the network should be inspected and Condition States should be known to make prudent management decisions.

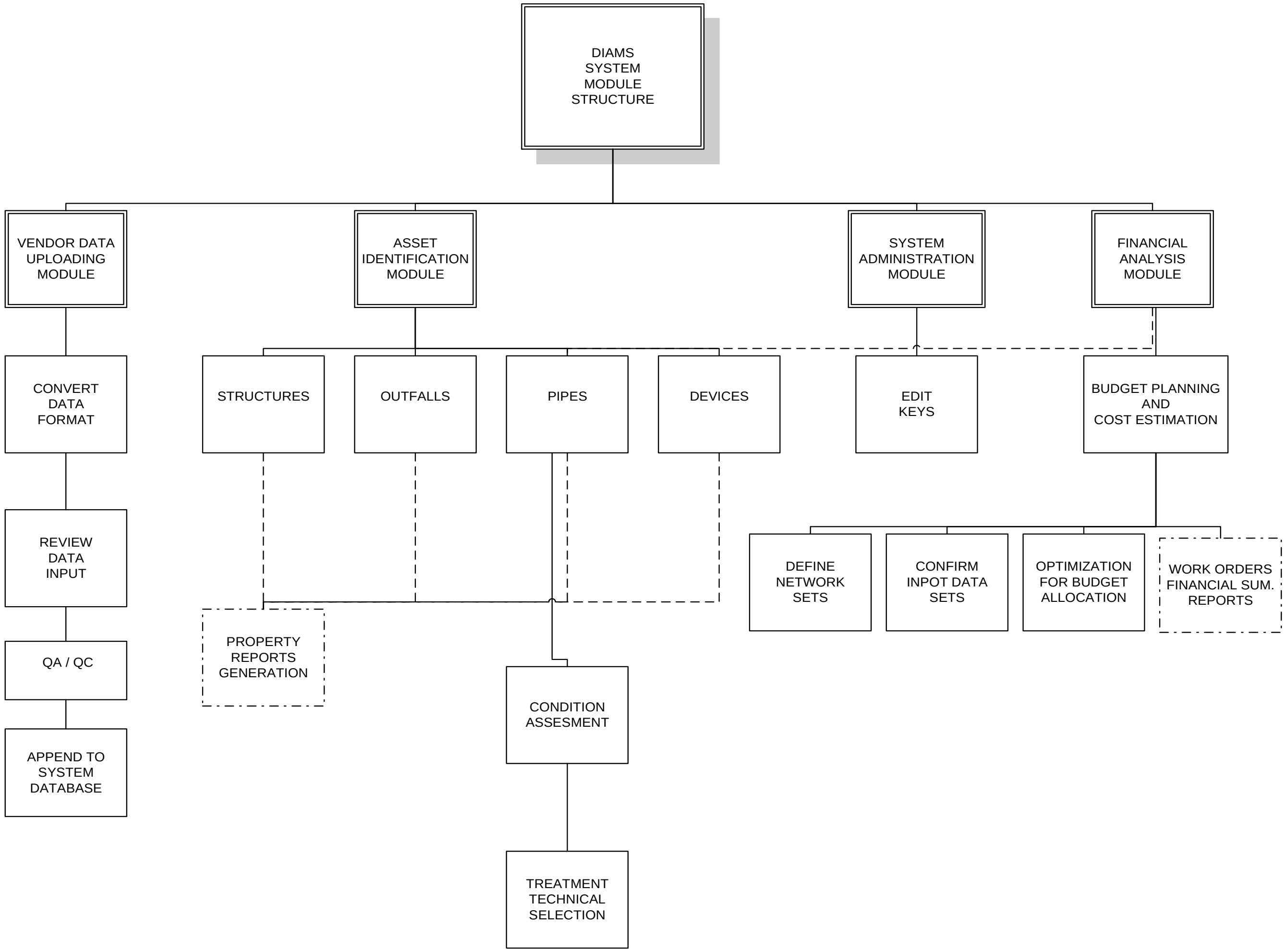


Figure 3. DIAMS Structure

The above information and associated financial information will be used in making the required pipe management decisions. Pipes in the network should be inspected and Condition States should be known to make prudent management decisions.

Uploading of DVD's will be done via online submission into DIAMS. Vendor data that has been collected through this process is arranged according to location, condition state, GPS coordinates as well as type of asset. The Data Uploading Module consists of a process of four sequential steps. First, the vendor data is converted from field inspections and formatted to DIAMS. Second, data is reviewed or updated into the system. Third, a quality analysis and control is performed. Finally, the system appends the inspection data to DIAMS database. This module provides the functionality for users to upload data databases (Access 2000 format) into DIAMS data database. The data are initially stored in an Access Database format and converted to a SQL Database after being uploaded. The details of the previously mentioned four-step data uploading process are as follows. First the vendor database is compacted into working template database. During the compacting process, the vendor name must be identified as being from the approved vendor list. Then the vendor data sets are appended into buffer data tables. The user could then choose options to manually check the vendor data integrity, e.g., make necessary modifications in key fields of displayed tables for structure names, types, route name, etc. By following system prompts, the user may also embed inspection photos into the buffer table records. After the vendor data are compacted into buffer tables, the vendor data sets are converted into required NJDOT data formats and checked for integrity. The system will briefly remind users if they have provided enough data inputs in the major data entry fields. The four converted buffer data tables may be reviewed before uploading them into the DIAMS data database. The final step will append the confirmed vendor data sets into the corresponding DIAMS data database tables so that users can review them with DIAMS Data Module interfaces.

Since the fully functional DIAM system will maintain an up-to-date inventory of eligible drainage infrastructure assets, condition assessments of those assets will need to be updated on a regular timetable using a replicable basis of measurement and measurement scale (Meegoda et al., 2006). In addition to the inspection digital videos, the continued collection of inspection and evaluation data of drainage infrastructure conditions will be complemented by the acquisition of new data, e.g., the effects of sediment accumulation within the pipe. Companion summary reports will note trends and any key factors that may have influenced trends in the information reported, and they may also include individual digital images of trouble spots as well as the digital video inspection file of the pipe.

Quality Assurance and Quality Control (QA/QC)

The Quality Assurance (QA) serves as a final check of the data, to locate any problems that may have been missed by Quality Control (QC) procedures carried out as the data is created. QA also serves as a regular test of whether or not the production and QC processes are producing data of the required quality.

The QA/QC procedure includes online data submissions. Vendors will be given a login to upload their data for initial screening. The QA/QC module is set up to verify data entries (existence (E), checking format (F), extract from NJDOT document (N), compare item with on existing dimensional (database) table (M), and check data limits (P)). The symbols (E, F, N, M and P) will be used to guide the QA/QC process and the final verification of data approval.

The system is designed to capture data inconsistencies from the data the vendors upload and then compare against the bid specification. For example, the vendors use their own convention to describe material type so that the potential for errors in the description attribute field requires rigorous QA/QC methods.

There should be consistent QA/QC for the condition state of structures and pipes. For example, in the condition state for the INSPECTION, the system will perform E, F, and M verifications, whereas the system only performs E and M checking for the ASSET table entries. The condition state for the PIPE ASSET is generated from manual inspection of video footage captured during inspection.

A quantitative check was used to validate the accuracy of the positional attribute of the DIAMS asset. A computerized check compared the asset coordinates to the road centerline coordinates. The latter dataset was obtained from the NJDOT's straight line diagram (SLD) database. In order to verify the acceptable limits of vendor-provided GPS coordinates, a simple radius search is performed. The circle radius will be determined based on project criterion and database functionality. The objective of this QA/QC is to check if the GPS coordinates are within a prescribed limit (say a circle of radius 0.1 mile) from the GIS coordinate. The concept is illustrated in Figure 4.

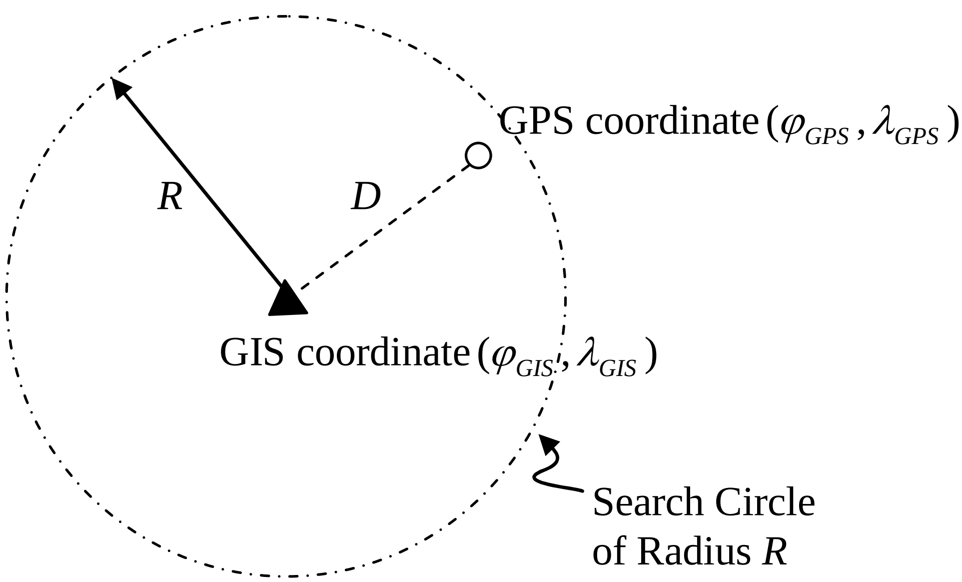


Figure 4. Quantitative Position Validation Procedure

In DIAMS the asset ID is developed from several geospatial features surrounding a particular asset. The ID is composed of a combination of the state route name, the nearest mile post, and the type of structure (manhole, catch basin, MTD etc.). The QA/QC process includes visual inspection of graphic displays of DIAMS assets overlain on an ArcGIS-supplied basemap (i.e., roads, census polygons, etc.). To check on the correctness of asset ID we used hierarchical proxies on location such as county, township and route number to verify the authenticity of the asset ID.

Asset Identification Module

Locating and assessing drainage infrastructure in a timely manner respective to their inspections require the skills to gather crucial information and the ability to analyze their probability of vulnerability over time. The information gathered through contracted drainage infrastructure inspections allows decision makers the ability to safely and proactively treat the condition assessment while allowing optimal financial cost benefits through the mathematical formulas presented over the long run. The quality analysis and quality reports that are used in the DIAMS assess the pipe condition states. Through research, a module will find the inspection, cleaning and repair unit costs according to their functionality of size and material type. Decision makers will have opportunities to choose and modify the types of information and input data in a manual form accordingly.

The DAIMS considers four types of drainage infrastructure (see Figure 5) namely structures (manhole, catch basins, head walls), outfalls (end of pipes, streams), pipes, and MTDs. Each of these type structures has its own data form that may be used to search and review the data for the particular type of structure.

<u>Structures Data Form:</u>

Inlet/outlet structures include all structures that are connected to pipes used to drain water from the surface of highways. The Inlet/Outlet Structure Data Form displays structure IDs and their attributes, as well as, their inspection results (see Figure 6). On top of the form, there are three combo boxes for the users to narrow down the searching scope for a particular structure record. Selections may be made for a location (Road); a rounded-up Milepost (one mile per interval); and inlet/outlet structure of interest to review the structure's records. On the upper portion of the form, structure asset information is displayed. The lower portion of the form contains related inspection information of the structure. Most data fields on this form may be edited to fill in missing data and save the changes. In order to keep data integrity, critical key fields should not be edited, such as 'Structure ID', 'Standard Route Index', 'Latitude' and 'Longitude'. They are supposed to be downloaded only from the source database. No asset record addition and deletion will be allowed at the present time. However, a new inspection record may be added for the current structure, or a photo may be embedded into structure records.

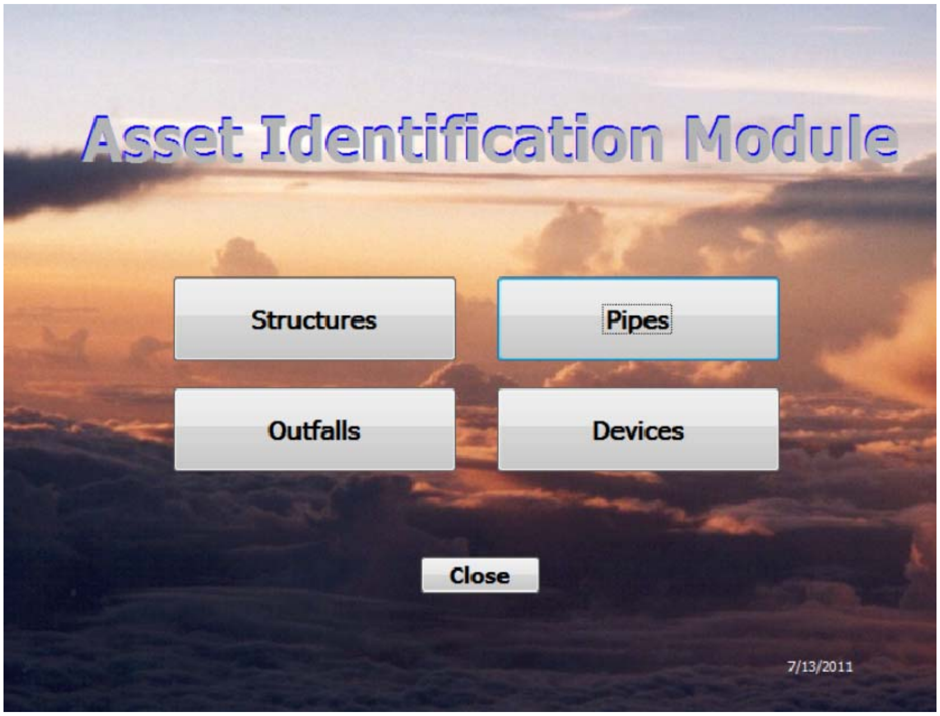


Figure 5. Asset Identification Module

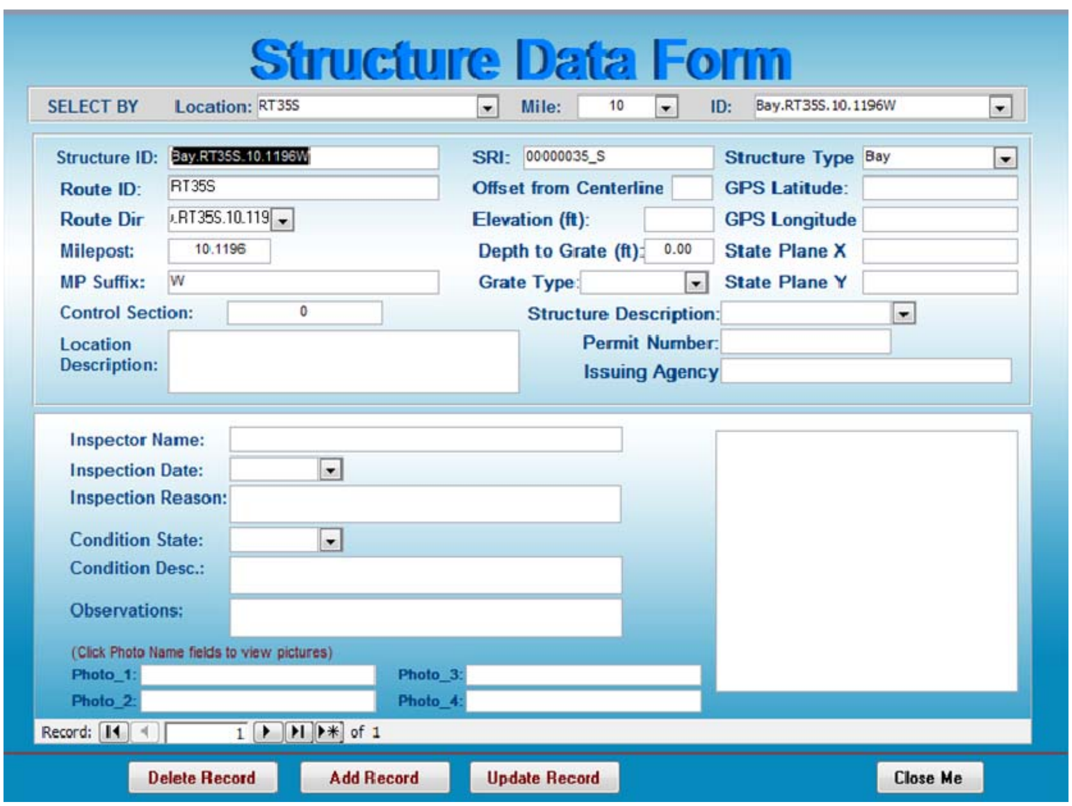


Figure 6. Structure Data Form

Outfall Data Form:

The outfall module has a form containing information for the outfall records. Users may narrow down their searching scope for an outfall record by first selecting a location (Road), then selecting a rounded Milepost (one mile per interval), and finally selecting the expected outfall that is close to the selected round-up milepost value to display the outfall record. The form also provides a list of all related inspection information for the selected outfall (see Figure 7). Most data fields on this form may also be edited to fill in missing data and save changes. In order to keep data integrity, critical key fields, such as 'Outfall ID', 'Route ID', 'Route Direction' and 'Milepost', GPS coordinates, etc. should not be edited. They are supposed to be downloaded from the source database only. Users can browse through all existing outfall records, by using the navigation arrows on the bottom of the main form. No asset record addition and deletion is allowed at the present time, but users can add a new inspection record for the current outfall, or add a photo to be embedded into the records.

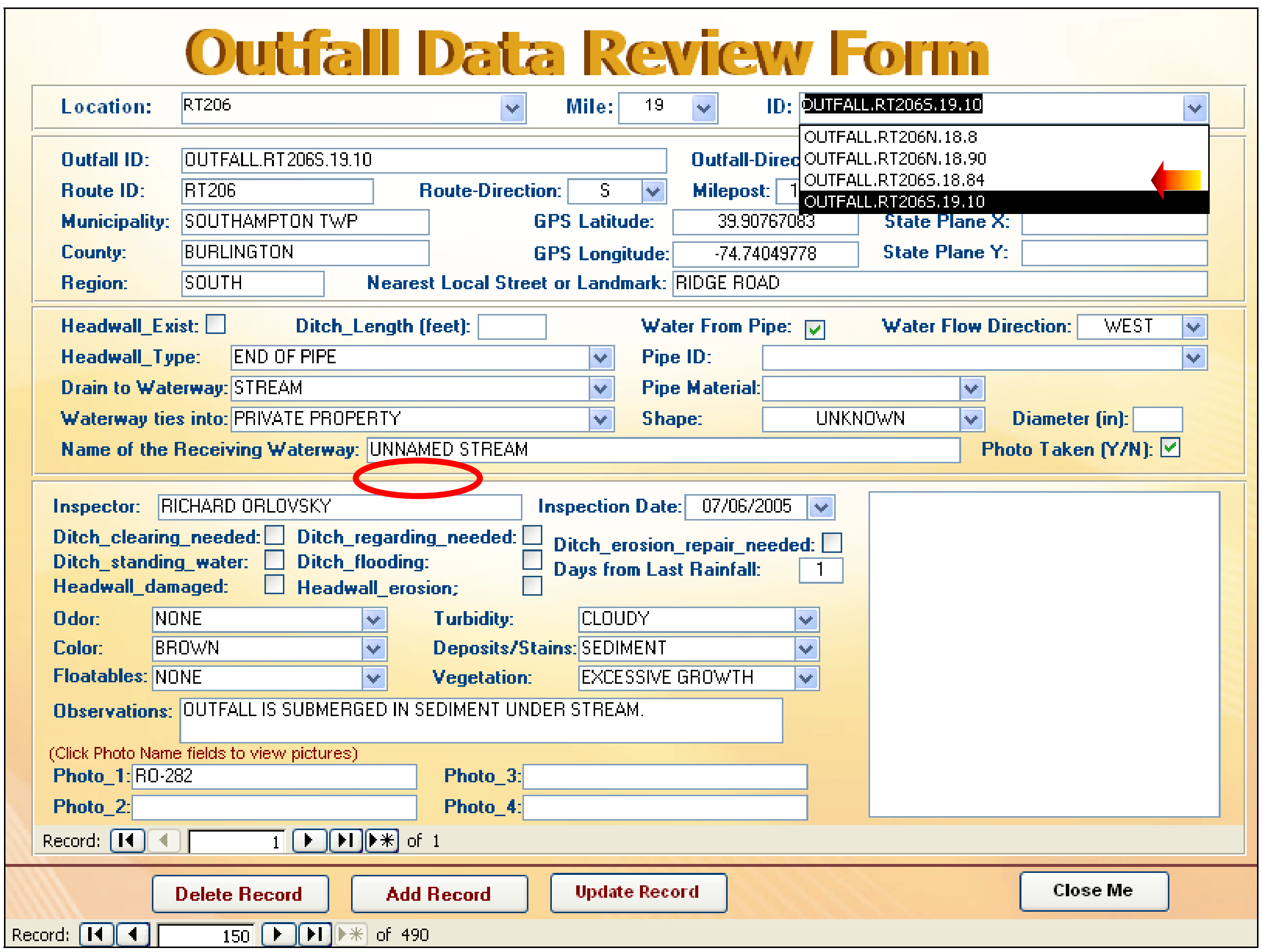
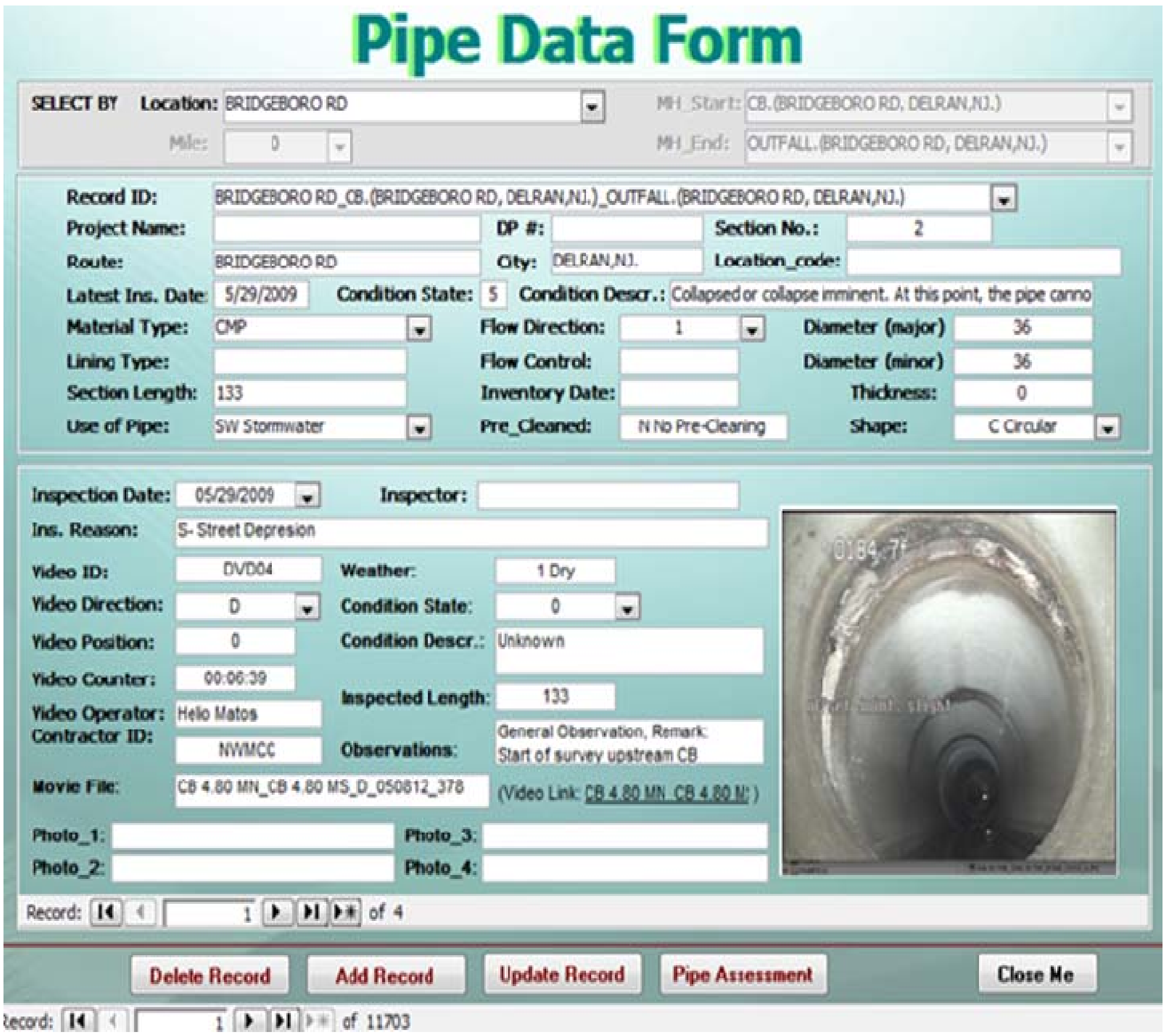


Figure 7. Outfall Data Review Form

Pipe Data Form:

The Pipe Data Form presents single record data information for a pipe segment. Similar to the Inlet/Outlet structure form, users may narrow the selection range of a particular pipe record by selecting a location (Road, City, State…), then the start-manhole, and finally selecting the end-manhole that will refresh the form to present a single pipe record (see Figure 8). Additional pipe records may also be retrieved, or users can directly select a pipe section record from the drop-down list. The pipe data form gives details of pipe asset data, as well as, a list of all related inspection information of the selected pipe including comments, photo file names, and movie file names, etc. Most data fields on this form may also be edited to fill in missing data and save the changes. In order to keep data integrity, critical key fields, such as 'Report ID' and 'Video ID' should not be edited. They should only be downloaded from the source database. No asset record addition or deletion is allowed at the present time. However, users can add a new inspection record for current pipe segment or embed a photo into the pipe records. A movie file may also be linked to the pipe data.


Pipe Data Form

SELECT BY Location: BRIDGEBORO RD
Mile: 0
MH_Start: CB.(BRIDGEBORO RD, DELRAN,NJ.)
MH_End: OUTFALL.(BRIDGEBORO RD, DELRAN,NJ.)

Record ID: BRIDGEBORO RD_CB.(BRIDGEBORO RD, DELRAN,NJ.)_OUTFALL.(BRIDGEBORO RD, DELRAN,NJ.)
Project Name:
DP #:
Section No.: 2
Route: BRIDGEBORO RD
City: DELRAN,NJ.
Location_code:
Latest Ins. Date: 5/29/2009
Condition State: 5
Condition Descr.: Collapsed or collapse imminent. At this point, the pipe canno
Material Type: CMP
Flow Direction: 1
Diameter (major): 36
Lining Type:
Flow Control:
Diameter (minor): 36
Section Length: 133
Inventory Date:
Thickness: 0
Use of Pipe: SW Stormwater
Pre_Cleaned: N No Pre-Cleaning
Shape: C Circular

Inspection Date: 05/29/2009
Inspector:
Ins. Reason: S- Street Depresion
Video ID: DVD04
Weather: 1 Dry
Video Direction: D
Condition State: 0
Video Position: 0
Condition Descr.: Unknown
Video Counter: 00:06:39
Inspected Length: 133
Video Operator: Helo Matos
Contractor ID: NWMCC
Observations: General Observation, Remark: Start of survey upstream CB
Movie File: CB 4.80 MN_CB 4.80 MS_D_050812_378
(Video Link: CB 4.80 MN_CB 4.80 M:)
Photo_1:
Photo_2:
Photo_3:
Photo_4:
Record: 1 of 4

Delete Record
Add Record
Update Record
Pipe Assessment
Close Me
Record: 1 of 11703

Figure 8. Pipe Data Form

Device Data Form:

Manufactured storm-water treatment technologies are designed for reducing storm-water runoff volume, reducing peak runoff rate, and reducing total phosphorus (TP). MTDs are also designed to remove highway trash and other pollutants such as nitrogen, oil/grease/hydrocarbons, heavy metals and bacteria. The MTD data entry form contains storm-water device asset data, inspection data and major maintenance records. All the information is contained in three tabular sub-forms under the following tabs: Device General Info., Inspection Information, and Maintenance Information. Users may search/specify the device ID, Type, and Model No. These three key fields will define the MTD category and attribute characters so as to link the device record to other related factual and dimensional data tables. For each device record, these three fields must be filled first in order to save the record into system databases. Due to the complexity and individual nature of the MTDs, specialized forms are provided for each manufacturer. Figure 9 shows the MTDs form for AquaShield.

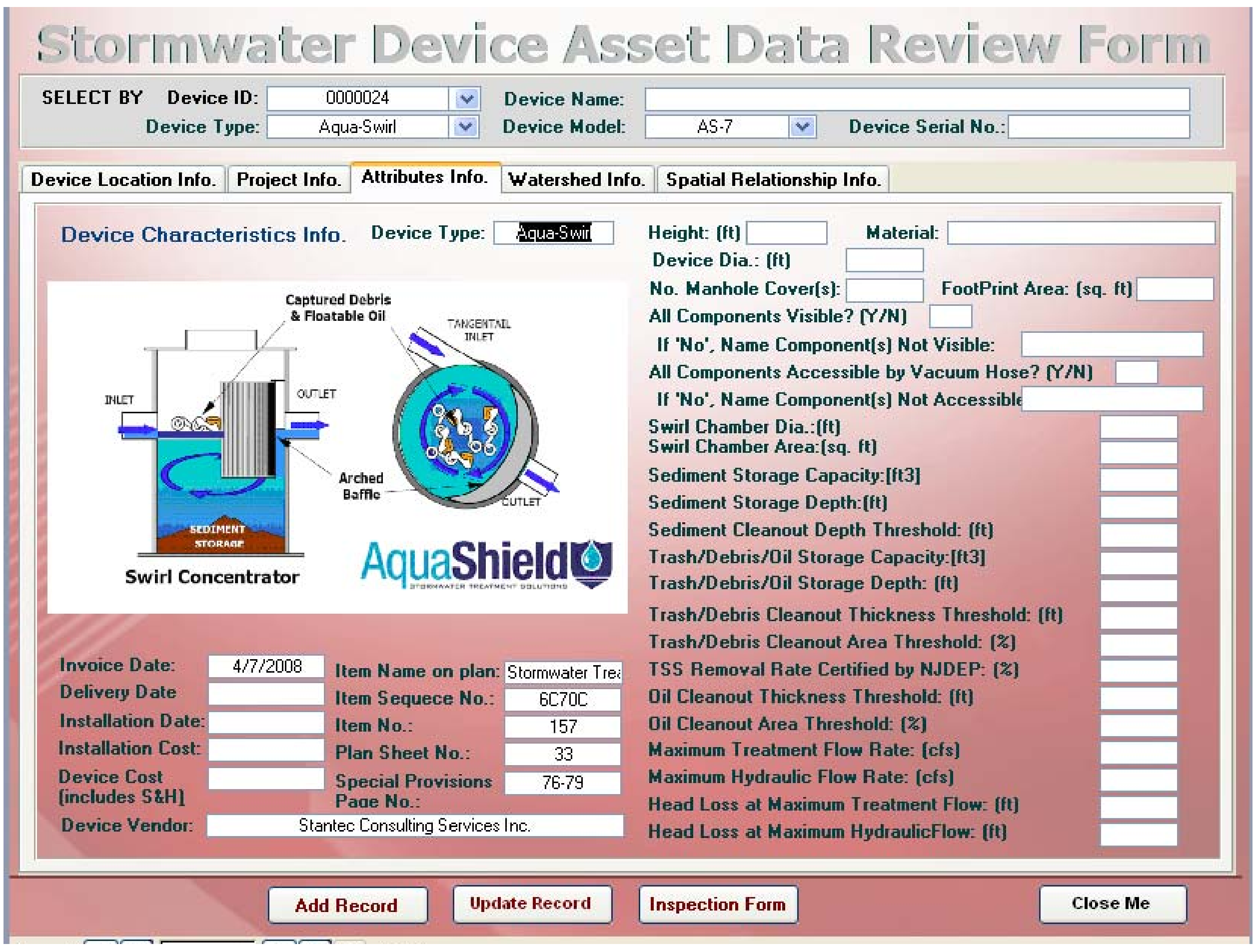


Figure 9. MTD Form for AquaShield

Financial Analysis Module

The DIAMS integrates Capital and Construction cost models capable of analyzing and reporting on the cost of drainage asset maintenance and operations (see Figure 10). The 72-item built-in Engineer's cost estimate (See **Table 1**) tool in DIAM will support planners/engineers in evaluating and making recommendations for best asset management practices. These scenarios include replacement, repair and rehabilitation or do nothing approaches based on a cost-benefit analysis.

At the project level, a drainage system infrastructure costs include expenditures for design, construction, maintenance, operation and administration. Costs for engineering, design and construction are called "first costs". Other costs, such as maintenance, operations and administration, occur continually, and are directly expressed as annual costs. All drainage asset costs are expressed as annual cost equivalents. Total capital costs (i.e. design, construction) may be expressed as annual equivalents using appropriate banking formulas assuming certain expected service life and interest rate. The annualized capital cost is then added to the annual costs of maintenance, operations, etc. to result in a total annual sum indicative of all drainage-related costs.

In starting a cost estimate, market value will provide the best available measure of value capital in terms of unit costs. The DIAMS incorporates unit costs based on 2010 RSMeans, a national U.S. yearly heavy construction cost estimating book and Bid Express, an online information service for bidding provided by BidX.com. Unit costs are incorporated into the New Jersey Department of Transportation (NJDOT) 72-itemized drainage restoration and repair contract bid as listed in Table 1 in order to estimate capital costs, asset worth, maintenance, repair and new construction costs.

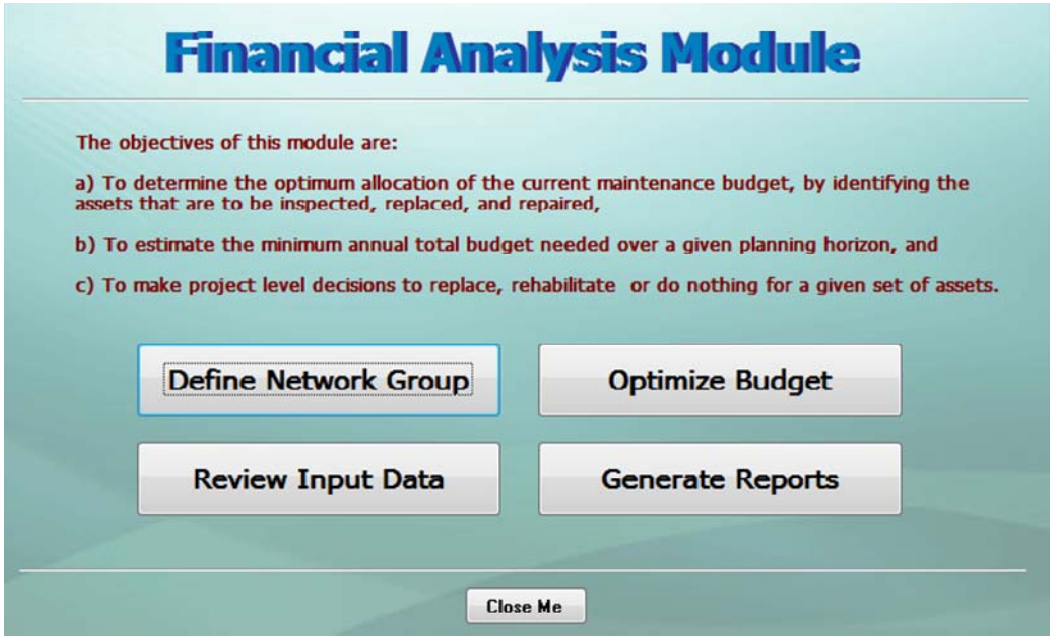


Figure 10. Optimization Module Switchboard Form

Table 1 – Unit Cost Table

NO	ITEM	UNIT	UNIT PRICE
151003M	PERFORMANCE BOND AND PAYMENT BOND	LUMP SUM	$10,000.00
152003P	OWNER'S AND CONTRACTOR'S PROTECTIVE LIABILITY INSURRANCE	LUMP SUM	$3,500.00
MMG007M	FIELD OFFICE EQUIPMENT	LUMP SUM	$7,500.00
MMG005M	CELLULAR PHONE SERVICE	LUMP SUM	$2,500.00
157003M	CONSTRUCTION LAYOUT	LUMP SUM	$30,000.00
MMD043M	MOBILIZATION OF DRAINAGE EQUIPMENT	UNIT	$2,500.00
MMG002M	FORCE ACCOUNT, LABOR	DOLL	$1.00
MMG003M	FORCE ACCOUNT, EQUIPMENT	DOLL	$1.00
MMG001M	FORCE ACCOUNT, MATERIALS	DOLL	$1.00
159003M	BREAKAWAY BARRICADE	UNIT	$15.00
159009M	TRAFFIC CONE	UNIT	$5.00
159006M	DRUM	UNIT	$15.00
159012M	CONSTRUCTION SIGN	S.F.	$5.00
MMR060M	FLASHING ARROW BAORD, 4'X8'	DAY	$50.00
MMG008M	TRAFFIC CONTROL TRUCK WITH CRASH CUASION & FLASHING ARROW BAORD,	DAY	$750.00
MMD006M	VARIABLE MESSAGE SIGN	DAY	$40.00
159141M	TRAFFIC DIRECTOR, FLAGGER	HOUR	$50.00
158006M	SILT FENCE	L.F	$5.00
158003M	CAUSION FENCE	L.F	$5.00
605212P	RESET FENCE	L.F	$15.00
158015M	HAYBALE	UNIT	$2.00
158045M	FLOADING TURBIDITY BARRIER, TYPE 2	L.F	$10.00
158072M	OIL ONLY EMERGENCY SPILL KIT, TYPE 1	UNIT	$1,000.00
MMD004M	FLOOD LIGHTS FOR NIGHTTIME OPERATIONS	DAY	$75.00
MMD039M	DISPOSAL OF TRASH AND BULKY WASTE	TON	$75.00
MMD041M	REUSE/RECYCLE OF SOIL/SEDIMENTS & MATERIALS	TON	$25.00
MMD025M	SLIP LINING 4" TO 24"	L.F.	$45.00
MMD025M	SLIP LINING 24" TO 48"	L.F.	$75.00
MMD025M	SLIP LINING 48" TO 72"	L.F.	$100.00
MMD029M	MINOR REPAIR OF STRUCTURES, LESS THAT 6' IN DEPTH	UNIT	$150.00
MMD030M	MINOR REPAIR OF STRUCTURES, GREATER THAT 6' IN DEPTH	UNIT	$300.00
602009M	INLET TYPE A LESS THAT 5' IN DEPTH	UNIT	$200.00
602009M	INLET TYPE A MORE THAT 5' IN DEPTH	UNIT	$300.00
602012M	INLET TYPE B LESS THAT 5' IN DEPTH	UNIT	$200.00
602012M	INLET TYPE B MORE THAT 5' IN DEPTH	UNIT	$300.00
602018M	INLET TYPE E LESS THAT 5' IN DEPTH	UNIT	$200.00
602018M	INLET TYPE E MORE THAT 5' IN DEPTH	UNIT	$300.00
602055M	MANHOLE	UNIT	$400.00
MMD009M	CLEANING AND VIDEO EQUIPMENT FOR PIPES AND STRUCTURES	DAY	$2,800.00
MMD024M	REPLACE PIPE 4" TO 24" DIAMETER R.C.P. (EDIT MATERIAL & UNIT PRICE)	L.F.	$75.00
MMD024M	REPLACE PIPE 4" TO 24" DIAMETER H.D.P.E. (EDIT MATERIAL & UNIT PRICE)	L.F.	$45.00
MMD024M	REPLACE PIPE 24" TO 48" DIAMETER R.C.P. (EDIT MATERIAL & UNIT PRICE)	L.F.	$90.00
MMD024M	REPLACE PIPE 24" TO 48" DIAMETER H.D.P.E. (EDIT MATERIAL & UNIT PRICE)	L.F.	$60.00
MMD024M	REPLACE PIPE 48" TO 72" DIAMETER R.C.P. (EDIT MATERIAL & UNIT PRICE)	L.F.	$120.00
MMD024M	REPLACE PIPE 48" TO 72" DIAMETER H.D.P.E. (EDIT MATERIAL & UNIT PRICE)	L.F.	$90.00
601760P	PIPE BEDDING	C.Y.	$35.00
601404P	SUB-BASE OUTLET DRAIN	L.F.	$30.00
158066M	ABSORBENT BOOM	L.F.	$10.00
158021M	TEMPORARY STONE CHECK DAM	C.Y.	$75.00
158024M	TEMPORARY SLOPE DRAIN	L.F.	$20.00
MMD007M	DISCHARGE PUMP	M.H.	$25.00
604003P	GABION WALL	C.Y.	$150.00
MMD021M	RIPRAP STONE PROTECTION, 6" THICK	S.Y.	$50.00
MMD021M	RIPRAP STONE PROTECTION, 6" - 12" THICK	S.Y.	$75.00
MMD019M	ROADWAY EXCAVATION, EARTH, LESS THAN 1.66 YARDS IN (VOLUME?)	C.Y.	$35.00
MMD020M	ROADWAY EXCAVATION, EARTH, GREATER THAN 1.66 YARDS IN	C.Y.	$60.00
MMD018M	SURFACE EXCAVATION	C.Y.	$70.00
202009P	EXCAVATION, UNCLASSIFIED	C.Y.	$25.00
202006M	EARTH EXCAVATION, TEST PIT	C.Y.	$85.00
302051P	DENSE-GARDED AGGREGATE BASE COURSE	C.Y.	$38.00
MMD017M	BITUMINOUS CONCRETE SURFACE & BASE COURSE	TON	$150.00
401030M	TACK COAT	L.F.	$3.50
606012P	CONCRETE SIDEWALK, 4" THICK	S.Y.	$40.00
607024P	9"X20" CONCRETE VERTICAL CURB	L.F.	$25.00
607087P	9"X8" HOT MIX ASPHALT CURB	L.F.	$20.00
609063M	RESET BEAM GUID RAIL WITH EXISTING POSTS	L.F.	$10.00
MMD042M	RETROFIT COVER PLATE FOR INLET CURB PIECE	UNIT	$150.00
801012M	SELECTIVE CLEARING	S.Y.	$15.00
MMD033M	TREE REMOVAL	UNIT	$150.00
806018P	FERTILIZING AND SEEDING, TYPE F	S.Y.	$7.00
804006M	TOPSOILING, 4" THICK	S.Y.	$5.00
807003M	TOPSOIL STABILIZATION, TYPE 1 MAT	S.Y.	$4.00

The total unit prices are gathered from the last column (Total Including O&P) for each item as found in the Existing Conditions, Concrete, Plumbing, Earthwork and Utilities sections of the 2010 RSMeans for items on the DIAMS Cost Estimate list. The RSMeans total unit prices include overhead and profit for material and equipment (about 10% of the total). In most cases, if the work is to be subcontracted, the general contractor will need to add an additional 10% to the total costs. Unit costs items, which were unavailable in cost estimation books were obtained from various NJDOT and Bid Express NJ contract bids and adjusted accordingly to the National Average for year 2010.

For DIAMS, the NJ unit prices are adjusted to the National Average (average of 30 major U.S. cities) using the CCI number of nearby NJ cities with similar economic characteristics to the location of projects. The RSMeans contains construction cost indexes for 316 U.S. cities. The City Cost index (CCI) number is a percentage ratio of a specific city's cost to the national average cost of the same item at a stated time period (RSMeans). The City of Paterson, with a factor of 110.2, was selected as the representative city for all projects performed in the North region of New Jersey. For the Central region, the City of Trenton was selected with a factor of 108.4. For the South region, Vineland was selected with a factor of 105.8. In the form of an equation as follows, the project cost is divided by the CCI number (expressed as a percentage, divide by 100) to obtain the National Average Cost (*NAC*) in equation 1 as shown below.

$$NAC = \frac{SCPC}{\frac{CIN}{100}} \text{ ------------ (1)}$$

Where, *SCPC* denotes the specific city project cost, and *CIN* denotes the city index number. For example, a pipe repair in 2000 on Rte 195 in NJ, in the township of Jackson cost $49,212 and the CCI equal 108.4 so that computed NAC is $49,212/(108.4/100) or $45,398.

The RSMeans Historical Cost Index (HCI) is used to convert national average construction costs at a particular time to the approximate construction costs for the project time using the time adjustment equation 2 shown below.

$$\frac{IY_A}{IY_B} \times \$Y_B = \$Y_A \text{ ----------- (2)}$$

Where IY_A and IY_B cost indices for years A and B respectively and $\$Y_A$ and $\$Y_B$ are the item costs for years A and B respectively. For example, to estimate the national average construction cost of the Route 195 Pipe repair in 2010, knowing that it cost $45,398 in 2000 with INDEX in 2010 (IY_A)= 183.5 and INDEX in 2000 (IY_B)= 120.9 would get, $45,398*(183.5/120.9) or $68,904. Hence, current cost estimates on construction costs and worth value are easily estimated based on a specific agencies' past projects.

The DIAMS financial analysis module is intended to produce a final product for work orders and financial summary reports. The simplified process of unit cost data incurred from pipe diameter size and type, estimating cost or manually input data, generating analysis with reports and a summary are key functions of the module. The process that is taken to develop the stages given as follows. Observations from vendors are collected via DVD video inspection data that includes information, comments, photo file names and movie files, are all input into the pipe data review form. The data review form consists of route identification, project name, diameter height, material type and location that can also be manually added to DIAMs. Data from pipes in the asset identification module are processed into a ranking system that is based on condition assessment. The condition assessments in turn will provide a technical treatment implementation suggestion upon the size and type of asset. Once information has been reported it is then taken through the financial analysis module and into budget planning and cost estimations that give definitive network sets according to various assets. Data from network sets are then confirmed for input data and a budget allocation for optimization is given. Finally, for demonstration purposes, the DIAMS developed a SQL statement builder form. It allows users to choose records they wish to display in a summary report. After a SQL statement is successfully generated, summary reports are built. This selection will open a report that displays the querying result based on current DIAMS database tables. The SQL builder querying results can be used to create a variety of customized summary reports. The following two forms explain the financial analysis of pipes in detail.

Pipe Assessment Forms:

The pipe assessment form enables users to choose pipe inspection or rehabilitation treatment techniques. It summarizes pipe material types, current condition, treatment cost as well as relevant date information for users allowing them to make operational decisions. From the current pipe condition and pipe age, the DIAMS will automatically take into account all available data about the selected pipe segment and reference to the pipe treatment policies defined by NJDOT (see Figure 11). DIAMS will automatically estimate and display the standardized pipe treatment costs for current pipe segment under review according to the pipe age, condition state, segment length and diameter as well as pipe material type information. (e.g., the Installation cost, the Inspection/Cleaning cost, the Rehabilitation cost and the Replacement cost). These standardized cost estimations come from a unit treatment cost table that could be modified in the editing system keywords module, based on user practice experiences.

Considering specific cost details, the user can request to estimate costs, which will open the cost modification form to make cost adjustments. A group of help buttons will guide users to consider certain relevant cost factors in estimating pipe treatment costs. The sub-module will guide users through a step-by-step process to estimate the do nothing cost used for the assessment process. By entering the cost item quantity, the sub-form will automatically calculate the total estimated rehabilitation cost for the pipe-repairing job. This estimated rehabilitation cost would be transferred back to the assessment form and recorded into database tables for later use. Combined with risk factors and consideration for user failure cost estimation, the system lists all suitable treatment techniques that the user can select. Users will also have the ability to compare their corresponding expenses. Based on the comparison, DIAMS will recommend or deny the user selection and remind the user to check existing data sets for accuracy.

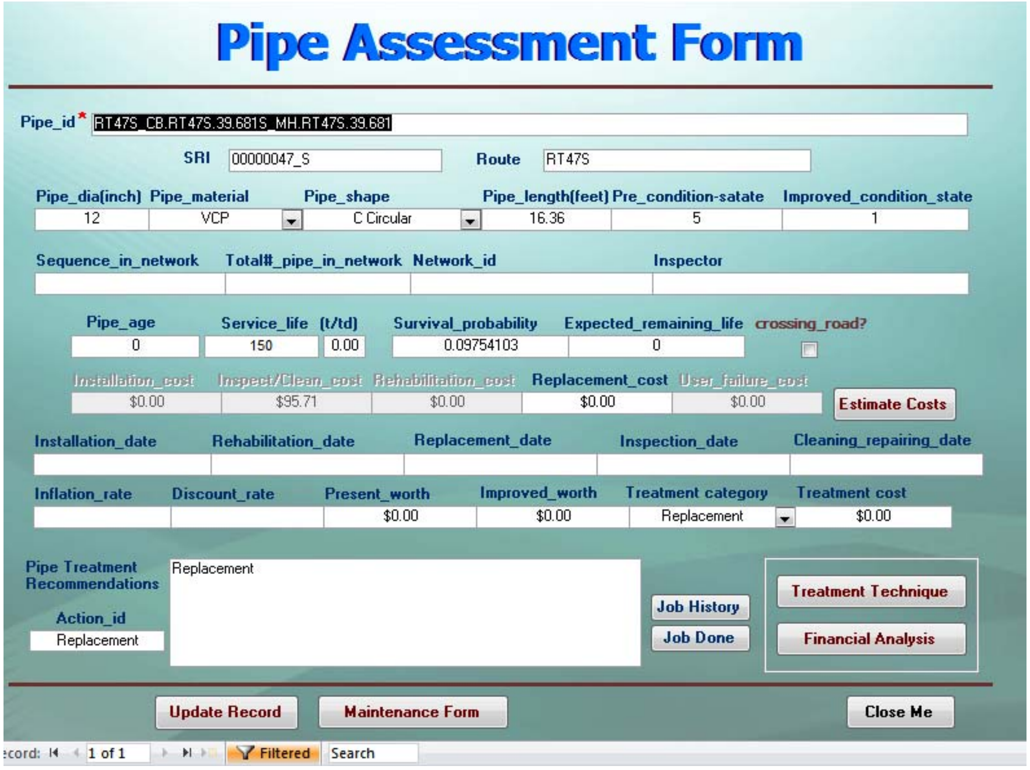


Figure 10. Pipe Assessment Form

Treatment Technique Selection:

Treatment technique selections are found in cases when both the pipe current condition state and pipe age are known. The treatment technique selection form displays the system recommended techniques and the current and improved condition states that are retrieved from treatment policy tables. Users can select the desired techniques and confirm treatment techniques, leading them to open the treatment cost justification form (see Figure 12). The form will automatically compare selected treatment technique costs, action costs, do nothing cost (i.e., the user failure cost) and notify the user if the selected action is justified, (indicated by text fields under the title justified). The user can either accept the system recommendation or input his/her choice. Once selected the recommend treatment technique will be saved in the decision comment text box and transferred back to the database. The decisions will be displayed on the updated pipe assessment form for the user to review.

Network Optimization:

The pipe assessment and optimization is the core component of DIAMS pipe financial analysis module. After the treatment techniques for the pipe segments have been determined, the user can define maintenance projects through the network optimization. Here, a project is defined as a group of pipe needing treatment within a certain amount of total budget (see Figure 13). With DIAMS, the user can search the optimal or near optimal solutions for the budget allocation among these pipe treatment jobs.

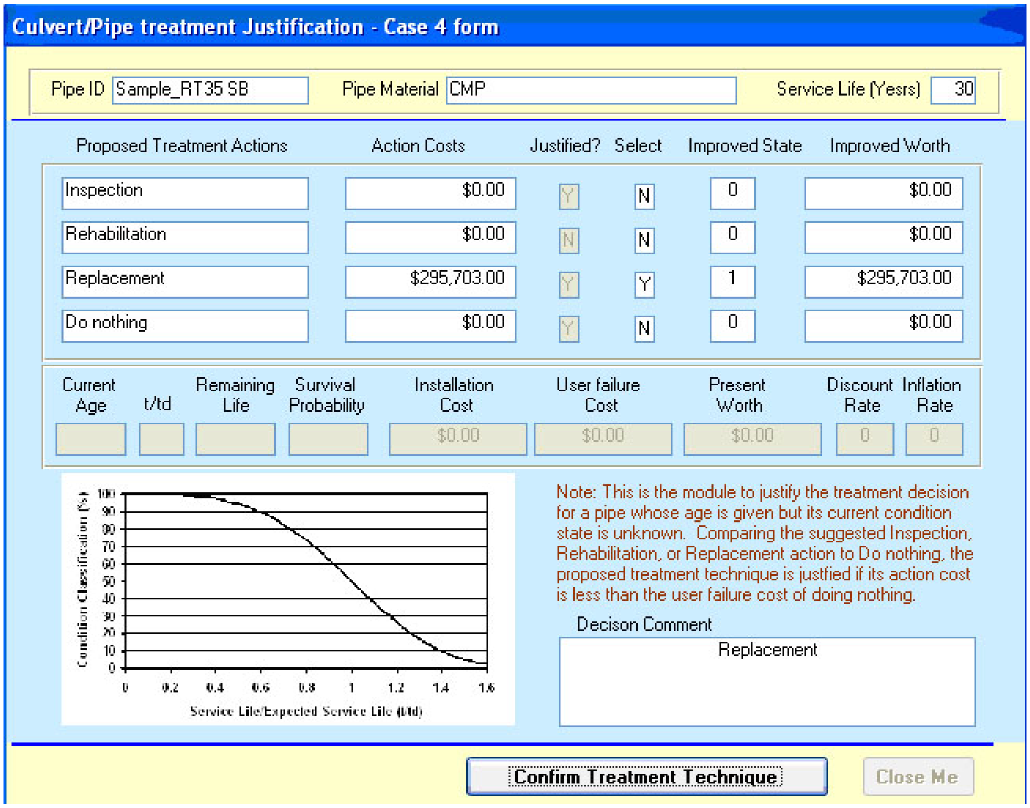


Figure 11. Structure/Pipe Treatment Cost Justification Form

The pipe financial analysis starts by grouping pipe segments into a particular project. Users have the option to select some of the segments to be included in the optimal solution no matter how much they cost. After a project has been defined the financial analysis module form will allow users to review the project input data where users are allowed to make changes to the input data. The pipe project optimization consists of four major components. The system will evaluate the input data set and summarizes its major attributions; such as how many pipe segments are in the project, the total capital cost are required, and how many are pre-fixed jobs as well as the minimum required capitals for these pre-fixed jobs (see Figure 14). The DIAMS has two optimization options, a heuristic procedure, such as 'catch-the-big-fish', or the 0-1 implicit enumeration algorithm that accounts for all possible combinations of the decision variables and compares their resulting objective function values to determine the real optimal solution. The reason for two algorithms is that the real optimal solution for the integer program problem has a 2^N computational complexity. When N>15, the enumeration will exceed 32768 combinations.

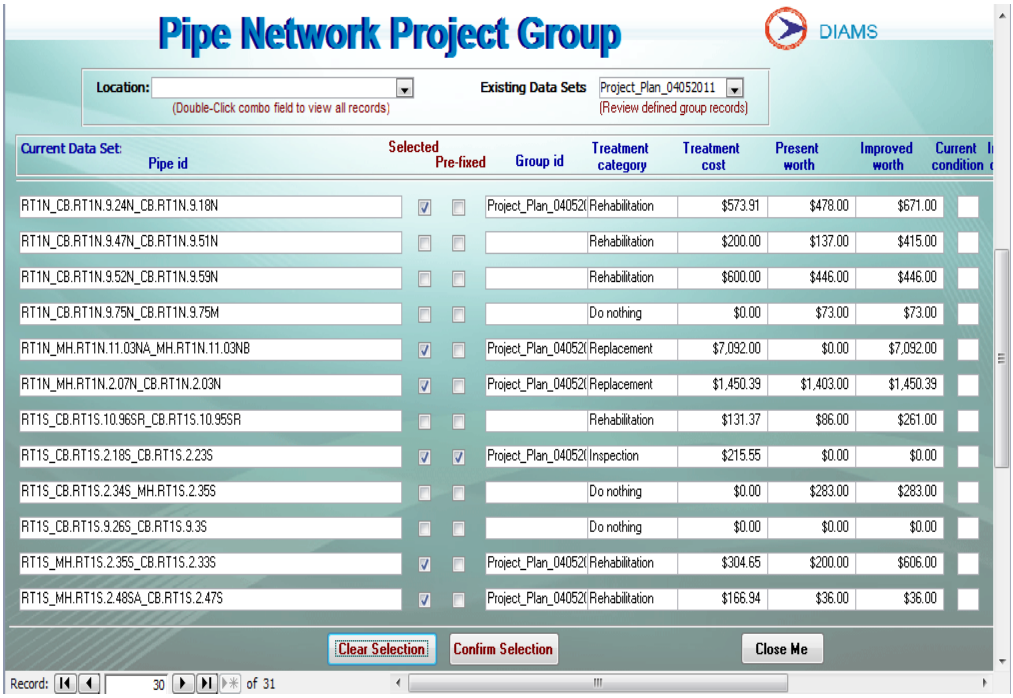


Figure 12. Pipe Network Selection Form

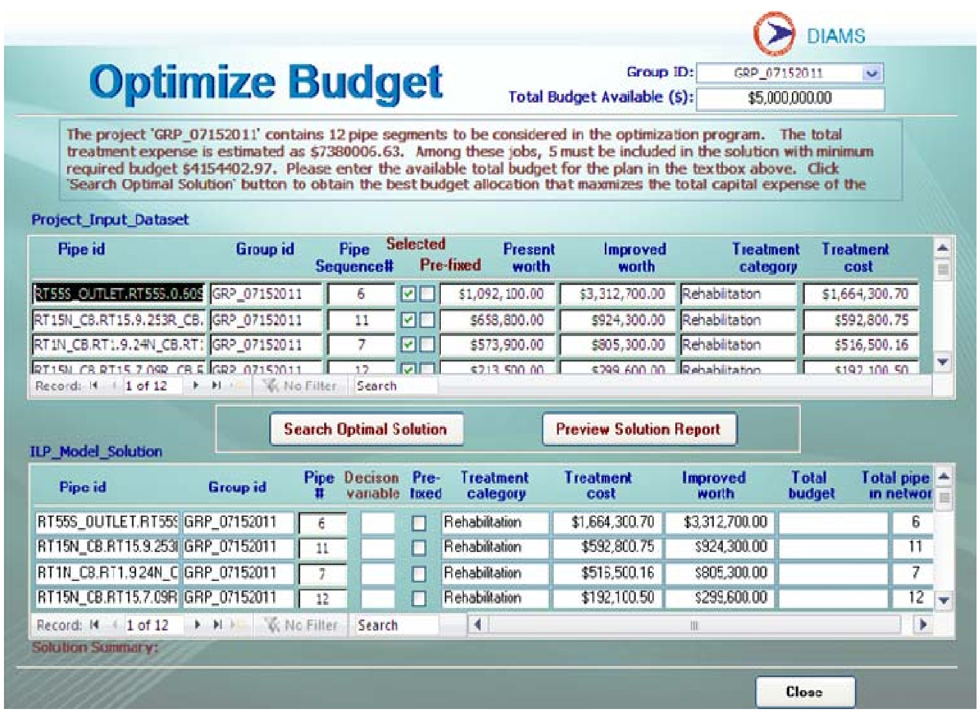


Figure 13. Optimize Budget Form

Although, the objective function and budget constraint are both simple linear additions, it may take a long time to evaluate all possible combinations when N is too large. The heuristic procedure is preferred when N>25. The heuristic approach covers the more costly segments first then the smaller ones until the available budget is exhausted.

DIAMS Report Generation:

Financial reports are an important part of DIAMS financial analysis module. These reports provide valuable information about the current status of the drainage system under NJDOT management. These timely generated reports are an effective tool for managers to set the priority of work orders and to schedule maintenance jobs in the most cost efficient way. Figure 14 shows one such report based on Network optimization.

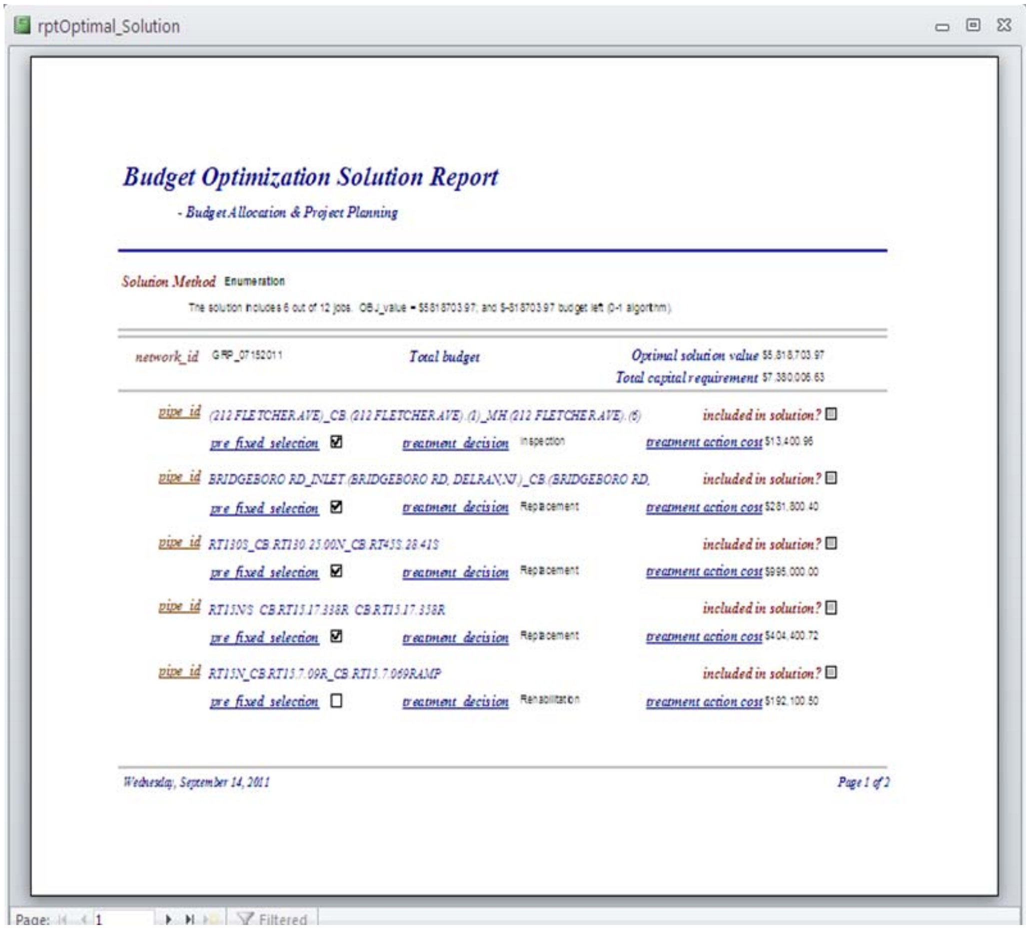


Figure 14. Sample Budget Solution Report

SUGGESTIONS FOR FUTURE RESEARCH

This project is a limited scope demonstration project of implementing the drainage information mapping system. There are several aspects that need further research and implementation. They are listed below.

1. The drainage information mapping system was developed in association with the NJDOT straight-line database. This should be upgraded to a database based on a geographic information system for visualization and planning.

2. The drainage information mapping system developed in this demonstration project contains only the assets inspected to date. To perform system wide optimization, one needs all information on all infrastructure assets in the state of New Jersey. Until that information is available, DIAMS will be unable to perform system wide optimization to comply with GASB 34 requirements. Hence, any future research should include the development of this component.

3. The DIAMS currently only considers in-kind replacement, which is not always possible. Therefore, the system should be upgraded to include replacement with different types of assets.

4. Since the majority of the assets are not inspected during the current year, a mechanism should be developed to predict the current condition state based on the past condition state. The historical records will help for financial analysis and planning purposes, but this capability involves substantial mathematical analysis, and hence it is proposed to be included in future developments.

5. Based on the current NJDOT administrative structure, capital investments and maintenance expenditure occur in two separate departments. However, DIAMS currently assumes that funds for both come from one source. Hence, the department might consider changing the administrative structure, or in the future, programs should split this into two separate optimizations.

6. Include a data streaming module for the NJDOT Video Inspection Van to upload directly into DIAMS.

7. Include the remaining structures (e.g. retention ponds, catch basins) for flood prevention purposes.

SUMMARY AND CONCLUSIONS

The following are the conclusions of this research:

1. Drainage Information Analysis and Mapping System (DIAMS) was developed. It is a two-layer system consisting of separate Structured Query Language (SQL) databases for pipes, inlet/outlet structures, outfalls, and manufactured storm-water treatment devices (MTDs). The 'front-end' of DIAMS is programmed on an Access 2003 application database with user-interfaces and queries for data review and manipulation. The 'back-end' consists of several database tables and related photo/movie files and reports. All database files are integrated into an effective data management system.

2. DIAMS is structured as four individual modules: asset identification, data upload, financial analysis and system administration. The data upload module has various sub-nodes to ensure that the contractor-supplied field data uploaded to the database is unified and consistent. The asset identification module accesses the key attributes of the various physical components, and assigns functionality attributes to the inventory of drainage infrastructure. The system administration module supports low-level data reviews and editing, and the financial analysis compares maintenance and repair costs to design and extension of drainage network.

3. Information gathered through contracted drainage infrastructure inspections allows decision makers the ability to safely and proactively treat the condition assessment while allowing optimal financial cost benefits through the mathematical formulas presented over the long run. Quality analysis and quality reports that are used in the DIAMS assess the pipe condition states. Modules will find the inspection, cleaning and repair unit costs according to their functionality of size and material type. Decision makers will have opportunities to choose and modify the types of information and input data in a manual form accordingly.

4. DAIMS considers four types of drainage infrastructure: structures (manhole, catch basins, head walls), outfalls (end of pipes, streams), pipes, and MTDs. Each of these type structures has its own data form that may be used to search and review the data for the particular type of structure.

5. DIAMS Financial Analysis Module integrates Capital and Construction cost models capable of analyzing and reporting on the cost of drainage asset maintenance and operations. It utilizes a 72-item built-in Engineer's cost estimate tool that will support planners/engineers in evaluating and making recommendations for best asset management practices. Unit prices are gathered for each item as found in the Existing Conditions, Concrete, Plumbing, Earthwork and Utilities sections of the 2010 RSMeans for items on the DIAMS Cost Estimate list. Scenarios include replacement, repair and rehabilitation or do nothing approaches based on a cost-benefit analysis.

6. DIAMS financial analysis module is also intended to produce a final product for work orders and financial summary reports. The simplified process of unit cost data incurred from pipe diameter size and type, estimating cost or manually input data, generating analysis with reports and a summary are key functions of the module. Data from pipes in the asset identification module are processed into a ranking system that is based on condition assessment, which in turn will provide a technical treatment implementation suggestion upon the size and type of asset.

7. Budget planning and cost estimations may be performed for definitive network sets according to various assets. Data from network sets are then confirmed for input data and a budget allocation for optimization is given. For demonstration purposes, the DIAMS developed an SQL statement builder form that allows users to choose records they wish to display in a summary report. After a SQL statement is successfully generated, summary reports are built. This selection will open a report that displays the querying result based on current DIAMS database tables. The SQL builder querying results can be used to create a variety of customized summary reports.

8. A limited scope pilot scale of the DIAMS was developed, tested and implemented for NJDOT. A detailed user manual and several on-site training sessions were also provided to ensure that NJDOT staff will be able to utilize DIAMS.

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Information for Cost-Effective Maintenance of Stormwater Manufactured Treatment Devices (MTDs)

Appendix A
October 2012

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EXECUTIVE SUMMARY

The intention of this project was to generate and provide data for the maintenance of Manufactured Treatment Devices (MTDs) installed on NJDOT project sites. MTDs are one type of stormwater Best Management Practices (BMPs) that can be used to control the quality of stormwater discharge in new developments and redevelopments in order to comply with increasingly stringent regulations. MTDs are commonly used on sites with limited space availability.

Section 1 of this report consists of a summary of the initial literature search conducted. Due to the limited scientific literature available on MTD maintenance, gray literature and documents produced by the manufacturers were included. Also, BMP databases were consulted, as well as NJDEP regulations and maintenance manuals for each type of device.

Section 2 of this report presents the results of a study that identified 132 MTDs installed under NJDOT jurisdiction for which the agency is responsible and has to provide maintenance. Documents such as bid lists, design submission lists, and construction plans from NJDOT were analyzed to identify and locate the devices. Several vendors provided lists of the devices they had sold and believed to be on NJDOT project sites. Key NJDOT personnel was consulted and provided invaluable information on the location of some devices. Finally, a few devices that had not been found through any of the previous methods were found by executing targeted searches on the World Wide Web. The key to the success of this part of the project was the in-depth analysis of over 79 sets of plans of NJDOT projects that had been previously identified as possibly containing MTDs.

The third section of the report presents forms developed to record data for each type of device present under NJDOT jurisdiction. Different manufacturers have developed proprietary MTD technologies that are being used on NJDOT projects. Each one of these technologies has different configurations and thus their maintenance procedures vary. Asset data, inspection, and maintenance forms for 7 types of hydrodynamic separators were developed as part of this study: Aqua Swirl, CDS, Downstream Defender, Stormceptor STC, Terre Kleen, Vortechs, and VortSentry. The asset data, inspection and maintenance forms were developed so that one section contains information that is common to all types of devices, while a second part contains information that will be specific to the device being tracked, inspected or maintained.

Finally, Section 4 of the report contains the results of the cleanout and characterization study conducted on eight (8) chosen devices. Initially, twelve Vortechs devices were chosen for cleanout and monitoring in 2007. Vortechs were the most common type of device installed on NJDOT sites at that time, with very few devices of other types found. After three years of monitoring, six (6) devices were found to have reached capacity and were scheduled for a second cleanout. Given the proliferation of other types of devices during the last few years, another two (2) devices were chosen for cleanout and monitoring in 2010: one Aqua-Swirl and one Downstream Defender. Cleanout procedures were documented for all the three types of hydrodynamic separators in order to provide guidance for future cleanout. The material removed from the devices was characterized in order to provide guidance for future disposal procedures and further develop of maintenance guidance.

A-1 LITERATURE SEARCH

Introduction

The use of manufactured treatment devices (MTDs) is rapidly increasing in order to meet escalating water quality regulatory requirements in re-development and new development situations where land space is not readily available to accommodate other types of stormwater Best Management Practices (BMPs).

MTDs are an emerging technology and are being installed at an accelerated pace in response to new stormwater regulations. As a result, scientific research is falling behind field applications. For this report, the literature search went beyond archived scientific literature and included gray literature and information generated by the industry.

Sources

Sources used in the literature search included:

1. Proceedings of World Environmental and Water Resources Congress, organized annually by Environmental and Water Resources Institute (EWRI) of the American Society of Civil Engineers (ASCE). Most of the stormwater researchers and consultants presented their latest results at this Congress.
2. Proceedings of Stormwater Conference (StormCon), organized by the industry group annually. Most of the stormwater manufacturers present their latest results at this conference.
3. Rutgers Library databases for books, journal articles, conference proceedings, technical reports, and government documents.
4. Web sites for agencies, organizations, and manufacturers.

MTDs Certified for Use in the State of New Jersey

Based on the list provided by the New Jersey Department of Environmental Protection (NJDEP) on its web site, http://www.njstormwater.org/treatment.html, as of May 2010, a total of 21 types of MTD have been certified for use in the State of NJ.

Among the certified MTDs, 14 are hydrodynamic separators. They were given a credit of 50% TSS removal efficiency. Since most of the devices were approved for use in NJ only in the last few years, most of the listed devices have not yet been installed in NJDOT projects.

1. Aqua-Swirl Concentrator
2. BaySeparator
3. Downstream Defender
4. FloGard Dual-Vortex Hydrodynamic Separator
5. High Efficiency Continuous Deflective Separator (CDS) Unit
6. Hydroguard
7. Nutrient Separating Bafflle Box
8. Stormceptor OSR
9. Stormceptor STC
10. TerreKleen Stormwater Device
11. Up-Flo Filter by Hydro
12. V2B1
13. Vortechs Stormwater Treatment System
14. VortSentry System

There are 6 certified filter devices. NJDOT has not allowed the filter devices to be used, primarily due to the concern of heavy maintenance. They were given a credit of 80% TSS removal efficiency:

1. AquaFilter Filtration Chamber
2. Bayfilter
3. Jellyfish Filter
4. Media Filtration Systems
5. Stormwater Management StormFilter
6. VortFilter System

There is one (1) certified underground storage device. It was given a credit of 80% TSS removal efficiency. NJDOT has been using the underground storage devices as a storage device for flood control instead of water quality:

1. StormVault

MTD Databases

Three existing databases for stormwater Best Management Practices (BMPs) were found:

1. International Stormwater BMP database (http://www.bmpdatabase.org/)

This database was created primarily to document pollutant removal performance of the BMPs, not maintenance requirements. There are a limited number of MTDs included, and none are located in NJ. Note that MTDs is only one (1) of the eleven (11) generally-recognized types of stormwater BMPs. Little effort has been placed on documenting the newly emerged MTDs.

2. UNHSC-NEMO Innovative Stormwater Management Inventory (http://www.erg.unh.edu/stormwater/index.asp)

New England stormwater Low Impact Development-BMP database. Covers Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont. No MTDs are mentioned.

3. NPDES Urban BMP Performance Tool (http://iaspub.epa.gov/urbanbmp/index.jsp?action=bmpSearch)

Several studies on BMPs in the United States are included. None of the studies found on the website were conducted in New Jersey.

Maintenance Requirements for MTDs

All the regulatory agencies require that stormwater BMPs be maintained properly. In the State of New Jersey, the NJDEP Stormwater Management Rules require a maintenance plan to be developed for all stormwater management measures incorporated into the design of a major development.

The paragraph of the New Jersey Stormwater Best Management Practices Manual (NJDEP, 2009) regarding the required maintenance plan reads as follows:

"This maintenance plan must contain specific preventative and corrective maintenance tasks, schedules, cost estimates, and the name, address, and telephone number of the person or persons responsible for the measures' maintenance." (1)

Maintenance Guidance on MTDs

All MTD manufacturers have provided specific maintenance guidance. For example, the guidance for Vortechs by CONTECH Stormwater Solutions is as follows: (http://www.contech-cpi.com/stormwater/products/hydrodynamic_separation/vortechs/72)

"Inspection is the key to effective maintenance and is easily performed. Pollutant deposition and transport may vary from year to year and regular inspections will help ensure that the system is cleaned out at the appropriate time. Inspections should be performed twice per year (i.e. spring and fall) however more frequent inspections may be necessary in equipment washdown areas and in climates where winter sanding operations may lead to rapid accumulations. It is useful and often required as part of a permit to keep a record of each inspection."

"The Vortechs system should be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more heavily on site activities than the size of the unit, e.g., unstable soils or heavy winter sanding will cause the swirl chamber to fill more quickly but regular sweeping will slow accumulation."

“The Vortechs system should be cleaned when inspection reveals that the sediment depth has accumulated to within 12 to 18 inches (300 to 450 mm) of the dry-weather water surface elevation. This determination can be made by taking two measurements with a stadia rod or similar measuring device; one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface.”

“Cleaning of the Vortechs system should be done during dry weather conditions when no flow is entering the system. Clean-out of the Vortechs system with a vacuum truck is generally the most effective and convenient method of excavating pollutants from the system. If such a truck is not available, a ‘clamshell’ grab may be used, but it is difficult to remove all accumulated pollutants using a ‘clamshell’. “

“In installations where the risk of petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, an oil or gasoline spill should be cleaned out immediately. Motor oil and other hydrocarbons that accumulate on a more routine basis should be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use adsorbent pads to solidify the oil since these pads are usually much easier to remove from the unit individually and less expensive to dispose of than the oil/water emulsion that may be created by vacuuming the oily layer. Floating trash can be netted out if you wish to separate it from the other pollutants.”

The stormwater profession has also started to act together to generate maintenance guidance. For example, a subcommittee was set up by a large ASCE/EWRI task committee (chaired by Dr. Q. Guo of Rutgers) to generate the MTDs maintenance guidelines (Hunt et al. 2008). Abstract of the subcommittee paper is as follows:

“ASCE/EWRI has assembled a Task Committee on guidelines for certification of manufactured stormwater BMPs. A nine-member subcommittee for maintenance was tasked by the larger committee to develop maintenance guidelines for manufactured stormwater BMPs. The subcommittee has developed recommendations for manufactured BMP maintenance in the following seven areas: (1) designing for maintenance, (2) defining standard maintenance triggers, (3) defining maintenance fundamentals for all manufactured BMPs, (4) defining maintenance tasks by BMP design; hydrodynamic or filter design, (5) identifying entities best able to maintain manufactured BMPs, and training requirements, (6) identifying entities to train maintenance providers, and (7) reviewing recommended disposal techniques for captured pollutants.” (2)

Maintenance (Cleanout) Interval for MTDs

Few field studies have been conducted to quantify the actual maintenance interval for MTDs and to relate it to the drainage area characteristics.

Recognizing the potentially high cost of maintaining MTDs, NJDOT sponsored Rutgers University for a maintenance interval research. Two conference papers resulted from this effort. The abstract for the first conference paper titled “Quantity and Quality of Stormwater Solids Trapped by Hydrodynamic Separators at Highway Sites” follows:

“Twelve (12) stormwater manufactured treatment devices along New Jersey highways were selected for monitoring, analysis, and development of maintenance guidelines. The quantity of bottom sediment, oil, and buoyant debris trapped in the hydrodynamic separators over the three to six years since installation were measured. The quality of bottom sediment was measured as well. Measured quantity and quality of the trapped stormwater solids varied widely from site to site. Total depth of the bottom sediment ranged from 2.7 feet (exceeding the maintenance limit of 2 feet) to 0.5 feet (well within the maintenance limit). On average, about 90 percent of the solids trapped at the bottom had a mean particle size larger than 75 microns: coarse sediment. Organic content of the bottom sediment ranged from 3 to 34 percent. Concentrations of all the measured heavy metals (copper, zinc, lead, cadmium, and arsenic) in the bottom sediment were much lower than New Jersey residential soil contamination limits. Concentrations of phosphorus and nitrogen in the bottom sediment were much lower than those in typical sewage sludge. The quantity and quality of the trapped solids have also been monitored continuously for over one year since the device cleanout. Combining the sediment depth measurements before and after the cleanout yielded a recommended maintenance interval typically longer than four years, but with a shorter maintenance interval of one and half years where land surface erosion problems were observed.”

The average maintenance (cleanout) interval measured for the devices in the study was far longer than one year, which is generally recommended by device manufacturers and regulatory agencies. The extended cleanout interval could potentially lead to a tremendous amount of savings.

A-2 IDENTIFICATION AND MAPPING OF STORMWATER MANUFACTURED TREATMENT DEVICES (MTDS)

Compilation of Information

When the project started, requests for information on installed Manufactured Treatment Devices (MTDs) were made to vendors and to the New Jersey Department of Transportation (NJDOT). Additionally, Rutgers had collected information on some MTDs for a previous research project for NJDOT.

The four (4) main sources of information used were:

1. Previous Rutgers research project for NJDOT. The information for this project had been obtained from NJDOT and vendors for MTDs installed between 2000 (the plan approval year) and 2007.
2. Lists of devices sold by vendors between 2008 and February 2010.
3. NJDOT lists of projects bid upon between September 2005 and January 2010 that were thought to contain MTDs.
4. NJDOT list of projects under design or not yet advertised that were thought to contain MTDs.

As the project progressed, other sources of information were added. Internet searches, for example, allowed the identification of one device not contained in any of the four (4) sources previously mentioned. The complete list of information sources used throughout the project is shown in Table 1 below.

Table 1 – Sources of information used to identify projects with MTDs under NJDOT jurisdiction

1	NJDOT, March 2007.
2	Vendors, April 2007.
3	Vendors, February 2010.
4	NJDOT Bid List, January 2010.
5	NJDOT Design Submission List, January 2010.
6	Internet Search
7	NJDOT J. Walsh, March 02, 2010.
8	NJDOT T. Wolfram, April 01, 2010.

The information gathered from these sources was organized and compiled in a list of devices that could potentially be MTDs. That list served as a starting point for identifying and locating MTDs.

Data Mining from Plans and Additional Sources

After exploring different alternatives to locate the listed devices, it was determined that the best approach would be to identify them on plans. Some of the projects in the original list of devices did not have a project number associated with them, which made it more difficult to locate the plans. NJDOT successfully identified the project number for many of the projects, while others were found by Rutgers by reviewing the construction bid awards available on the NJDOT website[1].

An initial batch of plans for twenty four (24) projects known to contain MTDs was requested to the NJDOT Engineering Document Unit (EDU). A second and third batch of plans, for twenty five projects (25) each, were requested through the landscape architecture and environmental solutions division of NJDOT. Additionally, NJDOT (Todd Wolfram) provided Rutgers with another twenty five (25) projects containing stormwater Best Management Practices (BMPs). From the plans requested, twenty projects were found to be either outside of the jurisdiction of NJDOT or no plans could be located with the available information. A total of seventy nine (79) sets of plans were received. Requests for additional pages were made in certain cases.

The review of the plans provided confirmation of the type of device (MTDs or other stormwater BMPs), their location and other useful information. Each plan was scanned thoroughly to identify the MTDs. A description of the location of the MTDs was tabulated as well as the name of the device on the plans, the standard item number and the sequence number. The page number in which each device was found on the plans was also recorded. The location details include the road on which the device is located (or the nearest road), the direction in which the vehicle would need to be moving to locate the MTD without crossing the road, the nearest cross road, the estimated mile post and additional landmark information that can aid to locate the device on site.

The key map (usually the front page of the plans, see Figure 1) was used to confirm details like the project name, project number, plan approval date and design company. Since some projects were listed under different names by different sources, the project name and number from the plans helped identify devices that had been listed twice. The plan approval date served as an additional cross reference by matching it with device delivery dates and construction awards lists.

Other references such as straight line diagrams and special provisions pages were also consulted in an effort to produce information as accurately as possible.

The most recent straight line diagrams (SLDs), available on the NJDOT website (http://www.state.nj.us/transportation/refdata/sldiag/) were used to estimate the mile

[1] http://www.state.nj.us/transportation/business/procurement/ConstrServ/awards10.shtm

post where the device is located relative to the main road. In the cases where the device is located on a secondary road, the mile post reference was left blank since only the state road SLDs were available at the time of performing this work.

The special provisions pages available were reviewed for certain projects to try to confirm doubts on the type of BMPs present. In one case, positive identification of a MTD was obtained from these special provisions pages.

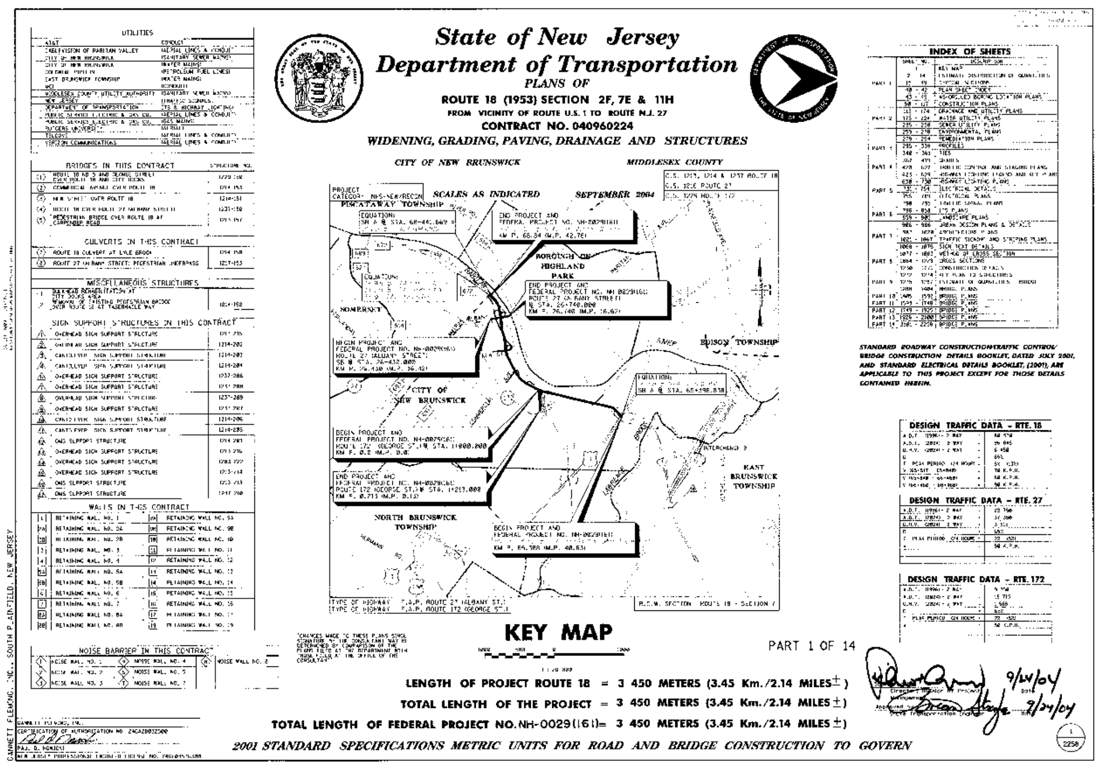


Figure 1. Key map sample

The MTD location table includes columns to tabulate the latitude and longitude that can be obtained with a GPS during physical inspection of the MTD. Rutgers had previously done another research project for NJDOT and obtained the latitude and longitude for twenty seven (27) devices. This information is included in the MTD location table attached to this report.

Mapping

In parallel to mining data from the plans, each device identified on the plans was marked on a street map that shows the adjacent roadways and the scale of the map. In most cases the device location must be accurate within fifty (50) feet. In one project (project number 064098006 – Route US 206 bypass section), the road where the device would be located was being built, at the time of performing the research, so the available online maps did not show the road yet (as of May 03, 2010). For this MTD the location was estimated from existing landmarks.

A county map of New Jersey was used to mark a roughly estimated location of the projects per county and the number of devices per project. The map (Figure 2) gives an overview of the distribution of MTDs in New Jersey.

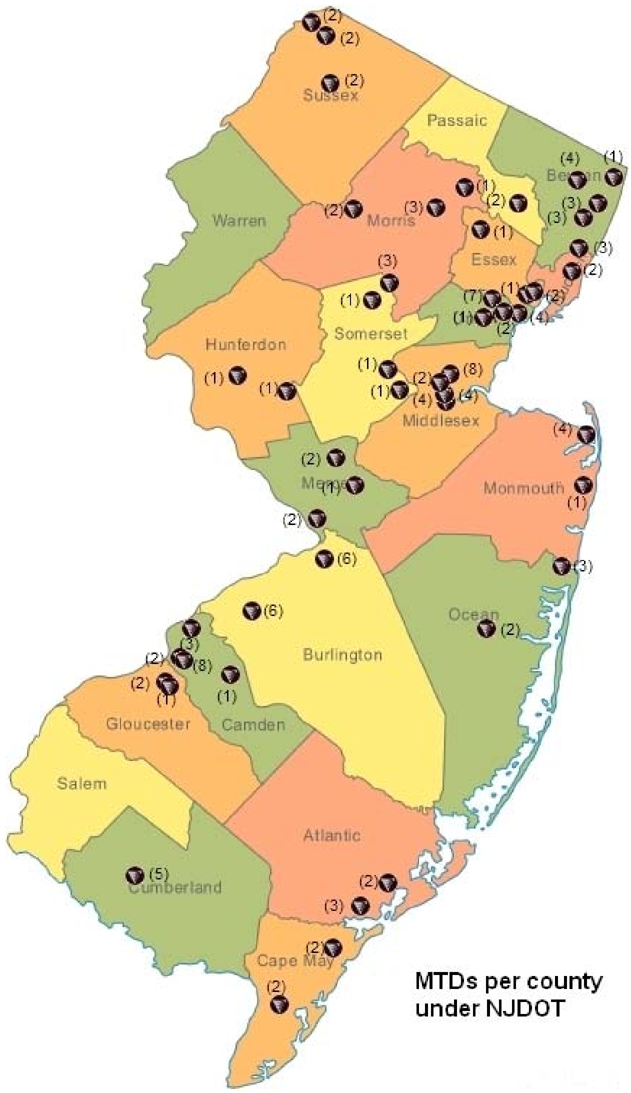


Figure 2. MTDs distribution along New Jersey.

A map was also made for each individual device; an example of these maps has been included in the next subsection. Each map is identified with the project number and the device number within that project (from the MTD location table). If additional information is needed to locate the device, the MTD location table provides a detailed description.

Results

Seventy nine (79) sets of project plans were searched for MTDs, of which only fifty (50) contained MTDs to be positively identified as being under NJDOT jurisdiction. One hundred and thirty two (132) individual MTDs under NJDOT jurisdiction were found using this method. A detailed MTD location table was produced for these devices (see Appendix A-I). The MTD location table produced by Rutgers contains detailed location information for each MTD including road and cross road, and estimated mile post (when available) among other data.

The MTD location table contains four (4) sections. The first section lists the one hundred and thirty two (132) devices mentioned in the preceding paragraph.

A second section lists seven (7) projects that might (or might not) contain MTDs and are under design process or not yet advertised. A third section lists eight (8) devices for which it was not possible to locate plans due to the limited information available. The final section lists other types of stormwater BMPs that were identified during the project but are not MTDs.

No plans were available for the seven (7) projects under design or not yet advertised (second section of the MTD location table) as of the writing of this report (May 03, 2010). At least one (1) of these projects (NJDOT project # 001998500) mentions MTDs in its DEP permit application.

The eight (8) devices listed under the third section of the MTD location table are known to be MTDs from the vendor lists but they might or might not be under the jurisdiction of NJDOT.

Finally the additional BMPs listed in the fourth section of the MTD location table do not contain detailed identification and location information because it was out of the scope of this project.

Table 2 summarizes the number of projects initially identified as potentially having MTDs under NJDOT jurisdiction along with the number of MTDs found in each project. The table contains information regarding the four separate sections of the MTD location table in order to differentiate between projects that have been unequivocally identified as being both under NJDOT jurisdiction and containing MTDs from projects where at least one of these conditions might not be met.

Table 2 – Summary of projects identified as potentially having MTDs under NJDOT jurisdiction

Category	**Number of Projects**	**Number of Devices/BMPs**
MTDs installed and under NJDOT jurisdiction	50	132
Projects under NJDOT jurisdiction but still under design or not yet advertised. Uncertain if these projects include MTDs	7	Unknown
MTDs for which no plans were located but are unlikely to be under NJDOT jurisdiction	5	8
Projects without MTDs under NJDOT jurisdiction that could include other types of Stormwater BMPs	38	Unknown

Note that all the project plans obtained from NJDOT have approval year in or after 2000. That is, all the identified MTDs were installed in or after year 2000.

Each identified device was marked on a Google map (see Figure 3 for a sample). See Appendix A-II for all the location maps.

Figure 3. Sample of map showing location of a MTD

A-3 MTD ASSET DATA FORM, INSPECTION FORM, AND MAINTENANCE FORM

INTRODUCTION

In order to inspect and maintain stormwater manufactured treatment devices (MTDs) properly, it is imperative to have complete information on the characteristics and location of each MTD. Also, keeping track of the dates of each inspection, cleanout procedure, and conditions at each site along time will facilitate maintenance forecasting and will allow adjusting the preventive maintenance plan as conditions and seasons change. To facilitate this task, it is recommended that at least three data forms are used to keep track of pertinent information: 1) MTD asset data form, 2) Inspection form, 3) Maintenance form.

The MTD asset data form contains detailed information on the type of device, the mode of installation (online or offline), the site where it is installed, etc. This form will generally be filled only once, but it might need to be updated as conditions around the site change. The inspection form contains information relative to the observations made during the regularly scheduled inspections to the MTD and will allow to schedule timely cleanout and maintenance activities. Finally, the maintenance form will be used to describe the tasks performed when the MTD is cleaned out or serviced. These forms were developed for the Vortechs device in a previous study (Guo and Kim, 2010). However, for the study concerning this report, forms were developed for 6 more types of MTDs. The forms were also made more user-friendly to facilitate their use in the field.

Seven types of MTDs were installed at NJDOT project sites at the start of the research project: Aqua-Swirl®, CDS®, Downstream Defender®, Stormceptor® STC, Terre Kleen®, Vortechs®, and VortSentry®. There are many common data fields for these different types of devices, such as watershed and location. The field data specific to certain devices, such as structural components, was identified and developed.

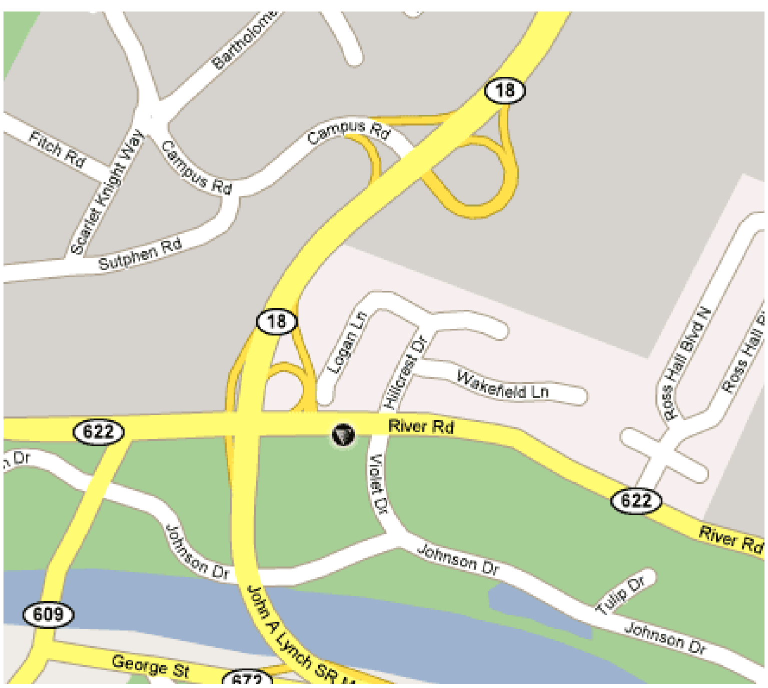
The MTD asset data, inspection, and maintenance forms proposed by Rutgers for use with MTDs are presented in the next three sections.

I. MTD Asset Data Form

<u>MTD Location Information (*common to all devices*)</u>

<table>
<tr><td>MTD ID</td><td colspan="4">Device Name</td><td colspan="4">Model</td><td>Serial No.</td></tr>
<tr><td></td><td colspan="4"></td><td colspan="4"></td><td></td></tr>
<tr><td colspan="4">Nearest Road</td><td colspan="6">[NB,SB,EB,WB]</td></tr>
<tr><td colspan="4"></td><td colspan="6">▼</td></tr>
<tr><td colspan="3">Municipality</td><td colspan="4">County</td><td colspan="3">Region</td></tr>
<tr><td colspan="3"></td><td colspan="4"></td><td colspan="3"></td></tr>
<tr><td colspan="3">GPS Latitude</td><td colspan="4">GPS Longitude</td><td colspan="3">Elevation (ft)</td></tr>
<tr><td colspan="3"></td><td colspan="4"></td><td colspan="3"></td></tr>
<tr><td colspan="3">State Plane Coordinate X</td><td colspan="4">State Plane Coordinate Y</td><td colspan="3" rowspan="3"></td></tr>
<tr><td colspan="3"></td><td colspan="4"></td></tr>
<tr><td colspan="3">Nearest Cross Road</td><td colspan="4">Nearest Landmark</td></tr>
<tr><td colspan="3"></td><td colspan="4"></td><td colspan="3"></td></tr>
<tr><td>Nearest Milepost</td><td colspan="5">Distance from Milepost (ft)</td><td colspan="4">Depth from Ground Surface to Device Bottom (ft)</td></tr>
<tr><td></td><td colspan="5"></td><td colspan="4"></td></tr>
<tr><td colspan="2">Distance from Roadway Centerline (ft)</td><td colspan="6">Physical Location</td><td colspan="2">Is Device in Vehicle Traffic?</td></tr>
<tr><td colspan="2"></td><td colspan="6">▼</td><td colspan="2">▼</td></tr>
</table>

Location Map



<u>NJDOT Project Information (*common to all devices*)</u>

Project Name	Project No.	Plan Approval Date	Project Completion Date

Project Description	

NJDOT Project Manager	Design Company / Organization	Designer Name

NJDOT Environment Contact	Contractor Company / Organization	Contractor Name	NJDOT Construction Field Manager

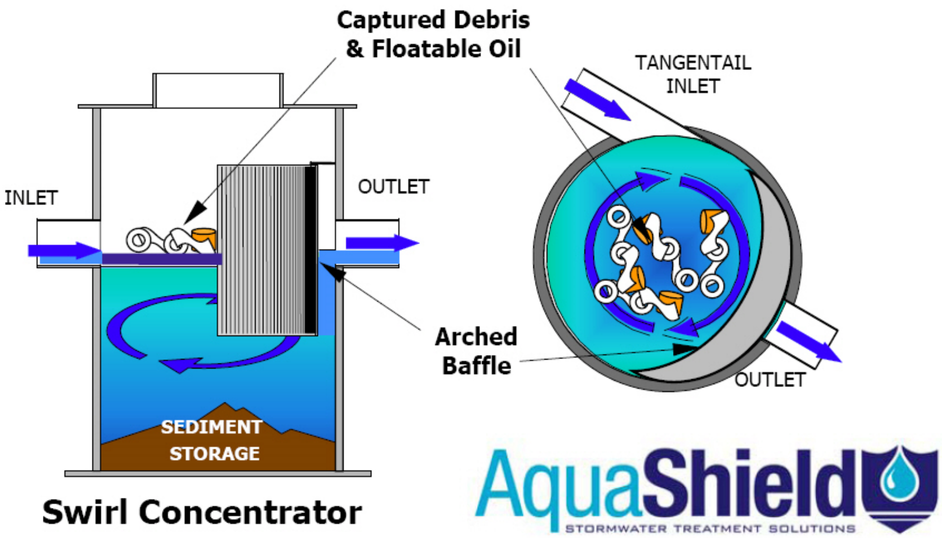
Env. Permit Issuer	Permit No.	Permit Date	Design Traffic Data (A.D.T)		
			Road	Present (vpd)	Future (vpd)

Water Quality Design Storm	Flood Control Design Storm (Maximum)	Groundwater Recharge Design Storm
▼	▼	▼

NJDOT UPC	NJDOT Job Number	Route No.	Milepost	Federal Project No.
Municipality 1	Municipality 2	Municipality 3	County 1	County 2
Bid Date	BD Number			

Device Characteristics Information (*device-specific form: forms for 7 types of devices are shown below)*

Schematic of Device: Aqua-Swirl®



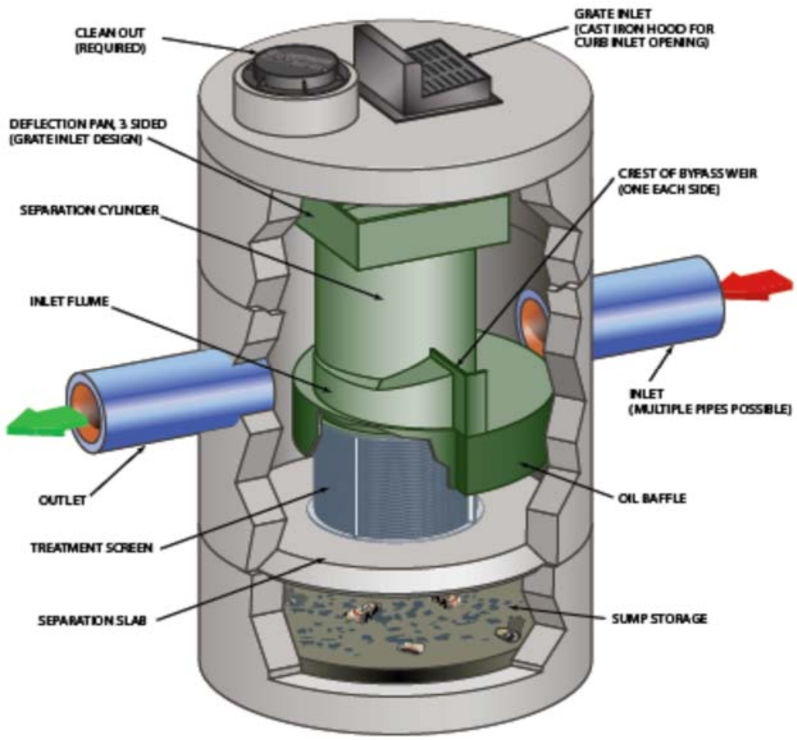
Device Height (ft)	Device Diameter (ft)	Device Footprint Area (sq. ft)	Materials Used for Manufacturing the Device

No. of Manhole Covers	All Components Visible from Ground?	If NO, Name Component(s) not visible from Ground	All Compartments Accessible to Vacuum Hose?	If NO, Name Compartment(s) not accessible to Vacuum Hose
	▼		▼	

Swirl Chamber Diameter (ft)	Swirl Chamber Area (sq. ft)	Sediment Storage Capacity (ft3)	Sediment Storage Depth (ft)	Sediment Cleanout Depth Threshold (ft)

Trash/Debris /Oil Storage Capacity (ft3)	Trash/Debris /Oil Storage Depth (ft)	Trash/Debris Cleanout Thickness Threshold (ft)	Trash/Debris Cleanout Area Threshold (%)	Oil Cleanout Thickness Threshold (ft)	Oil Cleanout Area Threshold (%)

Schematic of Device: CDS®



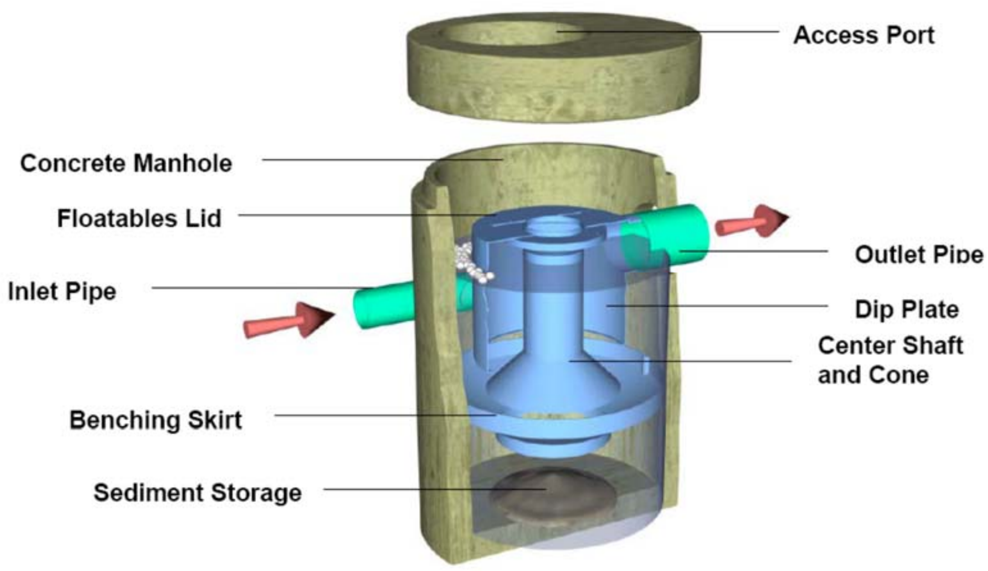
Device Height (ft)	Device Diameter (ft)	Device Footprint Area (sq. ft)	Materials Used for Manufacturing the Device

No. of Manhole Covers	All Components Visible from Ground?	If NO, Name Component(s) not visible from Ground	All Compartments Accessible to Vacuum Hose?	If NO, Name Compartment(s) not accessible to Vacuum Hose
	▼		▼	

Chamber Diameter (ft)	Chamber Area (sq. ft)	Sediment Storage Capacity (ft3)	Sediment Storage Depth (ft)	Sediment Cleanout Depth Threshold (ft)

Trash/Debris/Oil Storage Capacity (ft3)	Trash/Debris/Oil Storage Depth (ft)	Trash/Debris Cleanout Thickness Threshold (ft)	Trash/ Debris Cleanout Area Threshold (%)	Oil Cleanout Thickness Threshold (ft)	Oil Cleanout Area Threshold (%)

Schematic of Device Downstream Defender®



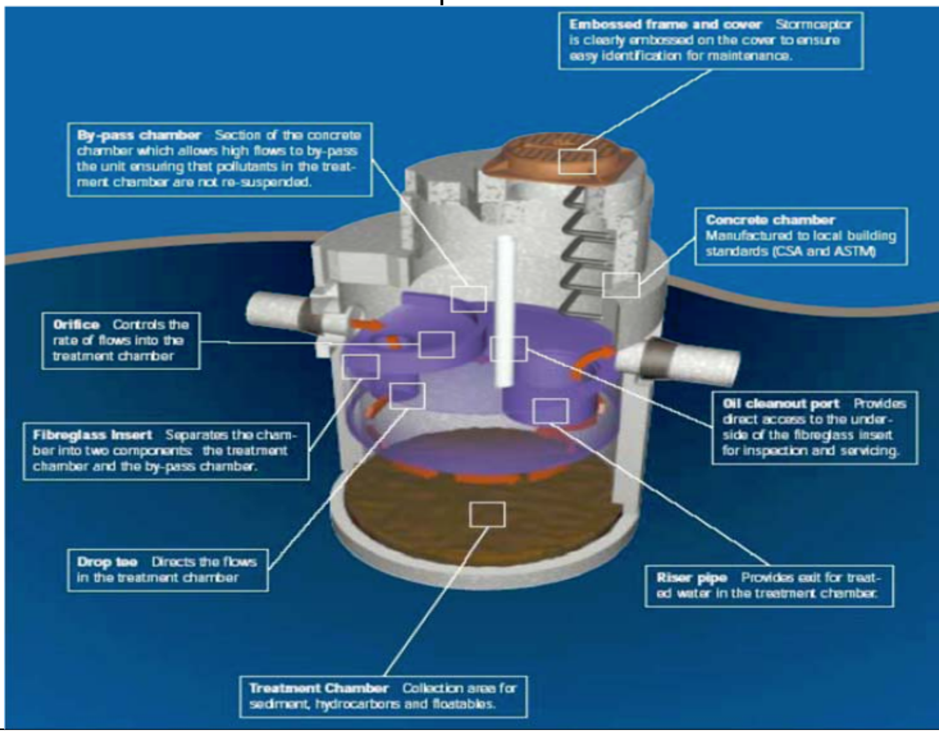
Device Height (ft)	Device Diameter (ft)	Device Footprint Area (sq. ft)	Materials Used for Manufacturing the Device

No. of Manhole Covers	All Components Visible from Ground?	If NO, Name Component(s) not visible from Ground	All Compartments Accessible to Vacuum Hose?	If NO, Name Compartment(s) not accessible to Vacuum Hose
	▼		▼	

Chamber Diameter (ft)	Chamber Area (sq. ft)	Sediment Storage Capacity (ft3)	Sediment Storage Depth (ft)	Sediment Cleanout Depth Threshold (ft)

Trash/Debris /Oil Storage Capacity (ft3)	Trash/Debris /Oil Storage Depth (ft)	Trash/Debris Cleanout Thickness Threshold (ft)	Trash/ Debris Cleanout Area Threshold (%)	Oil Cleanout Thickness Threshold (ft)	Oil Cleanout Area Threshold (%)

Schematic of Device: Stormceptor® STC



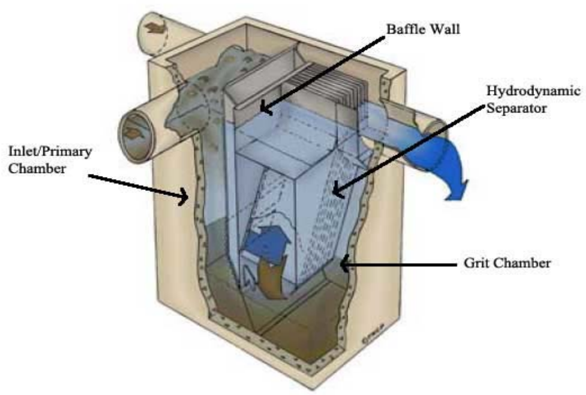
Device Height (ft)	Device Diameter (ft)	Device Footprint Area (sq. ft)	Materials Used for Manufacturing the Device

No. of Manhole Covers	All Components Visible from Ground?	If NO, Name Component(s) not visible from Ground	All Compartments Accessible to Vacuum Hose?	If NO, Name Compartment(s) not accessible to Vacuum Hose
	▼		▼	

Chamber Diameter (ft)	Chamber Area (sq. ft)	Sediment Storage Capacity (ft3)	Sediment Storage Depth (ft)	Sediment Cleanout Depth Threshold (ft)

Trash/Debris /Oil Storage Capacity (ft3)	Trash/Debris /Oil Storage Depth (ft)	Trash/Debris Cleanout Thickness Threshold (ft)	Trash/ Debris Cleanout Area Threshold (%)	Oil Cleanout Thickness Threshold (ft)	Oil Cleanout Area Threshold (%)

Schematic of Device: Terre Kleen®



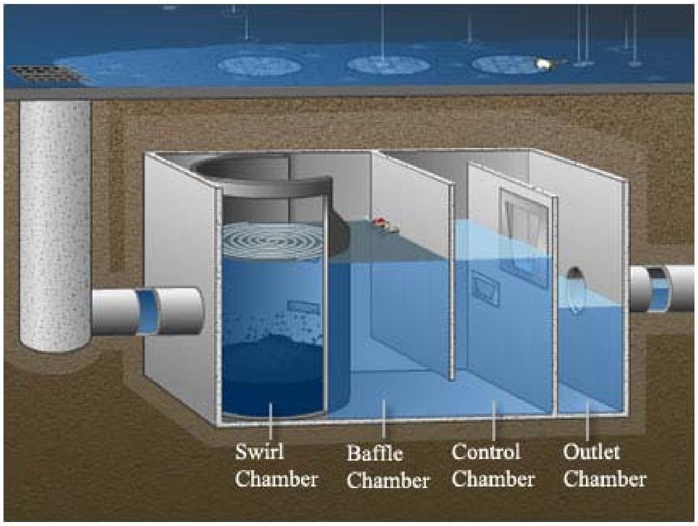
Device Height (ft)	Device Width (ft)	Device Length (ft)	Device Footprint Area (sq. ft)	Materials Used for Manufacturing the Device

No. of Manhole Covers	All Components Visible from Ground?	If NO, Name Component(s) not visible from Ground	All Compartments Accessible to Vacuum Hose?	If NO, Name Compartment(s) not accessible to Vacuum Hose
	▼		▼	

Primary Chamber					
Length (ft)	Width (ft)	Primary Chamber Area (sq. ft)	Sediment Storage Capacity (ft3)	Sediment Storage Depth (ft)	Sediment Cleanout Depth Threshold (ft)
Trash/Debris/Oil Storage Capacity (ft3)	Trash/Debris/Oil Storage Depth (ft)	Trash/Debris Cleanout Thickness Threshold (ft)	Trash/Debris Cleanout Area Threshold (%)	Oil Cleanout Thickness Threshold (ft)	Oil Cleanout Area Threshold (%)

Grit Chamber						
Length (ft)	Width (ft)	Grit Chamber Area (sq. ft)	Sediment Storage Capacity (ft3)	Sediment Storage Depth (ft)	Sediment Cleanout Depth Threshold (ft)	Sediment Storage Capacity (ft3)

Schematic of Device: Vortechs®



Device Height (ft)	Device Width (ft)	Device Length (ft)	Device Footprint Area (sq. ft)	Materials Used for Manufacturing the Device

No. of Manhole Covers	All Components Visible from Ground?	If NO, Name Component(s) not visible from Ground	All Compartments Accessible to Vacuum Hose?	If NO, Name Compartment(s) not accessible to Vacuum Hose
	▼		▼	

Swirl Chamber Diameter (ft)	Swirl Chamber Area (sq. ft)	Sediment Storage Capacity (ft^3)	Sediment Storage Depth (ft)	Sediment Cleanout Depth Threshold (ft)

Baffle Chamber Dimensions (approx.)		Baffle Chamber Area (sq. ft)	Trash/ Debris/ Oil Storage Capacity (ft^3)	Trash/ Debris/ Oil Storage Depth (ft)	Trash/ Debris Cleanout Thickness Threshold (ft)	Trash/ Debris Cleanout Area Threshold (%)	Oil Cleanout Thickness Threshold (ft)	Oil Cleanout Area Threshold (%)
Length (ft)	Width (ft)							

Schematic of Device: VortSentry®

Device Height (ft)	Device Diameter (ft)	Device Footprint Area (sq. ft)	Materials Used for Manufacturing the Device

No. of Manhole Covers	All Components Visible from Ground?	If NO, Name Component(s) not visible from Ground	All Compartments Accessible to Vacuum Hose?	If NO, Name Compartment(s) not accessible to Vacuum Hose
	▼		▼	

Swirl Chamber Diameter (ft)	Swirl Chamber Area (sq. ft)	Sediment Storage Capacity (ft³)	Sediment Storage Depth (f)	Sediment Cleanout Depth Threshold (ft)

Trash/Debris /Oil Storage Capacity (ft³)	Trash/Debris /Oil Storage Depth (ft)	Trash/Debris Cleanout Thickness Threshold (ft)	Trash/ Debris Cleanout Area Threshold (%)	Oil Cleanout Thickness Threshold (ft)	Oil Cleanout Area Threshold (%)

(*Common to all devices*)

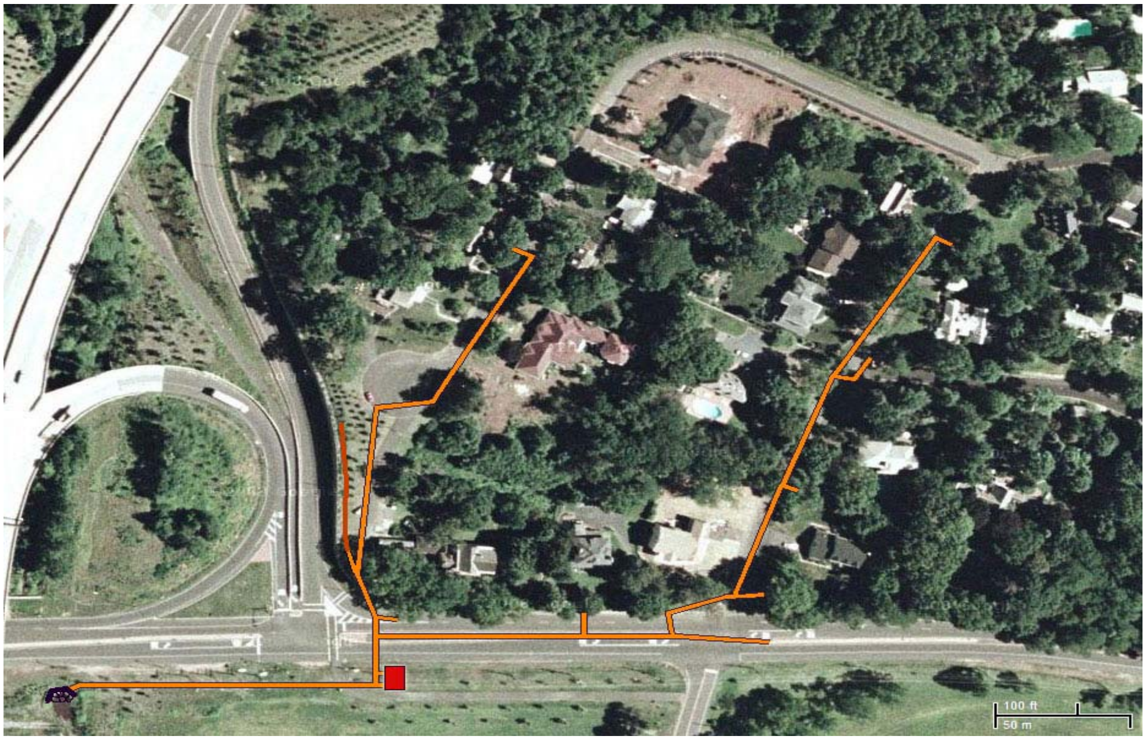
TSS Removal Rate Certified by NJDEP (%)	Maximum Treatment Flow Rate (cfs)	Maximum Hydraulic Flow Rate (cfs)	Head Loss at Maximum Treatment Flow (ft)	Head Loss at Maximum Hydraulic Flow (ft)

Device Vendor	Invoice Date	Delivery Date	Installation Date	Device Cost (includes S&H)	Installation Cost

Item Sequence No. on Plan	Item No. on Plan	Item Name on Plan	Plan Sheet No.	Special Provisions Page No.

Device Watershed Information (*common to all devices*)

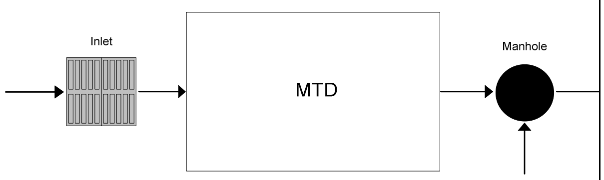
Aerial Satellite Image and Drainage Network



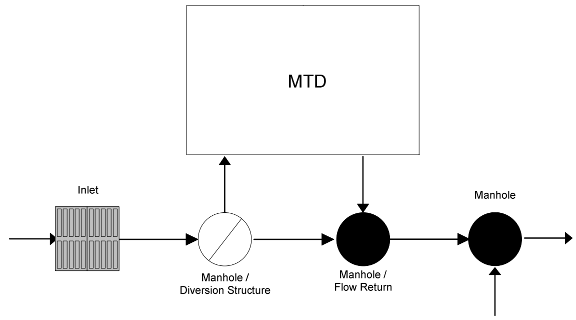
Drainage Area (acre)	Watershed Land Use	Watershed Soil Type	Percentage of Impervious Area (%)
	▼	▼	
Longest Flow Path Length (ft)	Slope along Flow Path	Manning's Roughness Coefficient along Flow Path	Time of Concentration (minutes)
Runoff Coefficient		NRCS Curve Number	

Device Spatial Relation Information (*common to all devices*)

Online System



Offline System



Is Device Offline?	▼

For both Offline and Online Device	ID of Upstream Inlet, Catch Basin or Manhole	Dimensions (Length x Width) of Upstream Inlet or Catch Basin, or Diameter of Upstream Manhole	Invert Elevation of Upstream Inlet, Catch Basin, or Manhole	Ground Elevation of Upstream Inlet, Catch Basin, or Manhole
	ID of Downstream Manhole or Catch Basin	Diameter of Downstream Manhole or Dimensions (Length x Width) of Catch Basin	Invert Elevation of Downstream Manhole or Catch Basin	Ground Elevation of Downstream Manhole or Catch Basin

	ID of Upstream Pipe	Diameter of Upstream Storm Sewer Pipe (ft)	Invert Elevation of Upstream Storm Sewer Pipe (ft)	Slope of Upstream Storm Sewer Pipe (ft)	Material of Upstream Storm Sewer Pipe (ft)
	ID of Downstrea m Pipe	Diameter of Downstream Storm Sewer Pipe (ft)	Invert Elevation of Downstream Storm Sewer Pipe (ft)	Slope of Downstream Storm Sewer Pipe (ft)	Material of Downstream Storm Sewer Pipe (ft)

For Offline Device Only	Diameter of Upstream Diversion Manhole	Invert Elevation of Upstream Diversion Manhole	Ground Elevation of Upstream Diversion Manhole
	Diameter of Downstream Return Manhole	Invert Elevation of Downstream Return Manhole	Ground Elevation of Downstream Return Manhole

	ID of Upstream Diversion Pipe (ft)	Diameter of Upstream Diversion Pipe (ft)	Invert Elevation of Upstream Diversion Pipe	Slope of Upstream Diversion Pipe (ft)	Material of Upstream Diversion Pipe (ft)

			(ft)		
	ID of Downstream Diversion Pipe (ft)	Diameter of Downstream Return Pipe (ft)	Invert Elevation of Downstream Return Pipe (ft)	Slope of Downstream Return Pipe (ft)	Material of Downstream Return Pipe (ft)

Device Outlet Drains to	Direction of Downstream Drain	
▼	▼	
Outfall ID	Outfall Drains to Waterway	Waterway ties into
	▼	▼
Name of Waterway		

Additional Comments (common to all devices)

Drop-down Menu Contents: (*common to all devices*)

[NB,SB,EB,WB] ▼ : NB,SB,EB,WB

Physical Location ▼ : On the Median, On Road, On Shoulder, On Sidewalk, On Mild-Slope Bank, On Steep-Slope Bank, On Large Traffic Island, On Small Traffic Island, On Parking Lot, on Flat Large Area Open Space, Other

Is Device in Vehicle Traffic? ▼ : Yes, No

Water Quality Design Storm▼ : NJDEP Uniform WQ Design Storm, Non-uniform WQ Design Storm

Flood Control Design Storm (Maximum) ▼ : 100-Year Storm, 50-Year Storm, 25-Year, 10-Year Storm, 5-Year Storm, 2-Year Storm

Groundwater Recharge Design Storm▼ : Average Annual Storm, 2-Year Storm

All Components Visible from Ground? ▼ : Yes, No

All Compartments Accessible by Vacuum Hose? ▼ : Yes, No

Watershed Land Use▼ : Commercial, Residential, Mixed(Commercial & Residential), Industrial, Rural, Open Space (Park, Woodland, Golf course, etc.)

Watershed Soil Type ▼ : Sand, Silt, Clay

Is the Device Offline? ▼ : Yes, No

Device Outlet Drains to ▼ : Other Types of Stormwater BMPs, Outfall

Direction of Downstream Drain (Other Types of Stormwater BMPs or Outfall) ▼ : N, NE, E, SE, S, SW, W, NW

Outfall Drains to Waterway ▼ : Ocean, River, Stream, Lake, Pond, Ditch, Wetland, Detention/Retention Area

Waterway ties into ▼ : State System, County System, Municipal System, Private Property, Unknown

II. MTD Inspection Form

(*Common to all devices*)

MTD ID	MTD_Inspection_RecID	Weather*	Air Temp. (^{o}F)

Inspection Date	Inspection Time		Purpose of Inspection	Inspector
MM-DD-YYYY	Start	End	Routine Inspection ( ) Inspection Immediately before Cleanout ( ) Inspection Immediately after Cleanout ( ) Other ( )	
	HH:MM	HH:MM		

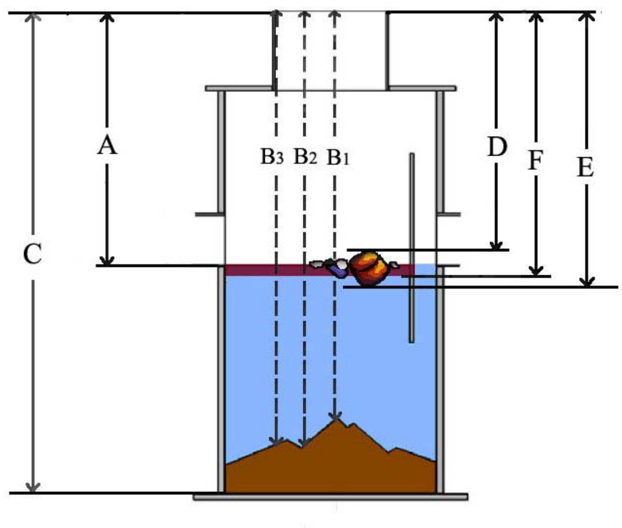
Inspection Cost	Last Inspection Date	Inspection Interval (months)	Projected Next Inspection Date	Recent Precipitation Event	
				Date	Depth (in)
	(Function)		(Function)	MM-DD-YYYY	

* Weather: Sunny, Windy, Cloudy, Rainy, Stormy, Blizzard

Measurements from ground above device (routine inspection or inspection immediately before cleanout)

(*Select a form below based on device*)

Schematic for Measurements: Aqua-Swirl®



A: Distance from Water / Oil Surface to Top of Manhole Rim

B1: Distance from Center of Sediment Surface to Top of Manhole Rim

B2: Distance from Intermediate Location of Sediment Surface to Top of Manhole Rim

B3: Distance from Far Side of Sediment Surface to Top of Manhole Rim

C: Distance from Bottom to Top of Manhole Rim

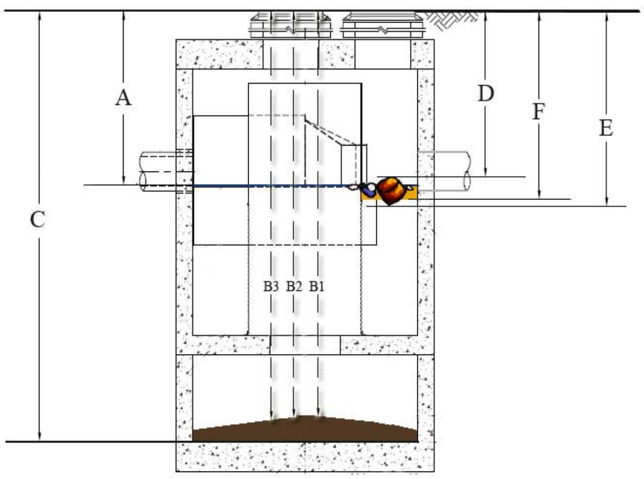
D: Distance from Trash/Debris Surface to Top of Manhole Rim

E: Distance from Trash/Debris Bottom to Top of Manhole Rim

F: Distance from Bottom of Oil Layer to Top of Manhole Rim

A (ft)		Trash/Debris Area Coverage (%)	
B1 (ft)		D (ft)	
B2 (ft)		E (ft)	
B3 (ft)		Oil Area Coverage (%)	
C (ft)		F (ft)	

Schematic for Measurements: CDS®



A: Distance from Water / Oil Surface to Top of Manhole Rim

B1: Distance from Center of Sediment Surface to Top of Manhole Rim

B2: Distance from Intermediate Location of Sediment Surface to Top of Manhole Rim

B3: Distance from Far Side of Sediment Surface to Top of Manhole Rim

C: Distance from Bottom to Top of Manhole Rim

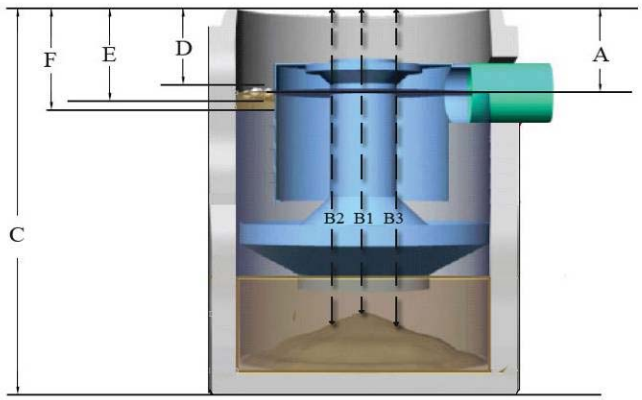
D: Distance from Trash/Debris Surface to Top of Manhole Rim

E: Distance from Trash/Debris Bottom to Top of Manhole Rim

F: Distance from Bottom of Oil Layer to Top of Manhole Rim

A (ft)		Trash/Debris Area Coverage (%)	
B1 (ft)		D (ft)	
B2 (ft)		E (ft)	
B3 (ft)		Oil Area Coverage (%)	
C (ft)		F (ft)	

Schematic for Measurements: Downstream Defender®



A: Distance from Water / Oil Surface to Top of Manhole Rim

B1: Distance from Center of Sediment Surface to Top of Manhole Rim

B2: Distance from Intermediate Location of Sediment Surface to Top of Manhole Rim

B3: Distance from Intermediate Location of Sediment Surface to Top of Manhole Rim

C: Distance from Bottom to Top of Manhole Rim

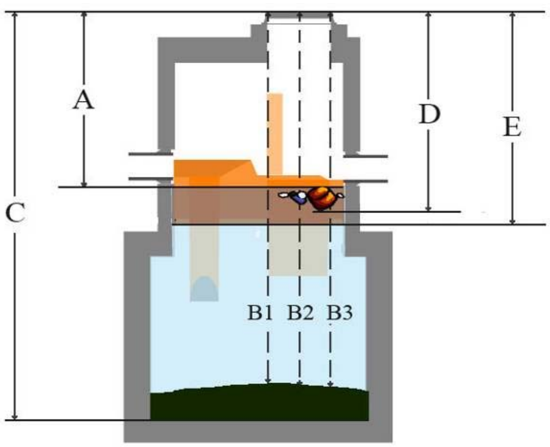
D: Distance from Trash/Debris Surface to Top of Manhole Rim

E: Distance from Trash/Debris Bottom to Top of Manhole Rim

F: Distance from Bottom of Oil Layer to Top of Manhole Rim

A (ft)		Trash/Debris Area Coverage (%)	
B1 (ft)		D (ft)	
B2 (ft)		E (ft)	
B3 (ft)		Oil Area Coverage (%)	
C (ft)		F (ft)	

Schematic for Measurements: Stormceptor® STC



A: Distance from Water / Oil / Trash /Debris Surface to Top of Manhole Rim

B1: Distance from Center of Sediment Surface to Top of Manhole Rim

B2: Distance from Intermediate Location of Sediment Surface to Top of Manhole Rim

B3: Distance from Far Side of Sediment Surface to Top of Manhole Rim

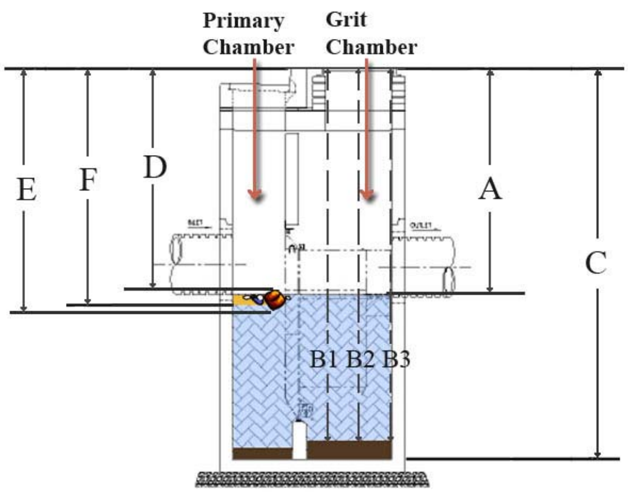
C: Distance from Bottom to Top of Manhole Rim

D: Distance from Trash/Debris Bottom to Top of Manhole Rim

E: Distance from Bottom of Oil Layer to Top of Manhole Rim

A (ft)		Trash/Debris Area Coverage (%)	
B1 (ft)		D (ft)	
B2 (ft)		E (ft)	
B3 (ft)		Oil Area Coverage (%)	
C (ft)			

Schematic for Measurements: Terre Kleen®



A: Distance from Water / Oil Surface to Top of Manhole Rim

B1: Distance from Center of Sediment Surface to Top of Manhole Rim

B2: Distance from Intermediate Location of Sediment Surface to Top of Manhole Rim

B3: Distance from Far Side of Sediment Surface to Top of Manhole Rim

C: Distance from Bottom to Top of Manhole Rim

D: Distance from Trash/Debris Surface to Top of Manhole Rim

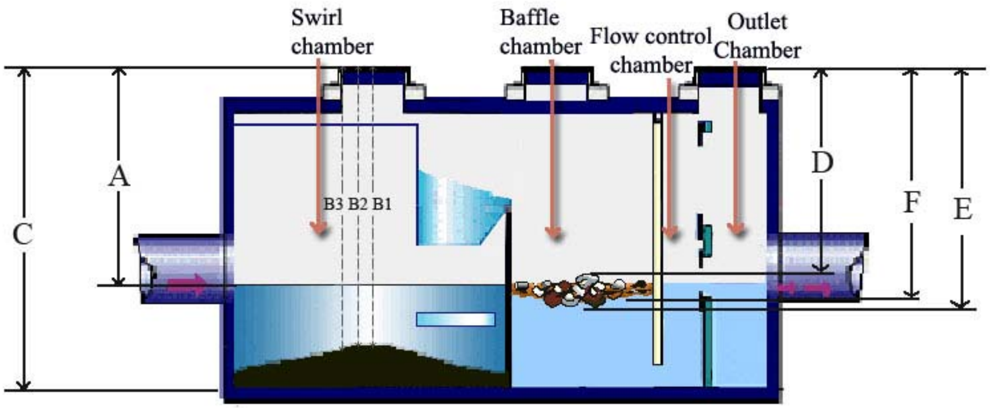
E: Distance from Trash/Debris Bottom to Top of Manhole Rim

F: Distance from Bottom of Oil Layer to Top of Manhole Rim

Primary Chamber			
Ap (ft)		Trash/Debris Area Coverage (%)	
Bp1 (ft)		Dp (ft)	
Bp2 (ft)		Ep (ft)	
Bp3 (ft)		Oil Area Coverage (%)	
Cp (ft)		Fp (ft)	

Grit Chamber			
Ag (ft)		Trash/Debris Area Coverage (%)	
Bg1 (ft)		Dg (ft)	
Bg2 (ft)		Eg (ft)	
Bg3 (ft)		Oil Area Coverage (%)	
Cg (ft)		Fg (ft)	

Schematic for Measurements: Vortechs®



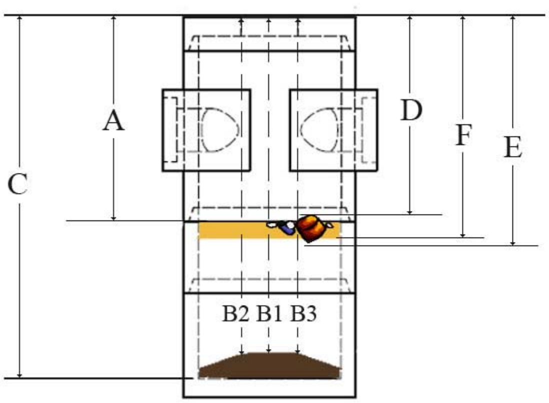
A: Distance from Water / Oil Surface to Top of Manhole Rim
B1: Distance from Center of Sediment Surface to Top of Manhole Rim
B2: Distance from Intermediate Location of Sediment Surface to Top of Manhole Rim
B3: Distance from Far Side of Sediment Surface to Top of Manhole Rim
C: Distance from Bottom to Top of Manhole Rim
D: Distance from Trash/Debris Surface to Top of Manhole Rim
E: Distance from Trash/Debris Bottom to Top of Manhole Rim
F: Distance from Bottom of Oil Layer to Top of Manhole Rim

Swirl Chamber			
As (ft)		Trash/Debris Area Coverage (%)	
Bs1 (ft)		Ds (ft)	
Bs2 (ft)		Es (ft)	
Bs3 (ft)		Oil Area Coverage (%)	
Cs (ft)		Fs (ft)	

Baffle Chamber			
Ab (ft)		Trash/Debris Area Coverage (%)	
Bb1 (ft)		Db (ft)	
Bb2 (ft)		Eb (ft)	
Bb3 (ft)		Oil Area Coverage (%)	
Cb (ft)		Fb (ft)	

Outlet Chamber			
Ao (ft)		Trash/Debris Area Coverage (%)	
Bo1 (ft)		Do (ft)	
Bo2 (ft)		Eo (ft)	
Bo3 (ft)		Oil Area Coverage (%)	
Co (ft)		Fo (ft)	

Schematic for Measurements: VortSentry®



A: Distance from Water / Oil Surface to Top of Manhole Rim

B1: Distance from Center of Sediment Surface to Top of Manhole Rim

B2: Distance from Intermediate Location of Sediment Surface to Top of Manhole Rim

B3: Distance from Intermediate Location of Sediment Surface to Top of Manhole Rim

C: Distance from Bottom to Top of Manhole Rim

D: Distance from Trash/Debris Surface to Top of Manhole Rim

E: Distance from Trash/Debris Bottom to Top of Manhole Rim

F: Distance from Bottom of Oil Layer to Top of Manhole Rim

A (ft)		Trash/Debris Area Coverage (%)	
B1 (ft)		D (ft)	
B2 (ft)		E (ft)	
B3 (ft)		Oil Area Coverage (%)	
C (ft)		F (ft)	

Observations of Device and Surrounding Drainage Area Characteristics (Routine Inspection or Inspection Immediately before Cleanout)

(Common to all devices)

Traffic Density	Gross Solids - Litter	Gross Solids – Debris	Gross Solids – Coarse Sediment
(Low, Medium, Heavy)	(Small, Medium, Large)	(Small, Medium, Large)	(Small, Medium, Large)

Any Soil Erosion and Sediment Deposition in Watershed?	If Severe, Location(s) of Erosion and Deposition in Watershed
(Low, Moderate, Severe)	

Construction Activities in Watershed?	If Yes, Condition of Source Control Management Practices	If Poor, Location of Source Control Management Practices	If Poor, Describe Condition of Source Control Management Practices
(Yes / No)	(Good, Moderate, Poor)		

Winter Sanding Operation?	Space Available for Cleanout Activities without Traffic Blockage?
(Yes / No)	(Yes / No)

Insects (Mosquitoes, Larvae, etc…) in MTD?	Vegetation Growth in MTD?	Any Blockage to Flow Path in MTD?	If Yes, Name Location of the Blockage
(Yes / No)	(Yes / No)	(Yes / No)	

Any Blockage in Inlet, Manhole, Catch Basin, or Pipe Upstream and Downstream of the Device?	Location of Blockage	Type of Solids in Inlet, Manhole, Catch Basin or Pipe
(Yes / No)		(Gravel, Sand, Silt, Clay, Mud, Debris, Litter)
Dry Weather Flow in inlet pipe and outlet Pipe?	Backwater to outlet pipe from downstream?	Blockage at Outfall?
(Yes / No)	(Yes / No)	(Yes / No)

Outfall Structure					
Sediment discharged from MTD?	(Yes / No)	Trash/Debris discharged from MTD?	(Yes / No)	Oil Spill Out from MTD?	(Yes / No)

Device Structural Inspection - Visual Observation from Ground above the Device (Routine Inspection or Inspection Immediately before Cleanout)

(Common to all devices)

Damage to Manhole Cover(s)	(No, Minor, Serious)	Description of Damage	
Damage to Side Walls	(No, Minor, Serious)	Description of Damage	
Damage to Inlet Pipe	(No, Minor, Serious)	Description of Damage	
Damage to Outlet Pipe	(No, Minor, Serious)	Description of Damage	

(Select a form below to fill based on type of the device)

Aqua-Swirl®

Damage to Arched Baffle	(No, Minor, Serious)	Description of Damage	

CDS®

Damage to Deflection Pan, Separation Cylinder, Crest of Bypass Weir, Oil Baffle, Treatment Screen or Separation Slab	(No, Minor, Serious)	Description of Damage	

Downstream Defender®

Damage to Dip Plate, Floatables Lid, Center Shaft and Cone or Benching Skirt	(No, Minor, Serious)	Description of Damage	

Stormceptor® STC

Damage to Weir, Oil Port, Orifice, Insert, Drop Tee or Riser Pipe	(No, Minor, Serious)	Description of Damage	

Terre Kleen®

Damage to Hydrodynamic Separator or Baffle Wall	(No, Minor, Serious)	Description of Damage	

Vortechs®

Damage to Swirl Chamber Aluminum Wall, Baffle Wall, Flow Control Wall or Orifice Plates	(No, Minor, Serious)	Description of Damage	

VortSentry®

Damage to Inlet Aperture, Flow Partition, Treatment Chamber Baffle, Head Equalizing Baffle or Outlet Flow Control Orifice	(No, Minor, Serious)	Description of Damage	

Photos Taken during Routine Inspection or Inspection Immediately before Cleanout (common to all devices)

Photo 1	Photo 2	Photo 3

Additional Comments from Routine Inspection or Inspection Immediately before Cleanout (common to all devices)

Device Structural Inspection – Visual Observation and Physical Testing from Inside of the Device (Inspection Immediately after Cleanout)

(Common to all devices)

Damage to Side Walls, Ceiling or Bottom	(No, Minor, Serious)	Description of Damage	
Damage to Inlet Pipe	(No, Minor, Serious)	Description of Damage	
Damage to Outlet Pipe	(No, Minor, Serious)	Description of Damage	

(Select a form below to fill based on type of the device)

Aqua-Swirl®

Damage to Arched Baffle	(No, Minor, Serious)	Description of Damage	

CDS®

Damage to Deflection Pan, Separation Cylinder, Crest of Bypass Weir, Oil Baffle, Treatment Screen or Separation Slab	(No, Minor, Serious)	Description of Damage	

Downstream Defender®

Damage to Dip Plate, Floatables Lid, Center Shaft and Cone or Benching Skirt	(No, Minor, Serious)	Description of Damage	

Stormceptor® STC

Damage to Weir, Oil Port, Orifice, Insert, Drop Tee or Riser Pipe	(No, Minor, Serious)	Description of Damage	

Terre Kleen®

Damage to Hydrodynamic Separator or Baffle Wall	(No, Minor, Serious)	Description of Damage	

Vortechs®

Damage to Swirl Chamber Aluminum Wall, Baffle Wall, Flow Control Wall or Orifice Plates	(No, Minor, Serious)	Description of Damage	

VortSentry®

Damage to Inlet Aperture, Flow Partition, Treatment Chamber Baffle, Head Equalizing Baffle or Outlet Flow Control Orifice	(No, Minor, Serious)	Description of Damage	

Photo Taken During Structural Inspection Immediately after Cleanout (Common to all devices)

Photo 1	Photo 2	Photo 3

Additional Comments from Structural Inspection Immediately after Cleanout (Common to all devices)

Calculation and Decision for Cleanout based on Measurements

Water Depth (ft)		Sediment Depth (ft)	
Device Cleanout Trigger: Sediment Depth (ft)		Cleanout Necessary Based on the Measured Sediment Depth?	Yes or No
Device Cleanout Trigger: Trash/Debris Thickness (ft)		Cleanout Necessary Based on the Measured Trash/Debris Thickness?	Yes or No
Device Cleanout Trigger: Trash/Debris Area Coverage (%)		Cleanout Necessary Based on the Measured Trash/Debris Areal Coverage?	Yes or No
Device Cleanout Trigger: Oil Thickness (ft)		Cleanout Necessary Based on the Measured Oil Thickness?	Yes or No
Device Cleanout Trigger: Oil Area Coverage (%)		Cleanout Necessary Based on the Measured Oil Areal Coverage?	Yes or No

AUTO Functions:

1. [Last Inspection Date]: From the Previous Inspection Record
2. [Projected Next Inspection Date] = [Last Inspection Date] + [Inspection Interval]
3. [Water Depth] and [Sediment Depth] are calculated automatically from measurements [Distance from Water Surface to Top of Manhole Rim], [Distance from Sediment Surface to Top of Manhole Rim] and [Distance from Bottom to Top of Manhole Rim].

   [Water Depth] = (The Average [Distance from Sediment Surface to Top of Manhole Rim] of [Center], [In Between], and [Side]) – [Distance from Water Surface to Top of Manhole Rim]

   [Sediment Depth] = [Distance from Bottom to Top of Manhole Rim] – (The Average [Distance from Sediment Surface to Top of Manhole Rim] of [Center], [In Between], and [Side])

4. Cleanout Necessary Based on Sediment Depth?

   Yes, if [Sediment Depth] is equal or larger than [Device Cleanout Trigger: Sediment Depth], No otherwise.

5. [Trash/Debris Thickness] = [E (Distance from Bottom of Trash/Debris to Top of Manhole Rim)] - [D (Distance from Trash/Debris Surface to Top of Manhole Rim)]
6. Cleanout Necessary Based on Trash/Debris Thickness?

   Yes, if [Trash/Debris Thickness] is equal or larger than [Device Cleanout Trigger: Trash/Debris Thickness], No otherwise.

7. Cleanout Necessary Based on Trash/Debris Areal Coverage?

   Yes, if [Trash/Debris Areal Coverage] is equal or larger than [Device Cleanout Trigger: Trash/Debris Areal Coverage], No otherwise.

8. [Oil Thickness] = [F (Distance from Bottom of Oil to Top of Manhole Rim)] - [A (Distance from Oil Surface to Top of Manhole Rim)]
9. Cleanout Necessary Based on Oil Thickness?

   Yes, if [Oil Thickness] is equal or larger than [Device Cleanout Trigger: Oil Thickness], No otherwise.

10. Cleanout Necessary Based on Oil Areal Coverage?

    Yes, if [Oil Areal Coverage] is equal or larger than [Device Cleanout Trigger: Oil Areal Coverage], No otherwise.

III. MTD Maintenance Form

General Information (*common to all devices*)

MTD ID	MTD_Inspection_Rec_ID	MTD_ Maintenance _Rec_ID	Weather	Air Temp. (ºF)
(Link to Asset Data Form)	(Link to Inspection Data Form)		▼	

Maintenance Date	Maintenance Time		Purpose of Maintenance	Maintenance Company	Number of MTD Maintenance Persons	Inspector
MM-DD-YYYY	Start	End	▼			
	HH:MM	HH:MM				

Maintenance Cost	Last Maintenance Date	Maintenance Interval (months)	Projected Maintenance Date
	(Auto)		(Auto)

Information for Cleanout Planning (common to all devices)

Need Blockage to Traffic?	Check Weather Forecast for Dry Day?
▼	▼

Estimated Volume of Sediment (cubic feet)	Estimated Volume of Water (cubic feet)	Estimated Volume of Trash/Debris (cubic feet)	Estimated Volume of Oil (cubic feet)	Vacuum Truck Storage Capacity (cubic feet)
(Auto)	(Auto)	(Auto)	(Auto)	

Any Other Device to be Cleaned out during the Same Trip?	▼					
(If Yes) Number of MTDs for Cleanout	(If Two MTDs total)		(If Three MTDs total)		(If Four MTDs total)	
	The 2nd MTD_ Maintenance _Rec_ID	Distance (miles)	The 3rd MTD_ Maintenance _Rec_ID	Distance (miles)	The 4th MTD_ Maintenance _Rec_ID	Distance (miles)

Sediment Disposal

Name of Sediment Disposal Facility	Distance from MTD Location to Facility (miles)	Estimated Disposal Cost

Water Disposal

Possible to Dispose Water into the Downstream Drainage Network?	(If No) Name of Water Disposal Facility	Distance from MTD Location to Facility (miles)	Estimated Disposal Cost
▼			

Trash/Debris Disposal

Need to Remove Trash/Debris before Cleanout?	(If Yes) Name of Trash/Debris Disposal Facility	Distance from MTD Location to Facility (miles)	Estimated Disposal Cost
▼			

Oil Disposal

Need to Remove Oil before Cleanout?	(If Yes) Name of Oil Disposal Facility	Distance from MTD Location to Facility (miles)	Estimated Disposal Cost
▼			

Need to Clean out Sediment/Trash/Debris/Oil Adjacent to MTD?				▼	
Inlet Pipe?	Outlet Pipe?	Inlet?	Manhole?	Catch Basin?	Outfall Structure?
▼	▼	▼	▼	▼	▼

Need to Block Inlet or Outlet Pipe by Pipe Plugs during Operation?	▼

Cleanout Record (common to all devices)

Sediment Disposal

Name of Sediment Disposal Facility	Distance from MTD Location to Facility (miles)	Disposal Cost

Water Disposal

Was Water Disposed into the downstream Drainage Network?	(If No) Name of Water Disposal Facility	Distance from MTD Location to Facility (miles)	Disposal Cost
▼			

Trash/Debris Disposal

Was Trash/Debris Removed before Cleanout?	(If Yes) Name of Trash/Debris Disposal Facility	Distance from MTD Location to Facility (miles)	Disposal Cost
▼			

Oil Disposal

Was Oil Removed before Cleanout?	(If Yes) Name of Oil Disposal Facility	Distance from MTD Location to Facility (miles)	Disposal Cost
▼			

Was Traffic Blocked?	▼	Was Inlet or Outlet Pipe Blocked by Pipe Plugs during Operation?	▼
Is Further Cleaning of MTD by Water Jet Necessary?	▼	(If Yes) Was MTD Further Cleaned Using Water Jet?	▼

Was Sediment/Trash/Debris/Oil Adjacent to MTD Cleaned out?	▼				
Inlet Pipe?	Outlet Pipe?	Inlet?	Manhole?	Catch Basin?	Outfall Structure?
▼	▼	▼	▼	▼	▼

Photos Taken Immediately after Cleanout (common for all types of devices)

Photo 1	Photo 2	Photo 3

Additional Comments on Cleanout (common to all devices)

(Select a form below to fill based on type of device)

Record of Repairs: Aqua-Swirl®

Were Any Components Repaired?			▼			
Manhole Cover(s)?	Side Walls?	Ceiling?	Bottom?	Arched Baffle?	Inlet Pipe?	Outlet Pipe?
▼	▼	▼	▼	▼	▼	▼

Record of Repairs: CDS®

Were Any Components Repaired?			▼		
Manhole Cover(s)?	Side Walls?	Ceiling?	Bottom?	Inlet Pipe?	Outlet Pipe?
▼	▼	▼	▼	▼	▼
Deflection Pan?	Separation Cylinder?	Crest of Bypass Weir?	Oil Baffle?	Treatment Screen?	Separation Slab?
▼	▼	▼	▼	▼	▼

Record of Repairs: Downstream Defender®

Were Any Components Repaired?			▼		
Manhole Cover(s)?	Side Walls?	Ceiling?	Bottom?	Inlet Pipe?	Outlet Pipe?
▼	▼	▼	▼	▼	▼
Floatables Lid?	Dip Plate?	Benching Skirt?	Center Shaft and Core?		
▼	▼	▼	▼		

Record of Repairs: Stormceptor® STC

Were Any Components Repaired?	▼				
Manhole Cover(s)?	Side Walls?	Ceiling?	Bottom?	Inlet Pipe?	Outlet Pipe?
▼	▼	▼	▼	▼	▼
Weir?	Oil Port?	Orifice?	Insert?	Drop Tee?	Riser Pipe?
▼	▼	▼	▼	▼	▼

Record of Repairs: Terre Kleen®

Were Any Components Repaired?	▼						
Manhole Cover(s)?	Side Walls?	Ceiling?	Bottom?	Hydrodynamic Separator?	Baffle Wall?	Inlet Pipe?	Outlet Pipe?
▼	▼	▼	▼	▼	▼	▼	▼

Record of Repairs: Vortechs®

Were Any Components Repaired?	▼				
Manhole Cover(s)?	Side Walls?	Ceiling?	Bottom?		
▼	▼	▼	▼		
Swirl Chamber Aluminum Wall?	Baffle Wall?	Flow Control Wall?	Orifice Plates?	Inlet Pipe?	Outlet Pipe?
▼	▼	▼	▼	▼	▼

Record of Repairs: VortSentry®

Were Any Components Repaired?	▼				
Manhole Cover(s)?	Side Walls?	Ceiling?	Bottom?	Inlet Pipe?	Outlet Pipe?
▼	▼	▼	▼	▼	▼
Inlet Aperture?	Flow Partition?	Treatment Chamber Baffle?	Head Equalizing Baffle?	Outlet Flow Control Orifice?	
▼	▼	▼	▼	▼	

Photos Taken Immediately after Repair (common to all devices)

Photo 1	Photo 2	Photo 3

Additional Comments on Repair (common to all devices)

(Select a form below to fill based on type of device)

Record of Replacement: Aqua-Swirl®

Were Any Components Replaced?			▼			
Manhole Cover(s)?	Side Walls?	Ceiling	Bottom?	Arched Baffle?	Inlet Pipe?	Outlet Pipe?
▼	▼	▼	▼	▼	▼	▼
Was Entire Device Replaced?			▼			

Record of Replacement: CDS®

Were Any Components Replaced?			▼		
Manhole Cover(s)?	Side Walls?	Ceiling?	Bottom?	Inlet Pipe?	Outlet Pipe?
▼	▼	▼	▼	▼	▼
Deflection Pan?	Separation Cylinder?	Crest of Bypass Weir?	Oil Baffle?	Treatment Screen?	Separation Slab?
▼	▼	▼	▼	▼	▼
Was Entire Device Replaced?			▼		

Record of Replacement: Downstream Defender®

Were Any Components Replaced?			▼		
Manhole Cover(s)?	Side Walls	Ceiling?	Bottom?	Inlet Pipe?	Outlet Pipe?
▼	▼	▼	▼	▼	▼
Floatables Lid?	Dip Plate?	Benching Skirt?	Center Shaft and Core?		
▼	▼	▼	▼		
Was Entire Device Replaced?			▼		

Record of Replacement: Stormceptor® STC

Were Any Components Replaced?			▼		
Manhole Cover s ?	Side Walls?	Ceiling?	Bottom?	Inlet Pipe?	Outlet Pipe?
▼	▼	▼	▼	▼	▼
Weir?	Oil Port?	Orifice?	Insert?	Drop Tee?	Riser Pipe?
▼	▼	▼	▼	▼	▼
Was Entire Device Replaced?			▼		

Record of Replacement: Terre Kleen®

Were Any Components Replaced?				▼			
Manhole Cover(s)?	Side Walls?	Ceiling?	Bottom?	Hydrodynamic Separator?	Baffle Wall?	Inlet Pipe?	Outlet Pipe?
▼	▼	▼	▼	▼	▼	▼	▼
Was Entire Device Replaced?				▼			

Record of Replacement: Vortechs®

Were Any Components Replaced?			▼		
Manhole Cover(s)?	Side Walls?		Ceiling ?	Bottom?	
▼	▼		▼	▼	
Swirl Chamber Aluminum Wall?	Baffle Wall?	Flow Control Wall?	Orifice Plates?	Inlet Pipe?	Outlet Pipe?
▼	▼	▼	▼	▼	▼
Was Entire Device Replaced?			▼		

Record of Replacement: VortSentry®

Were Any Components Replaced?			▼		
Manhole Cover(s ?	Side Walls?	eiling?	Bottom?	Inlet Pipe?	Outlet Pipe?
▼	▼	▼	▼	▼	▼
Inlet Aperture?	Flow Partition?	Treatment Chamber Baffle?	Head Equalizing Baffle?	Outlet Flow Control Orifice?	
▼	▼	▼	▼	▼	
Was Entire Device Replaced?			▼		

Photos Taken Immediately after Replacement (common for all types of devices)

Photo 1	Photo 2	Photo 3

Additional Comments on Replacement (common for all types of devices)

Notes:

MTD_ Maintenance _Rec_ID: Unique Maintenance id to indentify each maintenance record related to the same MTD ID

Drop-down Menu Contents:

General Information

Weather: Sunny, Windy, Cloudy, Rainy, Stormy, Blizzard

Purpose of Maintenance ▼ : Cleanout, Repair, Replacement

Need Blockage to Traffic? ▼ : Yes, No

Check Weather Forecast for Dry Day? ▼ :Yes, No

Any Other Device to be Cleaned out during the Same Trip? ▼ : Yes, No

Information for Cleanout Planning

Possible to Dispose Water into the Downstream Drainage Network? ▼ :Yes, No

Need to Remove Oil before Cleanout? ▼ :Yes, No

Need to Remove Trash/Debris before Cleanout? ▼ :Yes, No

Need to Clean out Sediment/Trash/Debris/Oil Adjacent to MTD? ▼ :Yes, No

Inlet Pipe? ▼ :Yes, No

Outlet Pipe? ▼ :Yes, No

Inlet? ▼ :Yes, No

Manhole? ▼ :Yes, No

Catch Basin? ▼ :Yes, No

Outfall Structure? ▼ :Yes, No

Need Blockage to Inlet or Outlet pipe by Pipe Plugs during Operation?▼ :Yes, No

Records after Cleanout

Was water disposed into the downstream drainage network? ▼ :Yes, No

Was Oil Removed before Cleanout? ▼ :Yes, No

Were Trash/Debris Removed before Cleanout? ▼ :Yes, No

Was Sediment/Trash/Debris/Oil Adjacent to MTD Cleaned out? ▼ :Yes, No

Inlet Pipe? ▼ :Yes, No

Outlet Pipe? ▼ :Yes, No

Inlet? ▼ :Yes, No

Manhole? ▼ :Yes, No

Catch Basin? ▼ :Yes, No

Outfall Structure? ▼ :Yes, No

Was Traffic Blocked? ▼ :Yes, No

Was Inlet or Outlet Pipe Blocked by Pipe Plugs during Operation? ▼ :Yes, No

Is Further Cleaning of MTD by Water Jet Necessary? ▼ : Yes, No

(If Yes) Was MTD Further Cleaned Using Water Jet? ▼ : Yes, No

(Select drop-down menus below based on type of device)

Record after Repairs: Aqua-Swirl®

Were Any Components Repaired? ▼ : Yes, No

Manhole Cover(s)?▼ : Yes, No

Side Walls?▼ : Yes, No

Ceiling? ?▼ : Yes, No

Bottom? ▼ : Yes, No

Arched Baffle?▼ : Yes, No

Inlet Pipe? ▼ : Yes, No

Outlet Pipe? ▼ : Yes, No

Record after Replacement: Aqua-Swirl®

Were Any Components Replaced? ▼ : Yes, No

Manhole Cover(s)?▼ : Yes, No

Side Walls?▼ : Yes, No

Ceiling? ?▼ : Yes, No

Bottom? ▼ : Yes, No

Arched Baffle?▼ : Yes, No

Inlet Pipe? ▼ : Yes, No

Outlet Pipe? ▼ : Yes, No

Was Entire Device Replaced? ▼ : Yes, No

Record after Repairs: CDS®

Were Any Components Repaired? ▼ : Yes, No

Manhole Cover(s)?▼ : Yes, No

Side Walls?▼ : Yes, No

Ceiling? ?▼ : Yes, No

Bottom? ▼ : Yes, No

Inlet Pipe? ▼ : Yes, No

Outlet Pipe? ▼ : Yes, No

Deflection Pan? ▼ : Yes, No

Separation Cylinder? ▼ : Yes, No

Crest of Bypass Weir? ▼ : Yes, No

Oil Baffle? ▼ : Yes, No

Treatment Screen? ▼ : Yes, No

Separation Slab? ▼ : Yes, No

Record after Replacement: CDS®

Were Any Components Replaced? ▼ : Yes, No

Manhole Cover(s)?▼ : Yes, No

Side Walls?▼ : Yes, No

Ceiling? ?▼ : Yes, No

Bottom? ▼ : Yes, No

Inlet Pipe? ▼ : Yes, No

Outlet Pipe? ▼ : Yes, No

Deflection Pan? ▼ : Yes, No

Separation Cylinder? ▼ : Yes, No

Crest of Bypass Weir? ▼ : Yes, No

Oil Baffle? ▼ : Yes, No

Treatment Screen? ▼ : Yes, No

Separation Slab? ▼ : Yes, No

Was Entire Device Replaced? ▼ : Yes, No

Record after Repairs: Downstream Defender®

Were Any Components Repaired? ▼ : Yes, No

Manhole Cover(s)?▼ : Yes, No

Side Walls?▼ : Yes, No

Ceiling? ?▼ : Yes, No

Bottom? ▼ : Yes, No

Inlet Pipe? ▼ : Yes, No

Outlet Pipe? ▼ : Yes, No

Floatables Lid? ▼ : Yes, No

Dip Plate? ▼ : Yes, No

Benching Skirt? ▼ : Yes, No

Center Shaft and Core? ▼ : Yes, No

Record after Replacement: Downstream Defender®

Were Any Components Replaced? ▼ : Yes, No

Manhole Cover(s)?▼ : Yes, No

Side Walls?▼ : Yes, No

Ceiling? ?▼ : Yes, No

Bottom? ▼ : Yes, No

Inlet Pipe? ▼ : Yes, No

Outlet Pipe? ▼ : Yes, No

Floatables Lid? ▼ : Yes, No

Dip Plate? ▼ : Yes, No

Benching Skirt? ▼ : Yes, No

Center Shaft and Core? ▼ : Yes, No

Was Entire Device Replaced? ▼ : Yes, No

Record after Repairs: Stormceptor® STC

Were Any Components Repaired? ▼ : Yes, No

Manhole Cover(s)?▼ : Yes, No

Side Walls?▼ : Yes, No

Ceiling? ?▼ : Yes, No

Bottom? ▼ : Yes, No

Inlet Pipe? ▼ : Yes, No

Outlet Pipe? ▼ : Yes, No

Weir? ▼ : Yes, No

Oil Port? ▼ : Yes, No

Orifice? ▼ : Yes, No

Insert? ▼ : Yes, No

Drop Tee? ▼ : Yes, No

Riser Pipe? ▼ : Yes, No

Record after Replacement: Stormceptor® STC

Were Any Components Replaced? ▼ : Yes, No

Manhole Cover(s)?▼ : Yes, No

Side Walls?▼ : Yes, No

Ceiling? ?▼ : Yes, No

Bottom? ▼ : Yes, No

Inlet Pipe? ▼ : Yes, No

Outlet Pipe? ▼ : Yes, No

Weir? ▼ : Yes, No

Oil Port? ▼ : Yes, No

Orifice? ▼ : Yes, No

Insert? ▼ : Yes, No

Drop Tee? ▼ : Yes, No

Riser Pipe? ▼ : Yes, No

Was Entire Device Replaced? ▼ : Yes, No

Record after Repairs: Terre Kleen®

Were Any Components Repaired? ▼ : Yes, No

Manhole Cover(s)?▼ : Yes, No

Side Walls?▼ : Yes, No

Ceiling? ?▼ : Yes, No

Bottom? ▼ : Yes, No

Hydrodynamic Separator?▼ : Yes, No

Baffle Wall?▼ : Yes, No

Inlet Pipe? ▼ : Yes, No

Outlet Pipe? ▼ : Yes, No

Record after Replacement: Terre Kleen®

Were Any Components Replaced? ▼ : Yes, No

Manhole Cover(s)?▼ : Yes, No

Side Walls?▼ : Yes, No

Ceiling? ?▼ : Yes, No

Bottom? ▼ : Yes, No

Hydrodynamic Separator?▼ : Yes, No

Baffle Wall?▼ : Yes, No

Inlet Pipe? ▼ : Yes, No

Outlet Pipe? ▼ : Yes, No

Was Entire Device Replaced? ▼ : Yes, No

Record after Repairs: Vortechs®

Were Any Components Repaired? ▼ : Yes, No

Manhole Cover(s)?▼ : Yes, No

Side Walls?▼ : Yes, No

Ceiling? ▼ : Yes, No

Bottom? ▼ : Yes, No

Swirl Chamber Aluminum Wall? ▼ : Yes, No

Baffle Wall? ▼ : Yes, No

Flow Control Wall? ?▼ : Yes, No

Orifice Plates? ▼ : Yes, No

Inlet Pipe? ▼ : Yes, No

Outlet Pipe? ▼ : Yes, No

Record after Replacement: Vortechs®

Were Any Components Replaced? ▼ : Yes, No

Manhole Cover(s)?▼ : Yes, No

Side Walls?▼ : Yes, No

Ceiling? ▼ : Yes, No

Bottom? ▼ : Yes, No

Swirl Chamber Aluminum Wall? ▼ : Yes, No

Baffle Wall? ?▼ : Yes, No

Flow Control Wall? ▼ : Yes, No

Orifice Plates? ▼ : Yes, No

Inlet Pipe? ▼ : Yes, No

Outlet Pipe? ▼ : Yes, No

Was Entire Device Replaced? ▼ : Yes, No

Record after Repairs: VortSentry®

Were Any Components Repaired? ▼ : Yes, No

Manhole Cover(s)?▼ : Yes, No

Side Walls?▼ : Yes, No

Ceiling? ?▼ : Yes, No

Bottom? ▼ : Yes, No

Inlet Aperture?▼ : Yes, No

Flow Partition?▼ : Yes, No

Treatment Chamber Baffle?▼ : Yes, No

Head Equalizing Baffle?▼ : Yes, No

Outlet Flow Control Orifice?▼ : Yes, No

Inlet Pipe? ▼ : Yes, No

Outlet Pipe? ▼ : Yes, No

Record after Replacement: VortSentry®

Were Any Components Replaced? ▼ : Yes, No

Manhole Cover(s)?▼ : Yes, No

Side Walls?▼ : Yes, No

Ceiling? ?▼ : Yes, No

Bottom? ▼ : Yes, No

Inlet Aperture?▼ : Yes, No

Flow Partition?▼ : Yes, No

Treatment Chamber Baffle?▼ : Yes, No

Head Equalizing Baffle?▼ : Yes, No

Outlet Flow Control Orifice?▼ : Yes, No

Inlet Pipe? ▼ : Yes, No

Outlet Pipe? ▼ : Yes, No

Was Entire Device Replaced? ▼ : Yes, No

<u>Auto Functions</u>

Last Maintenance Date: Import [Maintenance Date] data from previous record.

Projected Maintenance Date: [Maintenance Date] + [Maintenance Interval]

'Water Volume', 'Sediment Volume', 'Trash/Debris Volume', and 'Oil Volume' are estimated/calculated automatically based on the measurements recorded in the "Inspection Form."

(*Select functions below based on type of device*)

<u>Aqua-Swirl®, CDS®, Downstream Defender®, Stormceptor® STC and VortSentry®</u>

[Estimated Water Volume] = [Water Depth] (from Inspection Form) X [(Swirl) Chamber Area (from Asset Data Form)]

[Estimated Sediment Volume] = [Sediment Depth (from Inspection Form)] X [(Swirl) Chamber Area (from Asset Data Form)]

[Estimated Trash/Debris Volume] = [Trash/Debris Thickness (from Inspection Form)] X [(Swirl) Chamber Area (from Asset Data Form)]

[Estimated Oil Volume] = [Oil Thickness] X [(Swirl) Chamber Area (from Asset Data Form)]

<u>Terre Kleen®</u>

[Estimated Water Volume] = [Water Depth] (from Inspection Form) X [Device Footprint Area (from Asset Data Form)]

[Estimated Sediment Volume] = [Sediment Depth in Primary Chamber (from Inspection Form)] X [Primary Chamber Area (from Asset Data Form)] + [Sediment Depth in Grit Chamber (from Inspection Form)] X [Grit Chamber Area (from Asset Data Form)]

[Estimated Trash/Debris Volume] = [Trash/Debris Thickness in Primary Chamber (from Inspection Form)] X [Primary Chamber Area (from Asset Data Form)] + [Trash/Debris Thickness in Grit Chamber (from Inspection Form)] X [Grit Chamber Area (from Asset Data Form)]

[Estimated Oil Volume] = [Oil Thickness in Primary Chamber (from Inspection Form)] X [Primary Chamber Area (from Asset Data Form)] + [Oil Thickness in Grit Chamber (from Inspection Form)] X [Grit Chamber Area (from Asset Data Form)]

Vortechs®

[Estimated Water Volume] = [Water Depth] (from Inspection Form) X [Device Footprint Area (from Asset Data Form)]

> The water volume above may be over-estimated because water in the baffle, flow control, and outlet chambers does not need to be pumped out if clean.

[Estimated Sediment Volume] = [Sediment Depth (in Swirl Chamber) (from Inspection Form)] X [Swirl Chamber Area (from Asset Data Form)]

> If there is sediment in the baffle chamber, add [Sediment Volume in Baffle Chamber], where:
>
> [Sediment Volume in Baffle Chamber] = [Sediment Depth in Baffle Chamber (from Inspection Form)] X [Device Width (from Asset Data Form)] X [2.58 (use 3.00 if 'Model' is 16000 or larger (from Asset Data Form)]
>
> If there is sediment in the outlet chamber, add [Sediment Volume of Outlet Chamber], where:
>
> [Sediment Volume in Outlet Chamber] = [Sediment Depth in Outlet Chamber] X [Device Width (from Asset Data Form)] X [2.00]

[Estimated Trash/Debris Volume] = [Average Trash/Debris Thickness in Swirl Chamber and Baffle Chamber (from Inspection Form)] X [Device Width (from Asset Data Form)] X [Device Length (from Asset Data Form) – 3.50]

> If there is Trash/Debris in the outlet chamber, add [Trash/Debris Volume in Outlet Chamber], where
>
> [Trash/Debris Volume in Outlet Chamber] = [Trash/Debris Thickness in Outlet Chamber] X [Device Width (from Asset Data Form)] X [2.00]

[Estimated Oil Volume] = [Average Oil Thickness in Swirl Chamber and Baffle Chamber (from Inspection Form)] X [Device Width (ft) (from Asset Data Form)] X [Device Length (from Asset Data Form) – 3.50]

> If there is oil in the outlet chamber, add [Oil Volume in Outlet Chamber], where:

[Oil Volume in Outlet Chamber] = [Oil Thickness in Outlet Chamber (from Inspection Form)] X [Device Width (from Asset Data Form)] X [2.00]

A-4 CLEANOUT AND CHARACTERIZATION OF TRAPPED MATERIAL IN SELECTED DEVICES

I. Second Cleanout and Material Characterization for Six Selected Devices

This research project expands on a previous research effort where twelve Manufactured Treatment Devices (MTDs) had been selected for cleanout and subsequent monitoring. During 2007, a total of 63 MTDs were identified at NJDOT sites. Twelve out of these 63 MTDs were selected for monitoring. The twelve MTDs were cleaned out between December 2007 and May 2008. Monitoring of these twelve devices was conducted over a 3-year period after this initial cleanout. During this 3-year period, six of the twelve devices accumulated enough sediment and had to be cleaned out again. Determining the need for cleanout was based on sediment depth measurements taken at regular intervals as part of the monitoring program. The maximum sediment depth allowed before cleanout had been set at two feet from the manufacturer's specifications and results from a previous study.(4) Table 3 shows the site ID, model, and location of the six devices chosen for second cleanout and monitoring for this study.

Table 3 - Six (6) MTDs selected for second cleanout and monitoring

Site ID	Model	Municipality	County	Location
RU01-04	VX7000	Piscataway	Middlesex	Rt. 18 Extension along River Road
RU04-02	VX11000	Elizabeth	Union	Pearl Street & Grove Street
RU06-01	VX3000	North Bergen	Hudson	36th Street
RU07-01	VX9000	Deptford	Gloucester	Rt. 47 near Cattle Road
RU14-01	VX16000	Parsippany	Morris	Rt. 46 & New Road
RU16-01	VX5000	Frankford	Sussex	Rt.15 & US 206

Rutgers University took sediment samples during cleanout activities and collected all floatables and oils immediately before cleanout. Analysis of the sediment contents extracted from the devices will help determine better disposal methods, maintenance intervals and mitigation measures. Table 4 shows the cleanout dates and sediment depth measured immediately before cleanout.

Table 4 - Depth of sediment trapped and removed

Site ID	Model Number	Previous Cleanout Date	Cleanout Date	Sediment Depth in Grit Chamber
RU01-04	VX7000	2008-01-11	2011-05-11	2.3 ft
RU04-02	VX11000	2008-01-16	2011-05-19	2.0 ft
RU06-01	VX3000	2008-02-28	2011-06-13	3.0 ft
RU07-01	VX9000	2008-03-13	2011-06-14	3.9 ft
RU14-01	VX16000	2008-05-08	2011-05-24	1.9 ft
RU16-01	VX5000	2008-02-07	2011-06-03	2.2 ft

A. General cleanout standard procedures

The cleanout procedures were adapted from those utilized in a previous project.[3]

Preparation before site visit

1. Check the weather forecast when scheduling sampling days. A day when no precipitation is expected must be chosen for sampling.
2. Check the weather forecast the day before sampling is scheduled to confirm adequate weather. If weather forecast has changed, reschedule sampling.
3. Make arrangements to have a crash truck and a vacuum truck on site.
4. Make arrangements for sending samples to a laboratory for analysis.

Inspection immediately before cleanout

Before cleanout with a vacuum truck, the site needs to be inspected. Sediment, oil and other trapped material needs to be measured. The standard procedure used is:

1. Arrange sampling and measurement equipment.
2. Open manhole cover with appropriate equipment (i.e. hooks and claw).
3. Measure depth of floatables, water and sediment.
4. Remove floatables with pool skimmer and place in mesh or plastic bag.
5. Collect oil with oil absorbent booms and measure oil weight with scale.

The depth for floatables, water and sediment are measured using a telescoping measuring rod. Sediment depth is measured at three locations within the grit chamber: (1) center, (2) side and (3) midway between center and side. The three measurements are then averaged to record the sediment depth.

Floatable debris is skimmed off both the grit and floatables chambers. Mesh and/or plastic bags are used for storing floatables to be sorted later.

Procedure during cleanout

1. From the depth measurements, known device dimensions, and observation of sediment distribution, estimate the amount of sediment collected in the MTD.
2. Observe and record the kind of material collected (e.g. leaves, sand, soil, etc.).
3. Pump out water. (Optionally: discharge to the drainage system downstream)
4. Vacuum sediment.
5. Take sediment sample and store sample in the cooler.
6. Dispose of the bulk sediment at a maintainable yard or other suitable facility.
7. Send samples to the laboratory for analysis.

Two vacuuming procedures can be used:

1. Water is pumped and discharged to the drainage system downstream. This procedure requires minimizing disturbance to avoid sediment to be vacuumed out and discharged with the water. Once all the water has been pumped out, sediment can be sampled. The remaining sediment can be vacuumed and disposed of at a maintainable yard.
2. If the vacuum truck has a tank capable of holding all the contents in the device (water and sediment), everything is vacuumed together and later disposed of at a maintainable yard.

Inspection immediately after cleanout

Cleanout is finished by the contractor using jet spry to remove any attached sediments from the inside of the devices. Visual inspection of the devices is conducted by the contractor and any unusual material and/or any structural damage is reported.

Procedure for processing collected floatables

1. Wash floatables and place on plastic sheets to air dry.
2. Categorize litter.
3. Measure volume and weight of collected litter.

Procedure for processing sediment samples

1. Pack two 8 oz. jars of sample sediment and send to the laboratory for analysis.
2. Perform a Particle Size Distribution (PSD) analysis using soil sieves.
3. Determine the organic contents of the sediment.

B. Specific cleanout procedures used for selected devices

RU01-04: Two devices (RU01-04 and RU18-01) were cleaned out the same day. The vacuum truck did not have the capacity to contain the material from both devices. The truck had to dispose of the material collected from one device before vacuuming the second one. Both operations were completed using the standard procedure. (Date: 05/11/2011)

RU04-02: The cleanout date was not reported to Rutgers University, so the device was not inspected immediately prior to cleanout. However, the contractor took a sediment sample during cleanout and delivered it to Rutgers. It was reported that the cleanout operation was completed using the standard procedure. (Date: 05/19/2011)

RU06-01: Rutgers University reported two blocked catch basins upstream from the device. The blocked catch basins were vacuumed along with the MTD. Cleanout was completed using the standard procedure. (Date: 06/13/2011)

RU07-01: Rutgers University reported that water backed up from the outlet/creek could negatively impact the cleanout operation. The contractor prepared an additional pump and a plug-in for the outlet pipe. The cleanout operation was completed after placing the plug-in in the outlet pipe and using the supplemental pump. (Date: 06/14/2011)

RU14-01: Rutgers University reported that water was flowing from the inlet. The contractor prepared a wooden plug-in for the inlet. The cleanout operation was completed using the wooden plug-in. However, a proper 42-inch plug-in is recommended for subsequent cleanouts. (Date: 05/24/2011)
During inspection after cleanout, the contractor found that the high flow control weir was missing on the wall between the flow control chamber and the outlet chamber. This missing weir made the water in the device remain at an unusually high level.

RU16-01: Cleanout operation was completed using the standard procedure. (Date: 06/01/2011)

C. Specific observations from inspection of devices before and after cleanout

RU04-02

The diversion chamber connected to the device was blocked with soil. This obstruction impeded flow through the inlet. Both the device and the diversion chamber were cleaned out.

RU06-01

Construction activities (beneath the overpass) observed near Tonnelle Avenue have caused sand to wash into the storm sewers. Two catch basins in the stormwater network were completely backed-up due to sand deposits. On 36th street, beneath Paterson Plank Rd., there was a considerable amount of sediment on the roadway directly in front of the scupper.

A couple of oil sheens were observed at the outlet chamber and at the outfall after storm events. The device and catch basins were cleaned out for this research project.

RU07-01

A driveway comprised mostly of sand was eroding from an adjacent farm. The sand from this driveway was washing into the stormwater network. A large amount of deposited sand was observed on the driveways of a construction area. Sand deposition was observed outside the effluent culvert and inside the drainage manholes. Source control management practices on site were poor.

Water was backwashing from the outlet pipe/creek during cleanout operation. The device was cleaned out using a plug-in and a supplemental pump.

RU14-01

The high flow control weir was absent on the wall between the flow control and outlet chambers. Dry weather flow at the inlet pipe was observed to be unusually high.
The ground around the device was observed to be composed of very soft soil. This can be a safety concern during cleanout operations due to the weight of the vacuum truck.

D. Device Inspection Forms

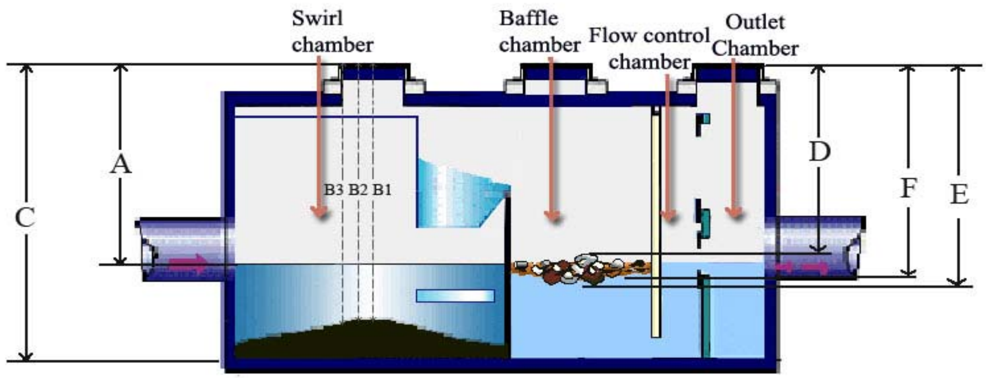
Inspection (Before & After Cleanout) Forms and Data

Vortechs®MTD Inspection Form

MTD ID			MTD_Inspection_Rec_ID		Weather*	Air Temp. (°F)	
RU01-04					Sunny	70 °	
Inspection Date	Inspection Time		Purpose of Inspection			Inspector	
05-11-2011	Start	End	Routine Inspection ( ) Inspection Immediately before Cleanout (v) Inspection Immediately after Cleanout (v) Other ( )			Junghoon Kim	
	07:30	08:00					
Inspection Cost	Last Inspection Date	Inspection Interval (months)	Projected Next Inspection Date		Recent Precipitation Event		
					Date	Depth (in)	
	04-03-2011	3	08-11-2011		04-16-2011	2.17	

* Weather: Sunny, Windy, Cloudy, Rainy, Stormy, Blizzard

Measurements from Ground above the Device (Routine Inspection or Inspection Immediately before Cleanout)



A: Distance from Water / Oil Surface to Top of Manhole Rim
B1: Distance from Center of Sediment Surface to Top of Manhole Rim
B2: Distance from Intermediate Location of Sediment Surface to Top of Manhole Rim
B3: Distance from Far Side of Sediment Surface to Top of Manhole Rim
C: Distance from Bottom to Top of Manhole Rim
D: Distance from Trash/Debris Surface to Top of Manhole Rim
E: Distance from Trash/Debris Bottom to Top of Manhole Rim
F: Distance from Bottom of Oil Layer to Top of Manhole Rim

Swirl Chamber			
A_s (ft)	7	Trash/Debris Area Coverage (%)	50
B_s1 (ft)	7.8	D_s (ft)	7
B_s2 (ft)	7.7	E_s (ft)	7
B_s3 (ft)	7.7	Oil Area Coverage (%)	25
C_s (ft)	10	F_s (ft)	7

Baffle Chamber			
A_b (ft)	7	Trash/Debris Area Coverage (%)	50
B_b1 (ft)	ND	D_b (ft)	7
B_b2 (ft)	ND	E_b (ft)	7
B_b3 (ft)	ND	Oil Area Coverage (%)	25
C_b (ft)	10	F_b (ft)	7

Outlet Chamber			
A_o (ft)	7	Trash/Debris Area Coverage (%)	ND
B_o1 (ft)	ND	D_o (ft)	ND
B_o2 (ft)	ND	E_o (ft)	ND
B_o3 (ft)	ND	Oil Area Coverage (%)	ND
C_o (ft)	10	F_o (ft)	ND

Observations of Device and Surrounding Drainage Area Characteristics (Routine Inspection or Inspection Immediately before Cleanout)

Traffic Density	Gross Solids - Litter	Gross Solids – Debris	Gross Solids – Coarse Sediment
(Low, Medium, Heavy)	(Small, Medium, Large)	(Small, Medium, Large)	(Small, Medium, Large)

Any Soil Erosion and Sediment Deposition in Watershed?	If Severe, Location(s) of Erosion and Deposition in Watershed
(Low, Moderate, Severe)	

Construction Activities in Watershed?	If Yes, Condition of Source Control Management Practices	If Poor, Location of Source Control Management Practices	If Poor, Describe Condition of Source Control Management Practices
(Yes / No)	(Good, Moderate, Poor)		

Winter Sanding Operation?	Space Available for Cleanout Activities without Traffic Blockage?
(Yes / No)	(Yes / No)

Insects (Mosquitoes, Larvae, etc…) in MTD?	Vegetation Growth in MTD?	Any Blockage to Flow Path in MTD?	If Yes, Name Location of the Blockage
(Yes / No)	(Yes / No)	(Yes / No)	

Any Blockage in Inlet, Manhole, Catch Basin, or Pipe Upstream and Downstream of the Device?	Location of Blockage	Type of Solids in Inlet, Manhole, Catch Basin or Pipe
(Yes / No)		(Gravel, Sand, Silt, Clay, Mud, Debris, Litter)
Dry Weather Flow in inlet pipe and outlet Pipe?	Backwater to outlet pipe from downstream?	Blockage at Outfall?
(Yes / No)	(Yes / No)	(Yes / No)

Outfall Structure					
Sediment discharged from MTD?	(Yes / No)	Trash/Debris discharged from MTD?	(Yes / No)	Oil Spill Out from MTD?	(Yes / No)

Device Structural Inspection - Visual Observation from Ground above the Device (Routine Inspection or Inspection Immediately before Cleanout)

Damage to Manhole Cover(s)	(No, Minor, Serious)	Description of Damage	
Damage to Side Walls	(No, Minor, Serious)	Description of Damage	
Damage to Swirl Chamber Aluminum Wall, Baffle Wall, Flow Control Wall or Orifice Plates	(No, Minor, Serious)	Description of Damage	
Damage to Inlet Pipe	(No, Minor, Serious)	Description of Damage	
Damage to Outlet Pipe	(No, Minor, Serious)	Description of Damage	

Photos Taken during Routine Inspection or Inspection Immediately before Cleanout

Photo 1	Photo 2	Photo 3
		

Additional Comments from Routine Inspection or Inspection Immediately before Cleanout

Device Structural Inspection – Visual Observation and Physical Testing from Inside of the Device (Inspection Immediately after Cleanout)

Damage to Side Walls, Ceiling or Bottom	(No, Minor, Serious)	Description of Damage	
Damage to Swirl Chamber Aluminum Wall, Baffle Wall, Flow Control Wall or Orifice Plates	(No, Minor, Serious)	Description of Damage	
Damage to Inlet Pipe	(No, Minor, Serious)	Description of Damage	
Damage to Outlet Pipe	(No, Minor, Serious)	Description of Damage	

Photo Taken During Structural Inspection Immediately after Cleanout

Photo 1	Photo 2	Photo 3
		

Additional Comments from Structural Inspection Immediately after Cleanout

Calculation and Decision for Cleanout based on Measurements

Water Depth **(ft)**		Sediment Depth **(ft)**	
	0.8		2.3
Device Cleanout Trigger: Sediment Depth **(ft)**		Cleanout Necessary Based on the Measured Sediment Depth?	Yes or No
Device Cleanout Trigger: Trash/Debris Thickness **(ft)**		Cleanout Necessary Based on the Measured Trash/Debris Thickness?	Yes or No
Device Cleanout Trigger: Trash/Debris Areal Coverage **(%)**		Cleanout Necessary Based on the Measured Trash/Debris Areal Coverage?	Yes or No
Device Cleanout Trigger: Oil Thickness **(ft)**		Cleanout Necessary Based on the Measured Oil Thickness?	Yes or No
Device Cleanout Trigger: Oil Areal Coverage **(%)**		Cleanout Necessary Based on the Measured Oil Areal Coverage?	Yes or No

Vortechs®MTD Inspection Form

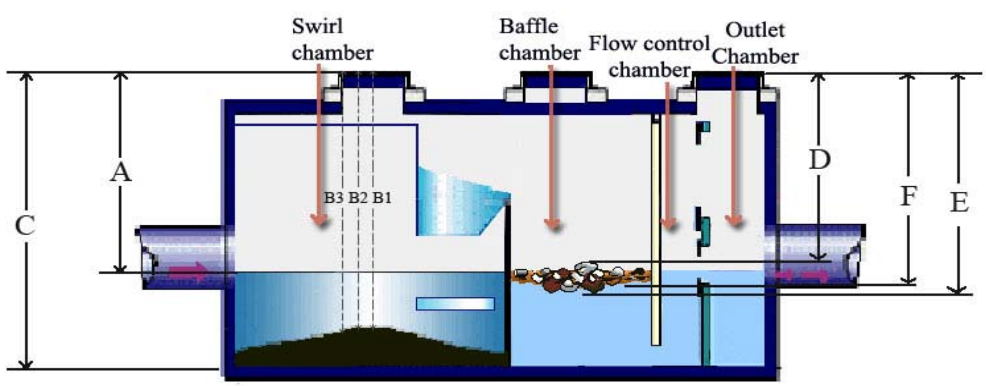
MTD ID	MTD_Inspection_Rec_ID	Weather*	Air Temp. (°F)
RU04-02		Overcast	65 °

Inspection Date	Inspection Time		Purpose of Inspection	Inspector
	Start	End		
04-05-2011 05-19-2011 (clean out)			Routine Inspection (v) Inspection Immediately before Cleanout (v) Inspection Immediately after Cleanout (v) Other ( )	Brad Amell, Junghoon Kim

Inspection Cost	Last Inspection Date	Inspection Interval (months)	Projected Next Inspection Date	Recent Precipitation Event	
				Date	Depth (in)
	04-05-2011	3	08-19-2011	04-16-2011	2.17

* Weather: Sunny, Windy, Cloudy, Rainy, Stormy, Blizzard

Measurements from Ground above the Device (Routine Inspection or Inspection Immediately before Cleanout)



A: Distance from Water / Oil Surface to Top of Manhole Rim
B1: Distance from Center of Sediment Surface to Top of Manhole Rim
B2: Distance from Intermediate Location of Sediment Surface to Top of Manhole Rim
B3: Distance from Far Side of Sediment Surface to Top of Manhole Rim
C: Distance from Bottom to Top of Manhole Rim
D: Distance from Trash/Debris Surface to Top of Manhole Rim
E: Distance from Trash/Debris Bottom to Top of Manhole Rim
F: Distance from Bottom of Oil Layer to Top of Manhole Rim

Swirl Chamber (05-19-2011)				
A_s (ft)	9	Trash/Debris Area Coverage (%)		25
B_s1 (ft)	10	D_s (ft)	ND	
B_s2 (ft)	10	E_s (ft)	ND	
B_s3 (ft)	10	Oil Area Coverage (%)		10
C_s (ft)	12	F_s (ft)	ND	

Baffle Chamber (05-19-2011)				
A_b (ft)	9	Trash/Debris Area Coverage (%)		25
B_b1 (ft)	ND	D_b (ft)	ND	
B_b2 (ft)	ND	E_b (ft)	ND	
B_b3 (ft)	ND	Oil Area Coverage (%)		10
C_b (ft)	11.5	F_b (ft)	ND	

Outlet Chamber (05-19-2011)				
A_o (ft)	ND	Trash/Debris Area Coverage (%)		ND
B_o1 (ft)	ND	D_o (ft)	ND	
B_o2 (ft)	ND	E_o (ft)	ND	
B_o3 (ft)	ND	Oil Area Coverage (%)		ND
C_o (ft)	ND	F_o (ft)	ND	

Observations of Device and Surrounding Drainage Area Characteristics (Routine Inspection or Inspection Immediately before Cleanout)

Traffic Density	Gross Solids - Litter	Gross Solids – Debris	Gross Solids – Coarse Sediment
(Low, Medium, Heavy)	(Small, Medium, Large)	(Small, Medium, Large)	(Small, Medium, Large)
Any Soil Erosion and Sediment Deposition in Watershed?		If Severe, Location(s) of Erosion and Deposition in Watershed	
(Low, Moderate, Severe)			
Construction Activities in Watershed?	If Yes, Condition of Source Control Management Practices	If Poor, Location of Source Control Management Practices	If Poor, Describe Condition of Source Control Management Practices
(Yes / No)	(Good, Moderate, Poor)		
Winter Sanding Operation?		Space Available for Cleanout Activities without Traffic Blockage?	
(Yes / No)		(Yes / No)	

Insects (Mosquitoes, Larvae, etc…) in MTD?	Vegetation Growth in MTD?	Any Blockage to Flow Path in MTD?	If Yes, Name Location of the Blockage
(Yes / No)	(Yes / No)	(Yes / No)	Upstream diversion chamber

Any Blockage in Inlet, Manhole, Catch Basin, or Pipe Upstream and Downstream of the Device?	Location of Blockage	Type of Solids in Inlet, Manhole, Catch Basin or Pipe
(Yes / No)	Upstream diversion chamber	(Gravel, Sand, Silt, Clay, Mud, Debris, Litter)
Dry Weather Flow in inlet pipe and outlet Pipe?	Backwater to outlet pipe from downstream?	Blockage at Outfall?
(Yes / No)	(Yes / No)	(Yes / No)

Outfall Structure					
Sediment discharged from MTD?	(Yes / No)	Trash/Debris discharged from MTD?	(Yes / No)	Oil Spill Out from MTD?	(Yes / No)

Device Structural Inspection - Visual Observation from Ground above the Device (Routine Inspection or Inspection Immediately before Cleanout)

Damage to Manhole Cover(s)	(No, Minor, Serious)	Description of Damage	
Damage to Side Walls	(No, Minor, Serious)	Description of Damage	
Damage to Swirl Chamber Aluminum Wall, Baffle Wall, Flow Control Wall or Orifice Plates	(No, Minor, Serious)	Description of Damage	
Damage to Inlet Pipe	(No, Minor, Serious)	Description of Damage	
Damage to Outlet Pipe	(No, Minor, Serious)	Description of Damage	

Photos Taken during Routine Inspection or Inspection Immediately before Cleanout

Photo 1	Photo 2	Photo 3

Additional Comments from Routine Inspection or Inspection Immediately before Cleanout

Device Structural Inspection – Visual Observation and Physical Testing from Inside of the Device (Inspection Immediately after Cleanout)

Damage to Side Walls, Ceiling or Bottom	(No, Minor, Serious)	Description of Damage	
Damage to Swirl Chamber Aluminum Wall, Baffle Wall, Flow Control Wall or Orifice Plates	(No, Minor, Serious)	Description of Damage	
Damage to Inlet Pipe	(No, Minor, Serious)	Description of Damage	
Damage to Outlet Pipe	(No, Minor, Serious)	Description of Damage	

Photo Taken During Structural Inspection Immediately after Cleanout

Photo 1	Photo 2	Photo 3

Additional Comments from Structural Inspection Immediately after Cleanout

It was reported there was blockage at the diversion chamber connected MTD's inlet pipe. The contactor cleaned the chamber.

Calculation and Decision for Cleanout based on Measurements

Water Depth **(ft)**		Sediment Depth **(ft)**	
	1		2
Device Cleanout Trigger: Sediment Depth **(ft)**		Cleanout Necessary Based on the Measured Sediment Depth?	Yes or No
Device Cleanout Trigger: Trash/Debris Thickness **(ft)**		Cleanout Necessary Based on the Measured Trash/Debris Thickness?	Yes or No
Device Cleanout Trigger: Trash/Debris Areal Coverage **(%)**		Cleanout Necessary Based on the Measured Trash/Debris Areal Coverage?	Yes or No
Device Cleanout Trigger: Oil Thickness **(ft)**		Cleanout Necessary Based on the Measured Oil Thickness?	Yes or No
Device Cleanout Trigger: Oil Areal Coverage **(%)**		Cleanout Necessary Based on the Measured Oil Areal Coverage?	Yes or No

Vortechs®MTD Inspection Form

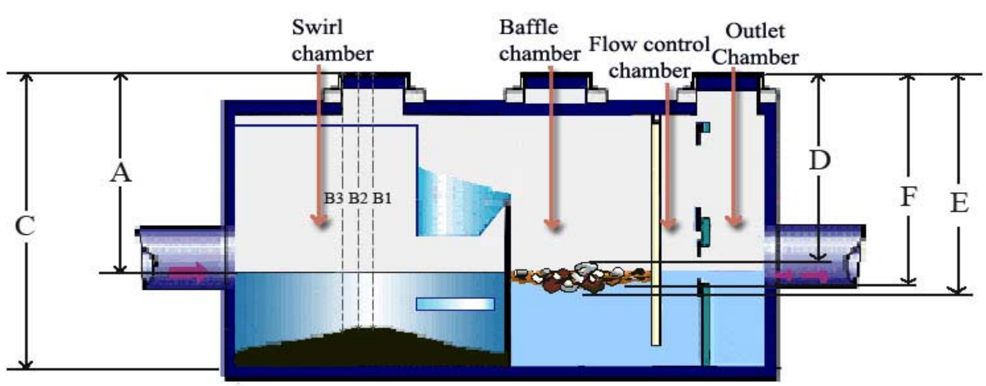
MTD ID	MTD_Inspection_Rec_ID	Weather*	Air Temp. (ºF)
RU06-01		Sunny	75 º

Inspection Date	Inspection Time		Purpose of Inspection	Inspector
	Start	End		
05-20-2011 06-13-2011 (clean out)			Routine Inspection (v) Inspection Immediately before Cleanout (v) Inspection Immediately after Cleanout (v) Other ( )	Brad Amell, Junghoon Kim

Inspection Cost	Last Inspection Date	Inspection Interval (months)	Projected Next Inspection Date	Recent Precipitation Event	
				Date	Depth (in)
	02-20-2011	3	09-13-2011	04-16-2011	2.17

* Weather: Sunny, Windy, Cloudy, Rainy, Stormy, Blizzard

Measurements from Ground above the Device (Routine Inspection or Inspection Immediately before Cleanout)



A: Distance from Water / Oil Surface to Top of Manhole Rim
B1: Distance from Center of Sediment Surface to Top of Manhole Rim
B2: Distance from Intermediate Location of Sediment Surface to Top of Manhole Rim
B3: Distance from Far Side of Sediment Surface to Top of Manhole Rim
C: Distance from Bottom to Top of Manhole Rim
D: Distance from Trash/Debris Surface to Top of Manhole Rim
E: Distance from Trash/Debris Bottom to Top of Manhole Rim
F: Distance from Bottom of Oil Layer to Top of Manhole Rim

Swirl Chamber			
A_s (ft)	4.5	Trash/Debris Area Coverage (%)	30
B_s1 (ft)	5.5	D_s (ft)	ND
B_s2 (ft)	5.5	E_s (ft)	ND
B_s3 (ft)	5.5	Oil Area Coverage (%)	10
C_s (ft)	8.5	F_s (ft)	ND

Baffle Chamber			
A_b (ft)	4.5	Trash/Debris Area Coverage (%)	30
B_b1 (ft)	5.5	D_b (ft)	ND
B_b2 (ft)	5.5	E_b (ft)	ND
B_b3 (ft)	5.5	Oil Area Coverage (%)	10
C_b (ft)	8.5	F_b (ft)	ND

Outlet Chamber			
A_o (ft)	4.5	Trash/Debris Area Coverage (%)	ND
B_o1 (ft)	ND	D_o (ft)	ND
B_o2 (ft)	ND	E_o (ft)	ND
B_o3 (ft)	ND	Oil Area Coverage (%)	1%
C_o (ft)	8.5	F_o (ft)	NA

Observations of Device and Surrounding Drainage Area Characteristics (Routine Inspection or Inspection Immediately before Cleanout)

Traffic Density	Gross Solids - Litter	Gross Solids – Debris	Gross Solids – Coarse Sediment
(Low, Medium, Heavy)	(Small, Medium, Large)	(Small, Medium, Large)	(Small, Medium, Large)

Any Soil Erosion and Sediment Deposition in Watershed?	If Severe, Location(s) of Erosion and Deposition in Watershed
(Low, Moderate, Severe)	Construction site at Rt1&9 and 36th street

Construction Activities in Watershed?	If Yes, Condition of Source Control Management Practices	If Poor, Location of Source Control Management Practices	If Poor, Describe Condition of Source Control Management Practices
(Yes / No)	(Good, Moderate, Poor)	Rt1&9 and 36th street	A large amount of sand on the road

Winter Sanding Operation?	Space Available for Cleanout Activities without Traffic Blockage?
(Yes / No)	(Yes / No)

Insects (Mosquitoes, Larvae, etc…) in MTD?	Vegetation Growth in MTD?	Any Blockage to Flow Path in MTD?	If Yes, Name Location of the Blockage
(Yes / No)	(Yes / No)	(Yes / No)	Catch Basin

Any Blockage in Inlet, Manhole, Catch Basin, or Pipe Upstream and Downstream of the Device?	Location of Blockage	Type of Solids in Inlet, Manhole, Catch Basin or Pipe
(Yes / No)	Catch Basin	(Gravel, Sand, Silt, Clay, Mud, Debris, Litter)
Dry Weather Flow in inlet pipe and outlet Pipe?	Backwater to outlet pipe from downstream?	Blockage at Outfall?
(Yes / No)	(Yes / No)	(Yes / No)

Outfall Structure					
Sediment discharged from MTD?	(Yes / No)	Trash/Debris discharged from MTD?	(Yes / No)	Oil Spill Out from MTD?	(Yes / No)

Device Structural Inspection - Visual Observation from Ground above the Device (Routine Inspection or Inspection Immediately before Cleanout)

Damage to Manhole Cover(s)	(No, Minor, Serious)	Description of Damage	
Damage to Side Walls	(No, Minor, Serious)	Description of Damage	
Damage to Swirl Chamber Aluminum Wall, Baffle Wall, Flow Control Wall or Orifice Plates	(No, Minor, Serious)	Description of Damage	
Damage to Inlet Pipe	(No, Minor, Serious)	Description of Damage	
Damage to Outlet Pipe	(No, Minor, Serious)	Description of Damage	

Photos Taken during Routine Inspection or Inspection Immediately before Cleanout

Photo 1	Photo 2	Photo 3

Additional Comments from Routine Inspection or Inspection Immediately before Cleanout

Construction Activity. A large amount of sand on the road. Oil sheen was observed at the outlet chamber and the outfall.

Device Structural Inspection – Visual Observation and Physical Testing from Inside of the Device (Inspection Immediately after Cleanout)

Damage to Side Walls, Ceiling or Bottom	(No, Minor, Serious)	Description of Damage	
Damage to Swirl Chamber Aluminum Wall, Baffle Wall, Flow Control Wall or Orifice Plates	(No, Minor, Serious)	Description of Damage	
Damage to Inlet Pipe	(No, Minor, Serious)	Description of Damage	
Damage to Outlet Pipe	(No, Minor, Serious)	Description of Damage	

Photo Taken During Structural Inspection Immediately after Cleanout

Photo 1	Photo 2	Photo 3

Additional Comments from Structural Inspection Immediately after Cleanout

There was blockage at two catch basins. The contactor cleaned them.

Calculation and Decision for Cleanout based on Measurements

Water Depth **(ft)**		Sediment Depth **(ft)**	
	1		3
Device Cleanout Trigger: Sediment Depth **(ft)**		Cleanout Necessary Based on the Measured Sediment Depth?	Yes or No
Device Cleanout Trigger: Trash/Debris Thickness **(ft)**		Cleanout Necessary Based on the Measured Trash/Debris Thickness?	Yes or No
Device Cleanout Trigger: Trash/Debris Areal Coverage **(%)**		Cleanout Necessary Based on the Measured Trash/Debris Areal Coverage?	Yes or No
Device Cleanout Trigger: Oil Thickness **(ft)**		Cleanout Necessary Based on the Measured Oil Thickness?	Yes or No
Device Cleanout Trigger: Oil Areal Coverage **(%)**		Cleanout Necessary Based on the Measured Oil Areal Coverage?	Yes or No

Vortechs®MTD Inspection Form

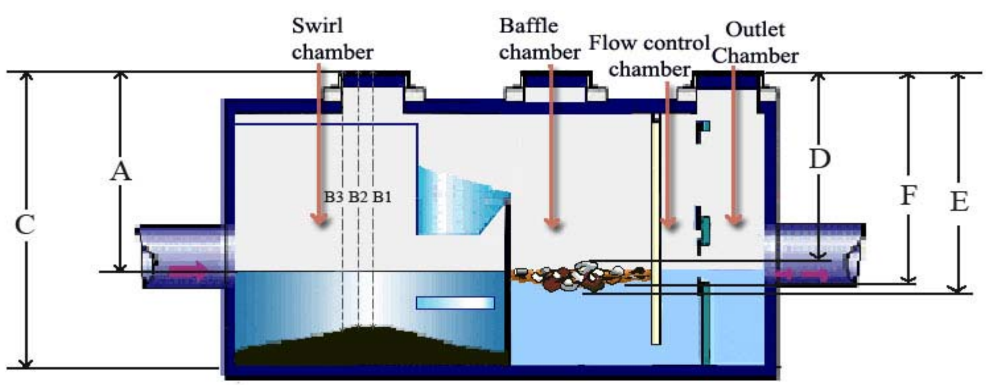
MTD ID	MTD_Inspection_Rec_ID	Weather*	Air Temp. (°F)
RU07-01		Sunny	74 °

Inspection Date	Inspection Time		Purpose of Inspection	Inspector
06-14-2011	Start	End	Routine Inspection ( ) Inspection Immediately before Cleanout (v) Inspection Immediately after Cleanout (v) Other ( )	Junghoon Kim
	07:30	08:00		

Inspection Cost	Last Inspection Date	Inspection Interval (months)	Projected Next Inspection Date	Recent Precipitation Event	
				Date	Depth (in)
	04-05-2011	3	09-14-2011	04-16-2011	2.17

* Weather: Sunny, Windy, Cloudy, Rainy, Stormy, Blizzard

Measurements from Ground above the Device (Routine Inspection or Inspection Immediately before Cleanout)



A: Distance from Water / Oil Surface to Top of Manhole Rim
B1: Distance from Center of Sediment Surface to Top of Manhole Rim
B2: Distance from Intermediate Location of Sediment Surface to Top of Manhole Rim
B3: Distance from Far Side of Sediment Surface to Top of Manhole Rim
C: Distance from Bottom to Top of Manhole Rim
D: Distance from Trash/Debris Surface to Top of Manhole Rim
E: Distance from Trash/Debris Bottom to Top of Manhole Rim
F: Distance from Bottom of Oil Layer to Top of Manhole Rim

Swirl Chamber				
A_s (ft)	11	Trash/Debris Area Coverage (%)		75
B_s1 (ft)	10.7	D_s (ft)	10.7	
B_s2 (ft)	10.7	E_s (ft)	10.7	
B_s3 (ft)	10.8	Oil Area Coverage (%)		ND
C_s (ft)	14.6	F_s (ft)	ND	

Baffle Chamber				
A_b (ft)	11	Trash/Debris Area Coverage (%)		75
B_b1 (ft)	14.3	D_b (ft)	11	
B_b2 (ft)	14.3	E_b (ft)	11	
B_b3 (ft)	14.3	Oil Area Coverage (%)		25
C_b (ft)	14.5	F_b (ft)	11	

Outlet Chamber				
A_o (ft)	11	Trash/Debris Area Coverage (%)		ND
B_o1 (ft)	ND	D_o (ft)	ND	
B_o2 (ft)	ND	E_o (ft)	ND	
B_o3 (ft)	ND	Oil Area Coverage (%)		ND
C_o (ft)	14.5	F_o (ft)	ND	

Observations of Device and Surrounding Drainage Area Characteristics (Routine Inspection or Inspection Immediately before Cleanout)

Traffic Density	Gross Solids - Litter	Gross Solids – Debris	Gross Solids – Coarse Sediment
(Low, Medium, Heavy)	(Small, Medium, Large)	(Small, Medium, Large)	(Small, Medium, Large)
Any Soil Erosion and Sediment Deposition in Watershed?		If Severe, Location(s) of Erosion and Deposition in Watershed	
(Low, Moderate, Severe)		Rt.47 and CR.665	
Construction Activities in Watershed?	If Yes, Condition of Source Control Management Practices	If Poor, Location of Source Control Management Practices	If Poor, Describe Condition of Source Control Management Practices
(Yes / No)	(Good, Moderate, Poor)	Rt.47 and CR.665	A large amount of sand on the road
Winter Sanding Operation?		Space Available for Cleanout Activities without Traffic Blockage?	
(Yes / No)		(Yes / No)	

Insects (Mosquitoes, Larvae, etc…) in MTD?	Vegetation Growth in MTD?	Any Blockage to Flow Path in MTD?	If Yes, Name Location of the Blockage
(Yes / No)	(Yes / No)	(Yes / No)	

Any Blockage in Inlet, Manhole, Catch Basin, or Pipe Upstream and Downstream of the Device?	Location of Blockage	Type of Solids in Inlet, Manhole, Catch Basin or Pipe
(Yes / No)		(Gravel, Sand, Silt, Clay, Mud, Debris, Litter)
Dry Weather Flow in inlet pipe and outlet Pipe?	Backwater to outlet pipe from downstream?	Blockage at Outfall?
(Yes / No)	(Yes / No)	(Yes / No)

Outfall Structure					
Sediment discharged from MTD?	(Yes / No)	Trash/Debris discharged from MTD?	(Yes / No)	Oil Spill Out from MTD?	(Yes / No)

Device Structural Inspection - Visual Observation from Ground above the Device (Routine Inspection or Inspection Immediately before Cleanout)

Damage to Manhole Cover(s)	(No, Minor, Serious)	Description of Damage	
Damage to Side Walls	(No, Minor, Serious)	Description of Damage	
Damage to Swirl Chamber Aluminum Wall, Baffle Wall, Flow Control Wall or Orifice Plates	(No, Minor, Serious)	Description of Damage	
Damage to Inlet Pipe	(No, Minor, Serious)	Description of Damage	
Damage to Outlet Pipe	(No, Minor, Serious)	Description of Damage	

Photos Taken during Routine Inspection or Inspection Immediately before Cleanout

Photo 1	Photo 2	Photo 3
		

Additional Comments from Routine Inspection or Inspection Immediately before Cleanout

Device Structural Inspection – Visual Observation and Physical Testing from Inside of the Device (Inspection Immediately after Cleanout)

Damage to Side Walls, Ceiling or Bottom	(No, Minor, Serious)	Description of Damage	
Damage to Swirl Chamber Aluminum Wall, Baffle Wall, Flow Control Wall or Orifice Plates	(No, Minor, Serious)	Description of Damage	
Damage to Inlet Pipe	(No, Minor, Serious)	Description of Damage	
Damage to Outlet Pipe	(No, Minor, Serious)	Description of Damage	

Photo Taken During Structural Inspection Immediately after Cleanout

Photo 1	Photo 2	Photo 3
		

Additional Comments from Structural Inspection Immediately after Cleanout

There was backwater from outlet pipe/creek. The device was cleaned out with plug-in and pump.

Calculation and Decision for Cleanout based on Measurements

Water Depth **(ft)**		Sediment Depth **(ft)**	
	0.0		3.9
Device Cleanout Trigger: Sediment Depth **(ft)**		Cleanout Necessary Based on the Measured Sediment Depth?	Yes or No
Device Cleanout Trigger: Trash/Debris Thickness **(ft)**		Cleanout Necessary Based on the Measured Trash/Debris Thickness?	Yes or No
Device Cleanout Trigger: Trash/Debris Areal Coverage **(%)**		Cleanout Necessary Based on the Measured Trash/Debris Areal Coverage?	Yes or No
Device Cleanout Trigger: Oil Thickness **(ft)**		Cleanout Necessary Based on the Measured Oil Thickness?	Yes or No
Device Cleanout Trigger: Oil Areal Coverage **(%)**		Cleanout Necessary Based on the Measured Oil Areal Coverage?	Yes or No

Vortechs®MTD Inspection Form

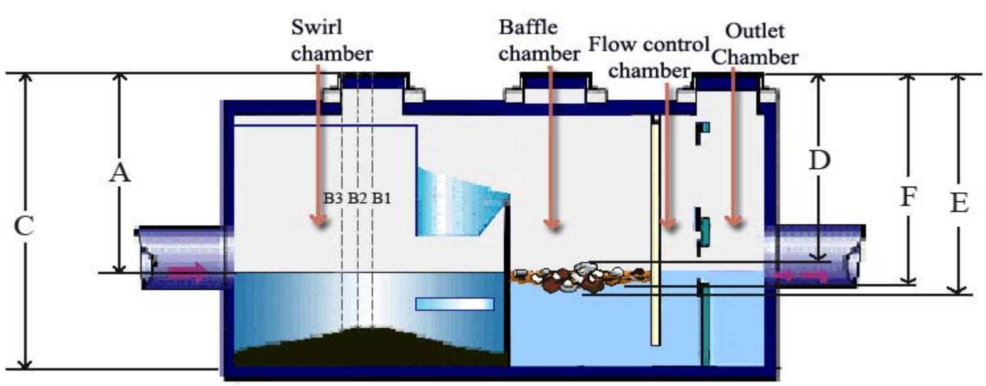
MTD ID	MTD_Inspection_Rec_ID	Weather*	Air Temp. (°F)
RU14-01		Cloudy	72 °

Inspection Date	Inspection Time		Purpose of Inspection	Inspector
	Start	End		
05-24-2011	07:30	08:00	Routine Inspection ( ) Inspection Immediately before Cleanout (v) Inspection Immediately after Cleanout (v) Other ( )	Junghoon Kim

Inspection Cost	Last Inspection Date	Inspection Interval (months)	Projected Next Inspection Date	Recent Precipitation Event	
				Date	Depth (in)
	04-08-2011	3	08-24-2011	04-16-2011	2.17

* Weather: Sunny, Windy, Cloudy, Rainy, Stormy, Blizzard

Measurements from Ground above the Device (Routine Inspection or Inspection Immediately before Cleanout)



A: Distance from Water / Oil Surface to Top of Manhole Rim
B1: Distance from Center of Sediment Surface to Top of Manhole Rim
B2: Distance from Intermediate Location of Sediment Surface to Top of Manhole Rim
B3: Distance from Far Side of Sediment Surface to Top of Manhole Rim
C: Distance from Bottom to Top of Manhole Rim
D: Distance from Trash/Debris Surface to Top of Manhole Rim
E: Distance from Trash/Debris Bottom to Top of Manhole Rim
F: Distance from Bottom of Oil Layer to Top of Manhole Rim

Swirl Chamber			
A_s (ft)	3	Trash/Debris Area Coverage (%)	25
B_s1 (ft)	7.6	D_s (ft)	3
B_s2 (ft)	7.5	E_s (ft)	3
B_s3 (ft)	7.5	Oil Area Coverage (%)	25
C_s (ft)	9.4	F_s (ft)	3

Baffle Chamber			
A_b (ft)	3	Trash/Debris Area Coverage (%)	50
B_b1 (ft)	ND	D_b (ft)	3
B_b2 (ft)	ND	E_b (ft)	3
B_b3 (ft)	ND	Oil Area Coverage (%)	25
C_b (ft)	9.5	F_b (ft)	3

Outlet Chamber			
A_o (ft)	3	Trash/Debris Area Coverage (%)	ND
B_o1 (ft)	ND	D_o (ft)	ND
B_o2 (ft)	ND	E_o (ft)	ND
B_o3 (ft)	ND	Oil Area Coverage (%)	ND
C_o (ft)	9.5	F_o (ft)	ND

Observations of Device and Surrounding Drainage Area Characteristics (Routine Inspection or Inspection Immediately before Cleanout)

Traffic Density	Gross Solids - Litter	Gross Solids – Debris	Gross Solids – Coarse Sediment
(Low, Medium, Heavy)	(Small, Medium, Large)	(Small, Medium, Large)	(Small, Medium, Large)

Any Soil Erosion and Sediment Deposition in Watershed?	If Severe, Location(s) of Erosion and Deposition in Watershed
(Low, Moderate, Severe)	

Construction Activities in Watershed?	If Yes, Condition of Source Control Management Practices	If Poor, Location of Source Control Management Practices	If Poor, Describe Condition of Source Control Management Practices
(Yes / No)	(Good, Moderate, Poor)		

Winter Sanding Operation?	Space Available for Cleanout Activities without Traffic Blockage?
(Yes / No)	(Yes / No)

Insects (Mosquitoes, Larvae, etc…) in MTD?	Vegetation Growth in MTD?	Any Blockage to Flow Path in MTD?	If Yes, Name Location of the Blockage
(Yes / No)	(Yes / No)	(Yes / No)	

Any Blockage in Inlet, Manhole, Catch Basin, or Pipe Upstream and Downstream of the Device?	Location of Blockage	Type of Solids in Inlet, Manhole, Catch Basin or Pipe
(Yes / No)		(Gravel, Sand, Silt, Clay, Mud, Debris, Litter)
Dry Weather Flow in inlet pipe and outlet Pipe?	Backwater to outlet pipe from downstream?	Blockage at Outfall?
(Yes / No)	(Yes / No)	(Yes / No)

Outfall Structure					
Sediment discharged from MTD?	(Yes / No)	Trash/Debris discharged from MTD?	(Yes / No)	Oil Spill Out from MTD?	(Yes / No)

Device Structural Inspection - Visual Observation from Ground above the Device (Routine Inspection or Inspection Immediately before Cleanout)

Damage to Manhole Cover(s)	(No, Minor, Serious)	Description of Damage	
Damage to Side Walls	(No, Minor, Serious)	Description of Damage	
Damage to Swirl Chamber Aluminum Wall, Baffle Wall, Flow Control Wall or Orifice Plates	(No, Minor, Serious)	Description of Damage	
Damage to Inlet Pipe	(No, Minor, Serious)	Description of Damage	
Damage to Outlet Pipe	(No, Minor, Serious)	Description of Damage	

Photos Taken during Routine Inspection or Inspection Immediately before Cleanout

Photo 1	Photo 2	Photo 3
		

Additional Comments from Routine Inspection or Inspection Immediately before Cleanout

Device Structural Inspection – Visual Observation and Physical Testing from Inside of the Device (Inspection Immediately after Cleanout)

Damage to Side Walls, Ceiling or Bottom	(No, Minor, Serious)	Description of Damage	
Damage to Swirl Chamber Aluminum Wall, Baffle Wall, Flow Control Wall or Orifice Plates	(No, Minor, Serious)	Description of Damage	There is not 'High flow control weir'.
Damage to Inlet Pipe	(No, Minor, Serious)	Description of Damage	
Damage to Outlet Pipe	(No, Minor, Serious)	Description of Damage	

Photo Taken During Structural Inspection Immediately after Cleanout

Photo 1	Photo 2	Photo 3
		

Additional Comments from Structural Inspection Immediately after Cleanout

There is no high flow control weir.

Calculation and Decision for Cleanout based on Measurements

Water Depth **(ft)**		Sediment Depth **(ft)**	
	4.5		1.9
Device Cleanout Trigger: Sediment Depth **(ft)**		Cleanout Necessary Based on the Measured Sediment Depth?	Yes or No
Device Cleanout Trigger: Trash/Debris Thickness **(ft)**		Cleanout Necessary Based on the Measured Trash/Debris Thickness?	Yes or No
Device Cleanout Trigger: Trash/Debris Areal Coverage **(%)**		Cleanout Necessary Based on the Measured Trash/Debris Areal Coverage?	Yes or No
Device Cleanout Trigger: Oil Thickness **(ft)**		Cleanout Necessary Based on the Measured Oil Thickness?	Yes or No
Device Cleanout Trigger: Oil Areal Coverage **(%)**		Cleanout Necessary Based on the Measured Oil Areal Coverage?	Yes or No

Vortechs®MTD Inspection Form

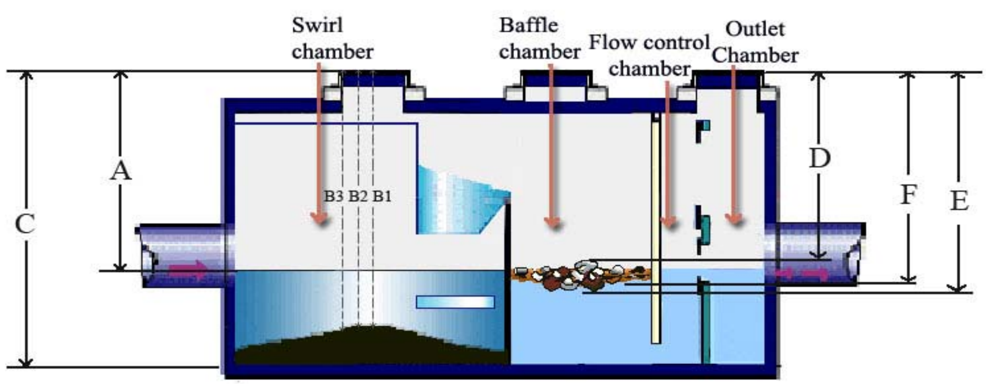
MTD ID	MTD_Inspection_Rec_ID	Weather*	Air Temp. (^oF)
RU16-01		Sunny	78 °

Inspection Date	Inspection Time		Purpose of Inspection	Inspector
06-03-2011	Start	End	Routine Inspection ( ) Inspection Immediately before Cleanout (v) Inspection Immediately after Cleanout (v) Other ( )	Junghoon Kim
	07:30	08:00		

Inspection Cost	Last Inspection Date	Inspection Interval (months)	Projected Next Inspection Date	Recent Precipitation Event	
				Date	Depth (in)
	04-08-2011	3	09-03-2011	04-16-2011	2.17

* Weather: Sunny, Windy, Cloudy, Rainy, Stormy, Blizzard

Measurements from Ground above the Device (Routine Inspection or Inspection Immediately before Cleanout)



A: Distance from Water / Oil Surface to Top of Manhole Rim
B1: Distance from Center of Sediment Surface to Top of Manhole Rim
B2: Distance from Intermediate Location of Sediment Surface to Top of Manhole Rim
B3: Distance from Far Side of Sediment Surface to Top of Manhole Rim
C: Distance from Bottom to Top of Manhole Rim
D: Distance from Trash/Debris Surface to Top of Manhole Rim
E: Distance from Trash/Debris Bottom to Top of Manhole Rim
F: Distance from Bottom of Oil Layer to Top of Manhole Rim

Swirl Chamber			
A_s (ft)	5	Trash/Debris Area Coverage (%)	10
B_s1 (ft)	7.9	D_s (ft)	8
B_s2 (ft)	7.9	E_s (ft)	8
B_s3 (ft)	8.0	Oil Area Coverage (%)	25
C_s (ft)	10.1	F_s (ft)	8

Baffle Chamber			
A_b (ft)	5	Trash/Debris Area Coverage (%)	10
B_b1 (ft)	ND	D_b (ft)	7
B_b2 (ft)	ND	E_b (ft)	7
B_b3 (ft)	ND	Oil Area Coverage (%)	25
C_b (ft)	10	F_b (ft)	7

Outlet Chamber			
A_o (ft)	5	Trash/Debris Area Coverage (%)	ND
B_o1 (ft)	ND	D_o (ft)	ND
B_o2 (ft)	ND	E_o (ft)	ND
B_o3 (ft)	ND	Oil Area Coverage (%)	ND
C_o (ft)	10	F_o (ft)	ND

Observations of Device and Surrounding Drainage Area Characteristics (Routine Inspection or Inspection Immediately before Cleanout)

Traffic Density	Gross Solids - Litter	Gross Solids – Debris	Gross Solids – Coarse Sediment
(Low, Medium, Heavy)	(Small, Medium, Large)	(Small, Medium, Large)	(Small, Medium, Large)
Any Soil Erosion and Sediment Deposition in Watershed?		If Severe, Location(s) of Erosion and Deposition in Watershed	
(Low, Moderate, Severe)			
Construction Activities in Watershed?	If Yes, Condition of Source Control Management Practices	If Poor, Location of Source Control Management Practices	If Poor, Describe Condition of Source Control Management Practices
(Yes / No)	(Good, Moderate, Poor)		
Winter Sanding Operation?		Space Available for Cleanout Activities without Traffic Blockage?	
(Yes / No)		(Yes / No)	

Insects (Mosquitoes, Larvae, etc…) in MTD?	Vegetation Growth in MTD?	Any Blockage to Flow Path in MTD?	If Yes, Name Location of the Blockage
(Yes / No)	(Yes / No)	(Yes / No)	

Any Blockage in Inlet, Manhole, Catch Basin, or Pipe Upstream and Downstream of the Device?	Location of Blockage	Type of Solids in Inlet, Manhole, Catch Basin or Pipe
(Yes / No)		(Gravel, Sand, Silt, Clay, Mud, Debris, Litter)
Dry Weather Flow in inlet pipe and outlet Pipe?	Backwater to outlet pipe from downstream?	Blockage at Outfall?
(Yes / No)	(Yes / No)	(Yes / No)

Outfall Structure					
Sediment discharged from MTD?	(Yes / No)	Trash/Debris discharged from MTD?	(Yes / No)	Oil Spill Out from MTD?	(Yes / No)

Device Structural Inspection - Visual Observation from Ground above the Device (Routine Inspection or Inspection Immediately before Cleanout)

Damage to Manhole Cover(s)	(No, Minor, Serious)	Description of Damage	
Damage to Side Walls	(No, Minor, Serious)	Description of Damage	
Damage to Swirl Chamber Aluminum Wall, Baffle Wall, Flow Control Wall or Orifice Plates	(No, Minor, Serious)	Description of Damage	
Damage to Inlet Pipe	(No, Minor, Serious)	Description of Damage	
Damage to Outlet Pipe	(No, Minor, Serious)	Description of Damage	

Photos Taken during Routine Inspection or Inspection Immediately before Cleanout

Photo 1	Photo 2	Photo 3
		

Additional Comments from Routine Inspection or Inspection Immediately before Cleanout

Device Structural Inspection – Visual Observation and Physical Testing from Inside of the Device (Inspection Immediately after Cleanout)

Damage to Side Walls, Ceiling or Bottom	(No, Minor, Serious)	Description of Damage	
Damage to Swirl Chamber Aluminum Wall, Baffle Wall, Flow Control Wall or Orifice Plates	(No, Minor, Serious)	Description of Damage	
Damage to Inlet Pipe	(No, Minor, Serious)	Description of Damage	
Damage to Outlet Pipe	(No, Minor, Serious)	Description of Damage	

Photo Taken During Structural Inspection Immediately after Cleanout

Photo 1	Photo 2	Photo 3
		

Additional Comments from Structural Inspection Immediately after Cleanout

Calculation and Decision for Cleanout based on Measurements

Water Depth **(ft)**		Sediment Depth **(ft)**	
3		2.2	
Device Cleanout Trigger: Sediment Depth **(ft)**		Cleanout Necessary Based on the Measured Sediment Depth?	Yes or No
Device Cleanout Trigger: Trash/Debris Thickness **(ft)**		Cleanout Necessary Based on the Measured Trash/Debris Thickness?	Yes or No
Device Cleanout Trigger: Trash/Debris Areal Coverage **(%)**		Cleanout Necessary Based on the Measured Trash/Debris Areal Coverage?	Yes or No
Device Cleanout Trigger: Oil Thickness **(ft)**		Cleanout Necessary Based on the Measured Oil Thickness?	Yes or No
Device Cleanout Trigger: Oil Areal Coverage **(%)**		Cleanout Necessary Based on the Measured Oil Areal Coverage?	Yes or No

E. Characterization of Oil and Litter

Oil and Grease

The amount of oil in the devices was measured using oil-only absorbents. This material absorbs and retains oil and oil-based liquids including lubricants, fuels, and cleaning agents. Each skimmer is designed to absorb 1.8 gallons of oil without absorbing water. The weight of oil in each device compared to previous results is shown in Figure 4. The 2011 cleanout date for RU04-02 device was not reported to Rutgers University. The sediment samples and floatables were collected by the contractor. However, the oil was not collected immediately prior to cleanout.

During both cleanout years, a larger amount of oil was observed at sites with higher commercial and industrial activity (i.e. RU06-01: North Bergen and RU14-01: Parsippany).

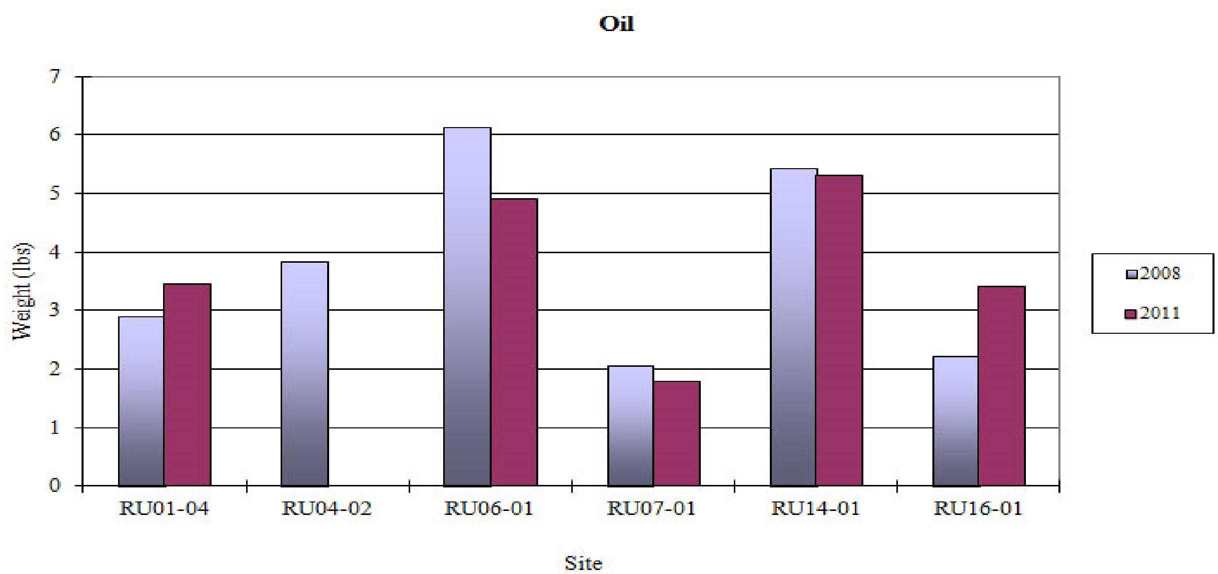


Figure 4. Comparison of weight of oil trapped in device from 2008 to 2011 (grit and floatables chambers)

Floatables

Immediately before the cleanout, floatable litter and organic debris were skimmed off the water surface. As a result, the sediment sampled and analyzed did not contain floatable litter. Collected floatables from each site were air dried, sorted and weighed in the laboratory. The most common types of floatables found were plastic, Styrofoam, and organic debris. The characterization study showed that Styrofoam constituted over 50 percent by volume while plastics constituted over 40 percent by weight of the floatable litter.

During the first cleanout in 2008, a large amount of Styrofoam was found at the device (Figure 5a). Most of those floatables were Styrofoam peanuts and Styrofoam boards usually used for packing. It was suspected that those materials had not come from roadway runoff but rather from activities not related to traffic or normal debris carried by storm runoff. During the second cleanout in 2011, however, RU14-01 still contained a large amount of Styrofoam (Figure 5b). The Styrofoam litter observed in 2011 consisted mostly of beverage cups, dishes, and packing peanuts, but no large Styrofoam boards were found like in 2008.

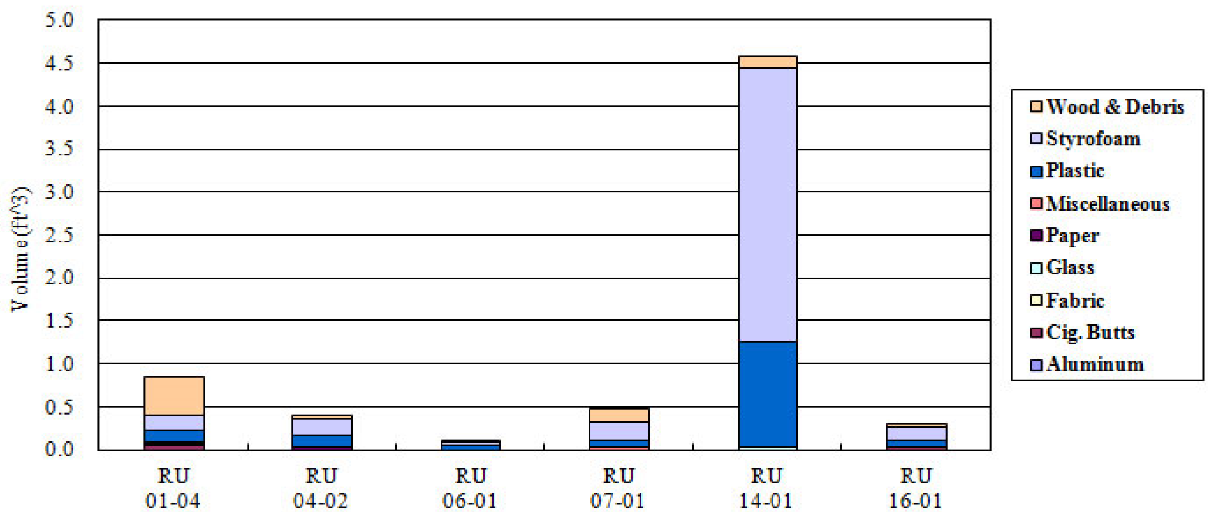


Figure 5. Volume and type of floatables trapped (2008)

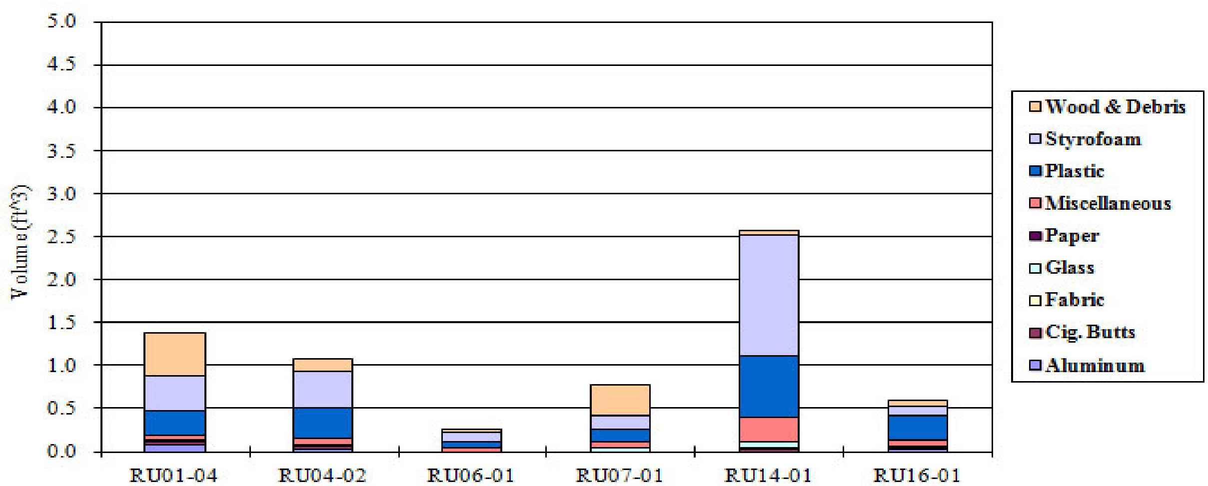


Figure 6. Volume and type of floatables trapped (2011)

F. Sediment Sample Analysis

<u>Sediment Particle Size Distribution Using Sieve Analysis</u>

The device is designed to remove litter and large particles from stormwater runoff. A sieve analysis was performed using standard procedures with five sieve sizes. The sieves used ranged from the #4 to the #200 sieve sizes. A #4 sieve (4.75 mm) was used to separate coarser material such as leaves, litter and debris from the sediment. Once the larger debris was sifted out, the Particle Size Distribution (PSD) analysis was conducted. The percentage of particles larger than 4.75 mm in the sediment samples is shown in Figure 7.

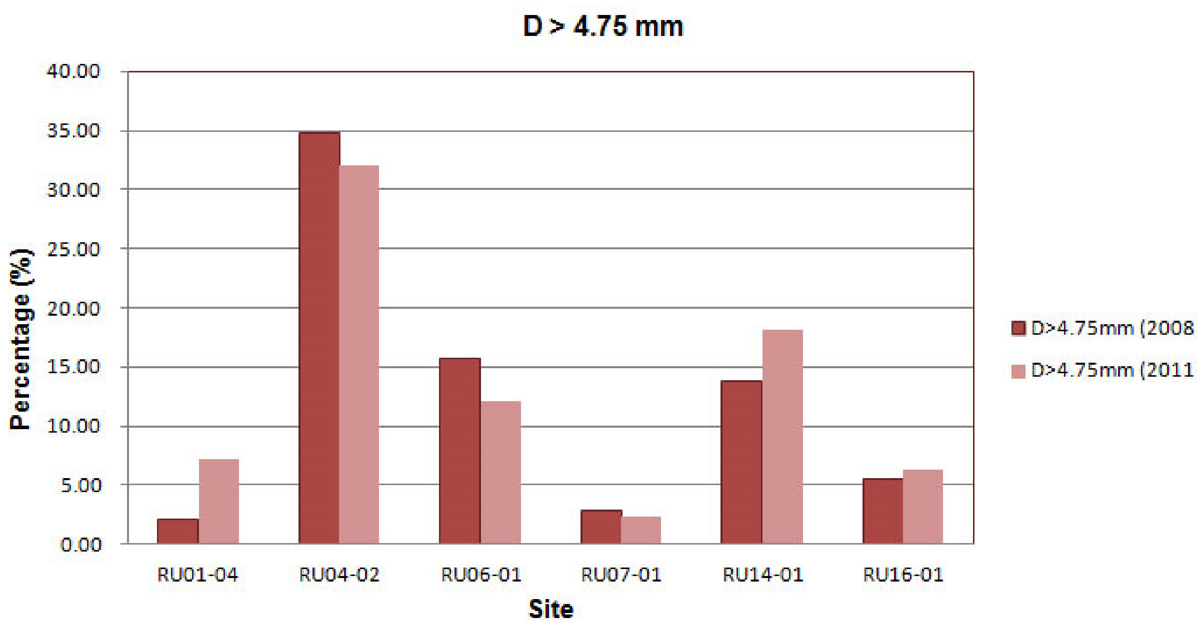


Figure 7. Comparison of particles larger than 4.75 mm

This monitoring guideline is designed for devices that primarily collect particles larger than 75 microns (0.075 mm). The sediment samples tested in this study contained 13 percent of particles larger than 4.75 mm and 7 percent of particles smaller than 75 microns by weight on average. In the previous study in 2008, 12 percent of particles by weight on average were larger than 4.75 mm and 11 percent was smaller than 75 microns found from the same 6 devices.

Chemical Analysis of Sediment Samples

Sample sediment was collected halfway through the cleanout operation. These sediment samples were sent to a laboratory for analysis. The results were similar to those from the previous study conducted in 2008. The sediment samples were tested for Arsenic, Cadmium, Copper, and Zinc. All the tested sediments had concentrations below regulated levels of Arsenic, Cadmium, Copper, and Zinc. Lead concentration at the RU06-01 device located in North Bergen, NJ was higher than the residential soil quality. The lead concentration of the sediment at RU06-01 was 419 mg/kg while the residential soil quality standard should be below 400 mg/kg. Total Kjeldahl Nitrogen and Total Phosphorus concentrations were higher in the tested sediments than the non-residential (pine barren) soil quality. Nitrogen and phosphorus are not considered toxic at these concentrations, but can cause disruptions to aquatic ecosystems.

Arsenic: The highest concentration of arsenic found was 9.37 mg/kg at RU07-01 (Figure 8). Arsenic concentration in all devices was lower than the standard median concentration for residential and non-residential soil quality (20 mg/kg).

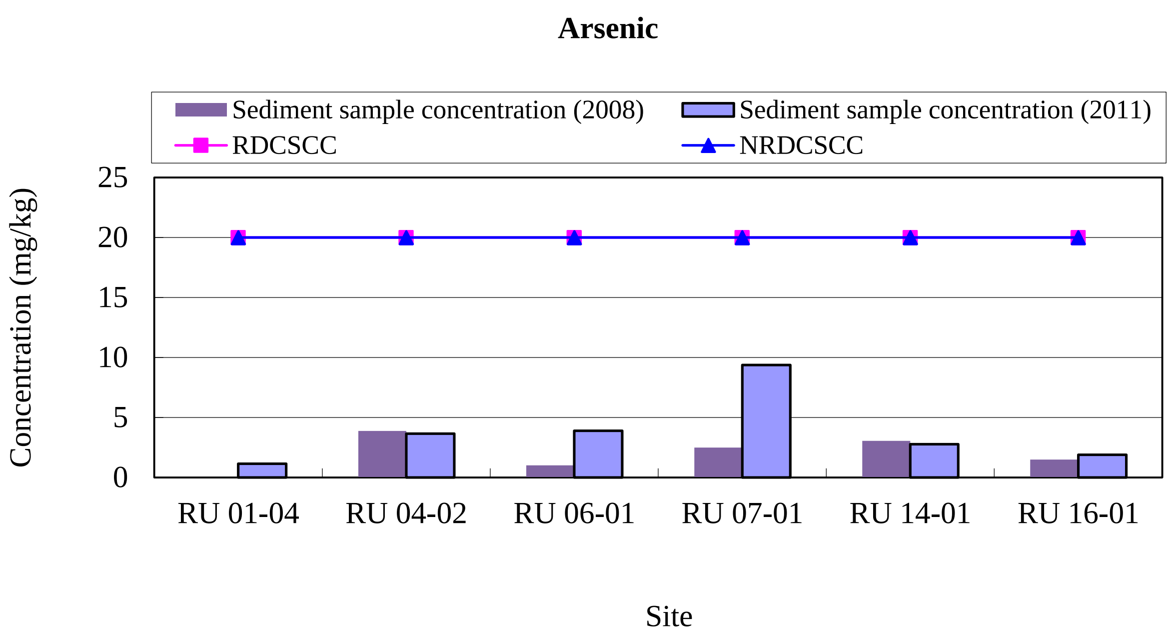


Figure 8. Comparison of arsenic concentration in sediment samples taken in 2008 and in 2011. (Residential direct contact soil criteria (RDCSCC) and non-residential direct contact soil cleanup criteria (NRDCSCC) are shown as reference.)

Copper: Copper concentration in the six devices sampled for this study ranged from 8.9 to 229 mg/kg (Figure 9). Measured copper concentration in all sediments tested was lower than the standard median concentration for residential and non-residential soil quality (600 mg/kg).

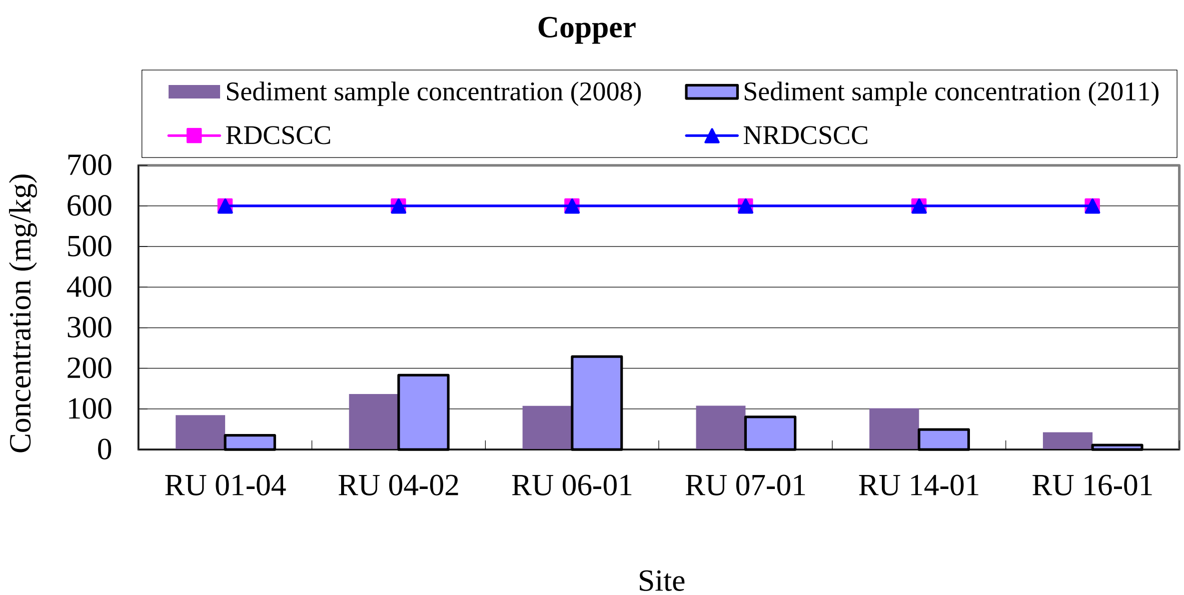


Figure 9. Comparison of copper concentration in sediment samples taken in 2008 and in 2011. RDCSCC and NRDCSCC are shown as reference.

Lead: Lead concentration was lower than the standard median concentration for residential soil quality (400 mg/kg) and non-residential soil quality (600 mg/kg) in all devices except RU06-01 (Figure 10). Lead concentration at RU06-01, located in North Bergen, was 419 mg/kg which exceeds the residential soil quality standard.

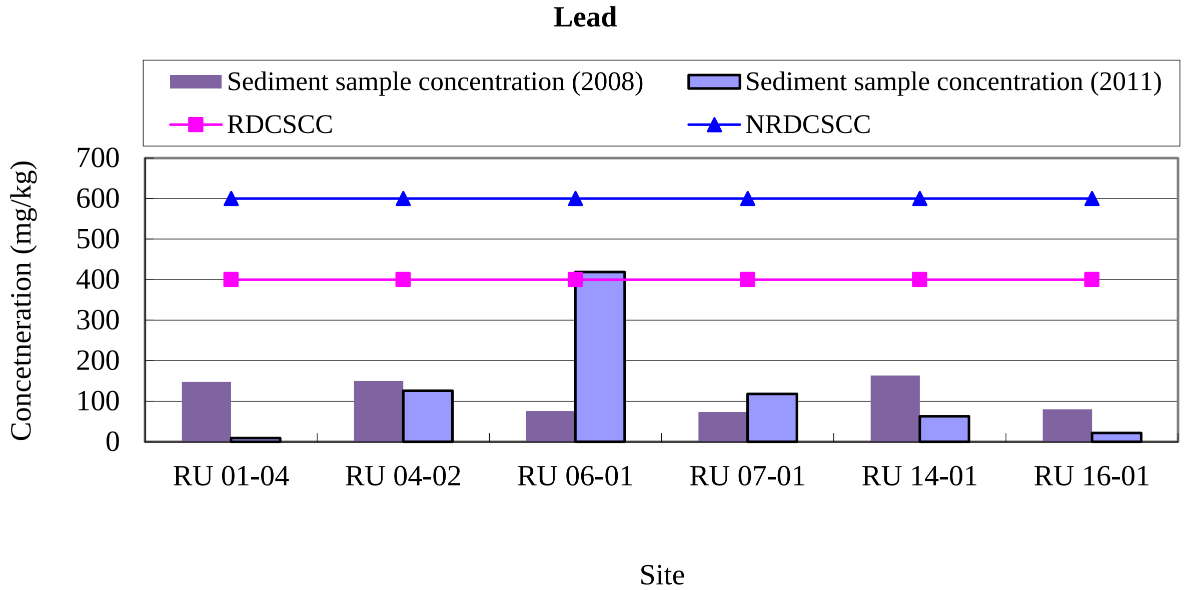


Figure 10. Comparison of lead concentration in sediment samples taken in 2008 and in 2011. RDCSCC and NRDCSCC are shown as reference.

Zinc: Zinc concentration for the six devices ranged from 24.8 to 769 mg/kg for this study (Figure 11). Zinc concentration was lower than the median standard concentrations for residential and non-residential soil quality (1500 mg/kg) in all devices.

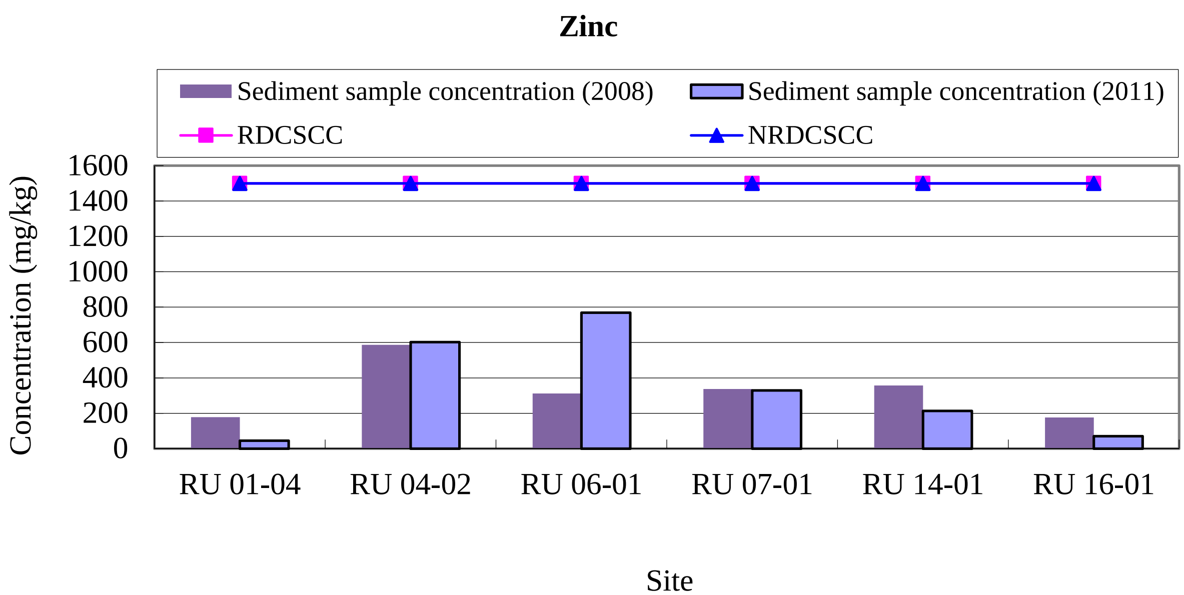


Figure 11. Comparison of zinc concentration in sediment samples taken in 2008 and 2011. RDCSCC and NRDCSCC are shown as reference.

Cadmium: Small concentrations of Cadmium were detected at three urban sites: RU04-2 (0.263 mg/kg), RU06-1(0.524 mg/kg) and RU14-1(0.105 mg/kg) (Figure 12). Cadmium was not detected at the other three sites. In the study conducted in 2008, a small concentration of Cadmium had been detected at these same sites and at the RU01-04 site. However, in all cases, the concentration was well below the acceptable standards.

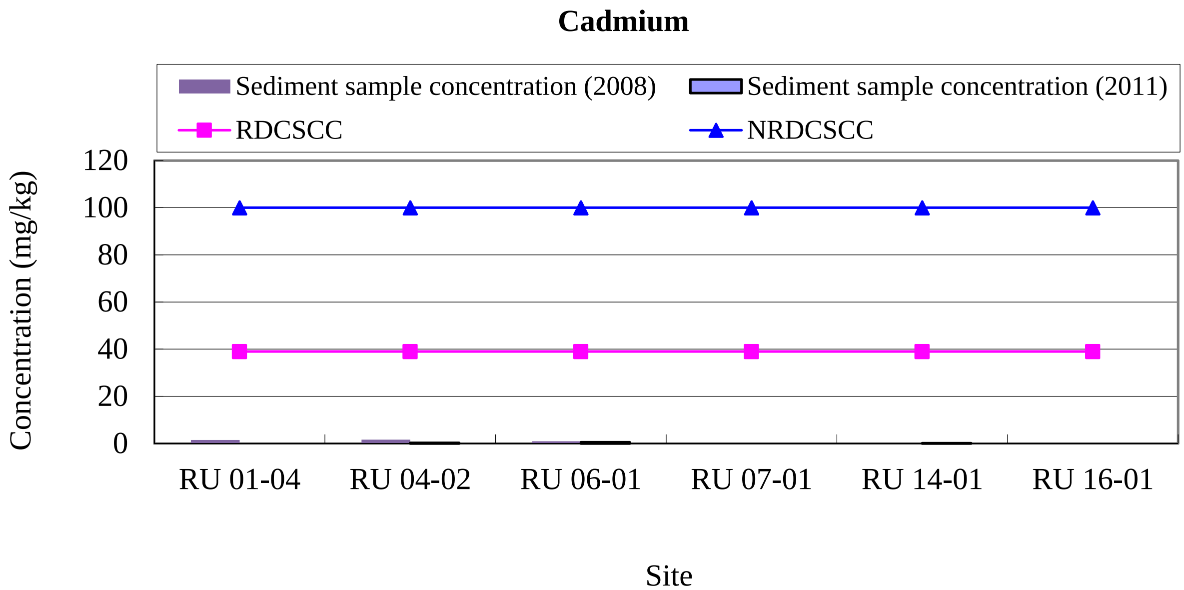


Figure 12. Comparison of cadmium concentration in sediment samples taken in 2008 and 2011. RDCSCC and NRDCSCC are shown as reference.

Total Phosphorus (TP): Total phosphorus concentration measure for the six devices ranged from 79 to 743 mg/L (Figure 13). The highest concentration was detected at RU04-02 located in Elizabeth. Total Phosphorus concentration in all devices exceeded the concentration of pine barren (forest) soil (94 mg/kg) taken from Rutgers pinelands field station.

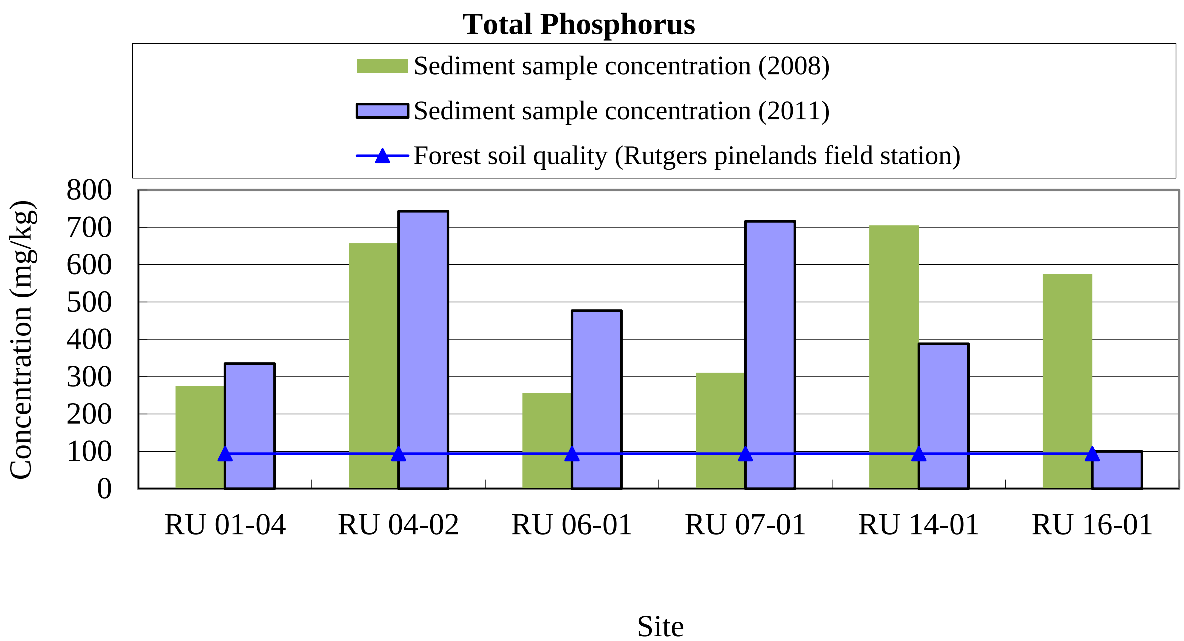


Figure 13. Comparison of total phosphorus concentration in sediment samples taken in 2008 and in 2011. Forest (pine barren) soil quality from Rutgers pinelands field station is shown as reference.

Total Kjeldahl Nitrogen (TKN): TKN concentration for the six devices ranged from 91 to 1340 mg/kg (Figure 14). TKN concentration in all devices exceeded the concentration of forest (pine barren) soil (219 mg/kg) taken from Rutgers pinelands field station.

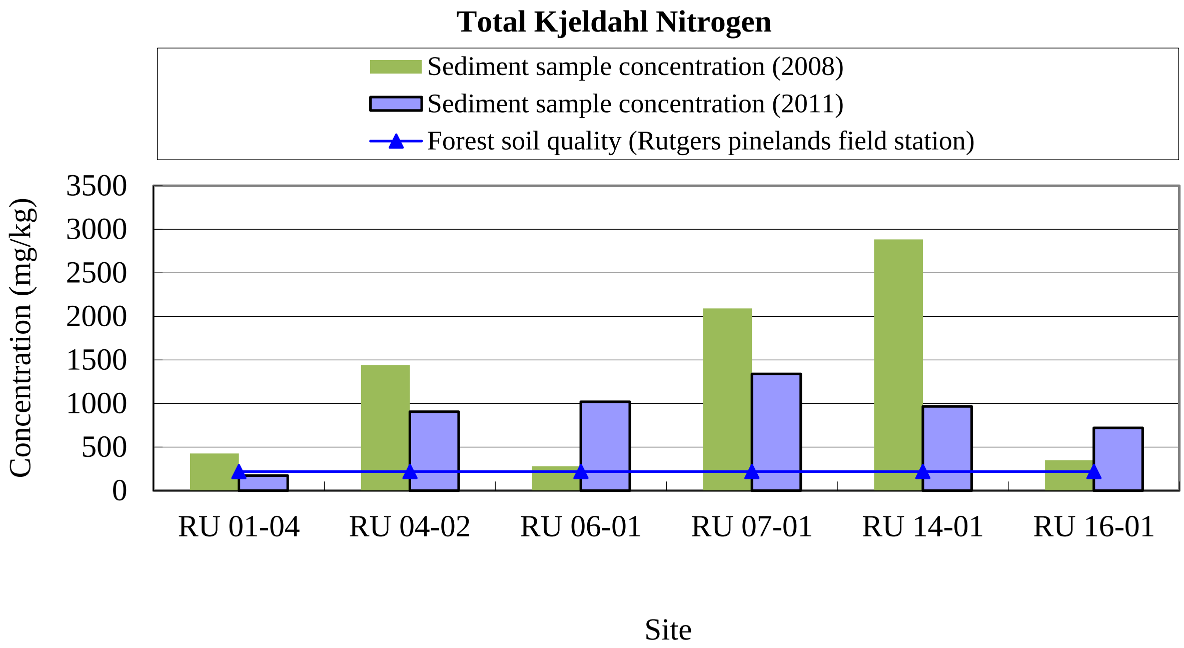


Figure 14. Comparison of total Kjeldahl nitrogen concentration in sediment samples taken in 2008 and in 2011. Forest soil quality from Rutgers pinelands field station is shown as reference.

Percent Organic Matter of Sediment

A common organic content analysis method is the loss-on-ignition (LOI) method. The LOI method is carried out at high temperatures. For this study, ASTM D2974 Method C was used. ASTM D2974 uses ash burning at 440 degrees Celsius. A concern with the LOI method is the possibility that inorganic constituents of the soil may lose structural water and carbonate minerals. Additionally, hydrated slats can be decomposed upon heating (Nelson and Sommers, 1996).

The organic content of the sediments ranged from 3.3 % to 28.1 % in 2011. The highest was 28.7% (2011) and 24.3% (2008) from site RU07-01, located in an open/suburban area (Table 5 and Figure 15).

Table 5 - Measurement of organic content in bottom sediments (2011)

ID	Weight of aluminum pan (mg)	Weight of residue + pan before ignition (mg)	Weight of residue + pan after ignition (mg)	Organic content(%)
RU01-04	15.51	221.53	180.51	18.5
RU04-02	14.01	233.11	215.50	7.6
RU06-01	14.40	155.41	151.21	3.3
RU07-01	15.02	215.36	150.92	28.1
RU14-01	15.30	153.13	146.55	4.3
RU16-01	14.90	243.43	192.12	21.1

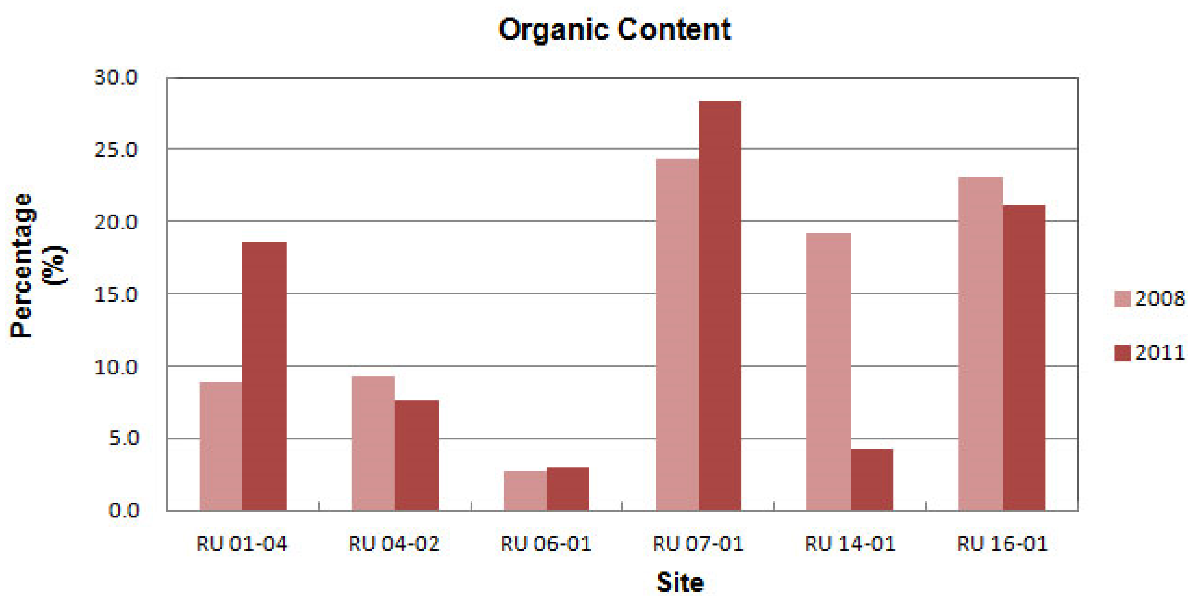


Figure 15. Organic content of bottom sediments

II. Selection, Cleanout and Material Characterization of Two Additional Types of Devices

In 2007, twelve (12) devices were chosen for cleanout and subsequent monitoring. All of those twelve devices were Vortechs MTDs, including the six chosen for second cleanout in 2011 as described in the previous section. In order to propose general evaluation and maintenance guidelines for MTDs, it is necessary to conduct research and monitoring of other types of MTDs as well.

Seven (7) types of MTDs have been installed in NJDOT projects. From the seven types of devices, the Aqua-Swirl and the Downstream Defender (Table 6) were chosen as the most suitable for further study. One Aqua-Swirl device and one Downstream Defender device were chosen for monitoring. This brings the total of devices chosen for extensive monitoring to fourteen (12 Vortechs, 1 Aqua-Swirl, 1 Downstream Defender).

Table 6 - Devices added to the monitoring list

RU ID: RU15-01
Model: Downstream Defender (DD 10) Project Name: RT 4 (1953) SEC 1L & 2W - RT 208 (1953) SEC 3T DOT Project #: UPC# 960690 Municipality: Fair Lawn County: Bergen Plan Approval Date: 7/11/2000 Dlvry/Ship/Inv. From vendors: N/A Sediment Depth: 4.5 ft (6/01/2010)
RU ID: RU18-01
Model: Aqua-Swirl (AS-7) Project Name: Route 33 over Conrail Bridge Elimination of Structure No. 1113-150 DOT Project #: 007950309 Municipality: Robbinsville County: Mercer Plan Approval Date: 4/7/2008 Dlvry/Ship/Inv. From vendors: 2007 -2009 Sediment Depth: 3.8 ft (5/11/2010)

A. Reasoning for additional device selection

CDS

CDS is manufactured by the same company (Contech) as Vortechs. Since the 12 devices being monitored so far were Vortechs, this type of device was placed at the lower priority for additional monitoring.

Aqua-Swirl

Sixteen (16) Aqua-Swirl devices were listed as being under NJDOT jurisdiction. However, 15 of these devices were under construction or installed at sites still under construction site at the time of starting the study. Only one device, located at Route 130 / Route 33 in Robbinsville, was available for inspecting and monitoring. The device is located on the median of the road. The width of the road at this point, including shoulders, is only 20 feet. Truck Mounted Attenuators (TMA) and traffic blockage will be required to perform cleanout.

Downstream Defender

Four (4) Downstream Defender devices were identified on a NJDOT project. After weighing safety and accessibility considerations, RU15-01 was selected as the most appropriate device for inspection and cleanout.

Stormceptor

There are 12 Stormceptor devices on the NJDOT project list. However, all the devices listed are an old model type (STC model). Devices of this type were placed at the lower priority for additional monitoring.

Terre Kleen

Two (2) Terre Kleen devices were identified to be under NJDOT jurisdiction. Both of these devices have a manhole located in the middle of road. These conditions pose a safety hazard and accessibility problems for inspection and cleanout.

VortSentry

VortSentry is manufactured by the same company (Contech) as Vortechs. Since the 12 devices being monitored so far were Vortechs, this type of device was placed at the lower priority for additional monitoring.

B. Specific cleanout procedure for the two additional devices

RU15-01: The cleanout operation was completed using the standard procedure.(Date: 06/01/2011). During inspection immediately after cleanout, a damaged coupler connecting the stub to the drainage pipe was found.

RU18-01: The cleanout operation was completed using the standard procedure (Date: 06/01/2011). Construction debris was found during the cleanout operation. It is suspected that this construction debris might have come from the device installation or other conditions that are not expected during normal operation.

C. Specific observations from inspection of the two additional devices

RU15-01

There was not enough water to skim off floatables. Inspection immediately after cleanout revealed a damaged coupler connecting the stub to the drainage pipe. Due to the gap in the coupler, smaller floatables were not being retained in the floatables chamber. The coupler was repaired to avoid having smaller floatables bypassing the device.

Figure 16. Damaged coupler connecting the device

RU18-01

During the cleanout operation, construction debris was found inside the device. The debris found included part of a manhole lid. It is suspected that this debris might have detached during installation. The debris was determined not to be from roadway runoff.

Figure 17. Construction debris found inside the Device

D. Device Inspection Forms

Inspection Forms and Data

Downstream Defender® MTD Inspection Form

MTD ID	MTD_Inspection_Rec_ID	Weather*	Air Temp. (^oF)
RU15-01		Sunny	78 °

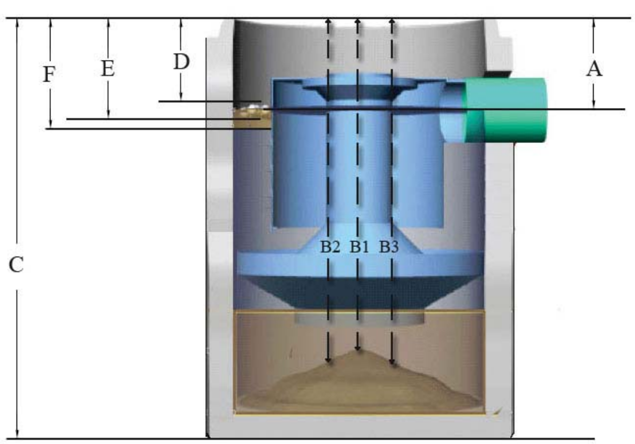
Inspection Date	Inspection Time		Purpose of Inspection	Inspector
	Start	End		
06-01-2011	07:30	08:00	Routine Inspection ( ) Inspection Immediately before Cleanout (v) Inspection Immediately after Cleanout (v) Other ( )	Junghoon Kim

Inspection Cost	Last Inspection Date	Inspection Interval (months)	Projected Next Inspection Date	Recent Precipitation Event	
				Date	Depth (in)
	12-07-2010	3	09-01-2011	04-16-2011	2.17

* Weather: Sunny, Windy, Cloudy, Rainy, Stormy, Blizzard

Measurements from Ground above the Device (Routine Inspection or Inspection Immediately before Cleanout)

Schematic for Measurements: Downstream Defender®



A: Distance from Water / Oil Surface to Top of Manhole Rim

B1: Distance from Center of Sediment Surface to Top of Manhole Rim

B2: Distance from Intermediate Location of Sediment Surface to Top of Manhole Rim

B3: Distance from Intermediate Location of Sediment Surface to Top of Manhole Rim

C: Distance from Bottom to Top of Manhole Rim

D: Distance from Trash/Debris Surface to Top of Manhole Rim

E: Distance from Trash/Debris Bottom to Top of Manhole Rim

F: Distance from Bottom of Oil Layer to Top of Manhole Rim

A (ft)	8.4	Trash/Debris Area Coverage (%)	99%
B1 (ft)	12	D (ft)	12
B2 (ft)	12	E (ft)	12
B3 (ft)	12	Oil Area Coverage (%)	N/A
C (ft)	16.5	F (ft)	12

Observations of Device and Surrounding Drainage Area Characteristics (Routine Inspection or Inspection Immediately before Cleanout)

Traffic Density	Gross Solids - Litter	Gross Solids – Debris	Gross Solids – Coarse Sediment
(Low, Medium, Heavy)	(Small, Medium, Large)	(Small, Medium, Large)	(Small, Medium, Large)

Any Soil Erosion and Sediment Deposition in Watershed?	If Severe, Location(s) of Erosion and Deposition in Watershed
(Low, Moderate, Severe)	

Construction Activities in Watershed?	If Yes, Condition of Source Control Management Practices	If Poor, Location of Source Control Management Practices	If Poor, Describe Condition of Source Control Management Practices
(Yes / No)	(Good, Moderate, Poor)		

Winter Sanding Operation?	Space Available for Cleanout Activities without Traffic Blockage?
(Yes / No)	(Yes / No)

Insects (Mosquitoes, Larvae, etc…) in MTD?	Vegetation Growth in MTD?	Any Blockage to Flow Path in MTD?	If Yes, Name Location of the Blockage
(Yes / No)	(Yes / No)	(Yes / No)	

Any Blockage in Inlet, Manhole, Catch Basin, or Pipe Upstream and Downstream of the Device?	Location of Blockage	Type of Solids in Inlet, Manhole, Catch Basin or Pipe
(Yes / No)		(Gravel, Sand, Silt, Clay, Mud, Debris, Litter)
Dry Weather Flow in inlet pipe and outlet Pipe?	Backwater to outlet pipe from downstream?	Blockage at Outfall?
(Yes / No)	(Yes / No)	(Yes / No)

Outfall Structure					
Sediment discharged from MTD?	(Yes / No)	Trash/Debris discharged from MTD?	(Yes / No)	Oil Spill Out from MTD?	(Yes / No)

Device Structural Inspection - Visual Observation from Ground above the Device (Routine Inspection or Inspection Immediately before Cleanout)

Damage to Manhole Cover(s)	(No, Minor, Serious)	Description of Damage	
Damage to Side Walls	(No, Minor, Serious)	Description of Damage	
Damage to Dip Plate, Floatables Lid, Center Shaft and Cone or Benching Skirt	(No, Minor, Serious)	Description of Damage	
Damage to Inlet Pipe	(No, Minor, Serious)	Description of Damage	
Damage to Outlet Pipe	(No, Minor, Serious)	Description of Damage	

Photos Taken during Routine Inspection or Inspection Immediately before Cleanout

Photo 1	Photo 2	Photo 3
		

Additional Comments from Routine Inspection or Inspection Immediately before Cleanout

Device Structural Inspection – Visual Observation and Physical Testing from Inside of the Device (Inspection Immediately after Cleanout)

Damage to Side Walls, Ceiling or Bottom	(No, Minor, Serious)	Description of Damage	
Damage to Dip Plate, Floatables Lid, Center Shaft and Cone or Benching Skirt	(No, Minor, Serious)	Description of Damage	Damaged the coupler connecting the device's stub to the drainage pipe.
Damage to Inlet Pipe	(No, Minor, Serious)	Description of Damage	
Damage to Outlet Pipe	(No, Minor, Serious)	Description of Damage	

Photo Taken During Structural Inspection Immediately after Cleanout

Photo 1	Photo 2	Photo 3
		

Additional Comments from Structural Inspection Immediately after Cleanout

Damaged coupler connecting the device to the drainage pipe.

Calculation and Decision for Cleanout based on Measurements

Water Depth **(ft)**		Sediment Depth **(ft)**	
	3.6		4.5
Device Cleanout Trigger: Sediment Depth **(ft)**		Cleanout Necessary Based on the Measured Sediment Depth?	Yes or No
Device Cleanout Trigger: Trash/Debris Thickness **(ft)**		Cleanout Necessary Based on the Measured Trash/Debris Thickness?	Yes or No
Device Cleanout Trigger: Trash/Debris Areal Coverage **(%)**		Cleanout Necessary Based on the Measured Trash/Debris Areal Coverage?	Yes or No
Device Cleanout Trigger: Oil Thickness **(ft)**		Cleanout Necessary Based on the Measured Oil Thickness?	Yes or No
Device Cleanout Trigger: Oil Areal Coverage **(%)**		Cleanout Necessary Based on the Measured Oil Areal Coverage?	Yes or No

Aqua-Swirl® MTD Inspection Form

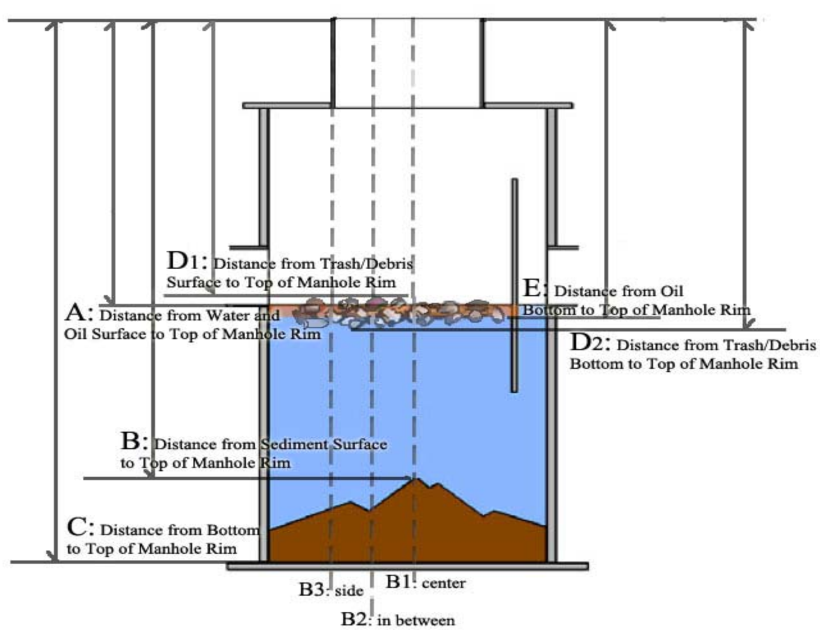
MTD ID	MTD_Inspection_Rec_ID	Weather	Air Temp. (ºF)
RU18-01	N/A	Sunny	70 º

Inspection Date	Inspection Time		Purpose of Inspection	Inspector
	Start	End		
05-11-2011	11:00	11:30	Routine Inspection ( ) Inspection Immediately before Cleanout (v) Inspection Immediately after Cleanout (v) Other ( )	Junghoon Kim

Inspection Cost	Last Inspection Date	Inspection Interval (months)	Projected Next Inspection Date	Recent Precipitation Event	
				Date	Depth (in)
	08-16-2010	3	08-11-2011	04-16-2011	2.7

Measurements from Ground above the Device (Routine Inspection or Inspection Immediately before Cleanout)

Schematic for Measurements: Aqua-Swirl®



Swirl Chamber				
A (ft)	B (ft)			C (ft)
7	B1 [Center]	B2 [In Between]	B3 [Side]	12.3
	8.5	8.5	8.4	

Trash/Debris Area Coverage (%)	D1(ft)	D2(ft)	Oil Area Coverage(%)	E(ft)
30	7	7	10	7

Observations of Device and Surrounding Drainage Area Characteristics

Traffic Density	Gross Solids - Litter	Gross Solids – Debris	Gross Solids – Coarse Sediment
Medium	Medium	Medium	Small

Observations of Device and Surrounding Drainage Area Characteristics (Routine Inspection or Inspection Immediately before Cleanout)

Traffic Density	Gross Solids - Litter	Gross Solids – Debris	Gross Solids – Coarse Sediment
(Low, Medium, Heavy)	(Small, Medium, Large)	(Small, Medium, Large)	(Small, Medium, Large)

Any Soil Erosion and Sediment Deposition in Watershed?	If Severe, Location(s) of Erosion and Deposition in Watershed
(Low, Moderate, Severe)	

Construction Activities in Watershed?	If Yes, Condition of Source Control Management Practices	If Poor, Location of Source Control Management Practices	If Poor, Describe Condition of Source Control Management Practices
(Yes / No)	(Good, Moderate, Poor)		

Winter Sanding Operation?	Space Available for Cleanout Activities without Traffic Blockage?
(Yes / No)	(Yes / No)

Insects (Mosquitoes, Larvae, etc…) in MTD?	Vegetation Growth in MTD?	Any Blockage to Flow Path in MTD?	If Yes, Name Location of the Blockage
(Yes / No)	(Yes / No)	(Yes / No)	

Any Blockage in Inlet, Manhole, Catch Basin, or Pipe Upstream and Downstream of the Device?	Location of Blockage	Type of Solids in Inlet, Manhole, Catch Basin or Pipe
(Yes / No)		(Gravel, Sand, Silt, Clay, Mud, Debris, Litter)
Dry Weather Flow in inlet pipe and outlet Pipe?	Backwater to outlet pipe from downstream?	Blockage at Outfall?
(Yes / No)	(Yes / No)	(Yes / No)

Outfall Structure					
Sediment discharged from MTD?	(Yes / No)	Trash/Debris discharged from MTD?	(Yes / No)	Oil Spill Out from MTD?	(Yes / No)

Device Structural Inspection - Visual Observation from Ground above the Device (Routine Inspection or Inspection Immediately before Cleanout)

Damage to Manhole Cover(s)	(No, Minor, Serious)	Description of Damage	
Damage to Side Walls	(No, Minor, Serious)	Description of Damage	
Damage to Arched Baffle	(No, Minor, Serious)	Description of Damage	
Damage to Inlet Pipe	(No, Minor, Serious)	Description of Damage	
Damage to Outlet Pipe	(No, Minor, Serious)	Description of Damage	

Photos Taken during Routine Inspection or Inspection Immediately before Cleanout

Photo 1	Photo 2	Photo 3
		

Additional Comments from Routine Inspection or Inspection Immediately before Cleanout

The device is located on the median. The median width, including shoulders is 20 ft., TMAs (Truck Mounted Attenuators) will be required for cleanout.

Device Structural Inspection – Visual Observation and Physical Testing Inside the Device (Inspection Immediately after Cleanout)

Damage to Side Walls, Ceiling or Bottom	(No, Minor, Serious)	Description of Damage	
Damage to Arched Baffle	(No, Minor, Serious)	Description of Damage	
Damage to Inlet Pipe	(No, Minor, Serious)	Description of Damage	
Damage to Outlet Pipe	(No, Minor, Serious)	Description of Damage	

Photo Taken During Structural Inspection Immediately after Cleanout

Photo 1	Photo 2	Photo 3
		

Additional Comments from Structural Inspection Immediately after Cleanout

Construction debris was found. The debris does not seem to have been originated from roadway runoff.

Calculation and Decision for Cleanout based on Measurements

Water Depth **(ft)**		Sediment Depth **(ft)**	
1.5		3.8	
Device Cleanout Trigger: Sediment Depth **(ft)**		Cleanout Necessary Based on the Measured Sediment Depth?	Yes or No
Device Cleanout Trigger: Trash/Debris Thickness **(ft)**		Cleanout Necessary Based on the Measured Trash/Debris Thickness?	Yes or No
Device Cleanout Trigger: Trash/Debris Areal Coverage **(%)**		Cleanout Necessary Based on the Measured Trash/Debris Area Coverage?	Yes or No
Device Cleanout Trigger: Oil Thickness **(ft)**		Cleanout Necessary Based on the Measured Oil Thickness?	Yes or No
Device Cleanout Trigger: Oil Areal Coverage **(%)**		Cleanout Necessary Based on the Measured Oil Area Coverage?	Yes or No

E. Post-Cleanout Monitoring

The monitoring program began once the device was cleaned out and field monitoring was performed every three months thereafter. The first inspection was in September of 2011 when a very thin layer of sediment was measured. The main purpose of the inspection was to measure the sediment depth, amount of floatables, and retained oil in the device.

RU15-01

Three months after cleanout, a very thin layer (less than 3 inches) of sediment was measured (09/18/2011). Nine months after cleanout, the depth of accumulated sediment was between 2 and 3 inches (Table 7). Since the device is installed deep underground and due to its particular design, floatables and oil sheen were difficult to observe.

Table 7 - Monitored accumulated sediment in Aqua-Swirl® unit (RU15-01)

Monitoring Date	09/18/2011	12/26/2011	03/27/2012
Sediment Depth (in)	2.4	2.76	3

RU18-01

Four months after cleanout, a very thin layer of sediment was measured but it only covered half of the bottom area adjacent to the swirl chamber inlet. The depth of accumulated sediment was 3 inches at the highest point. .After seven months, sediment covered the entire bottom of the swirl chamber. Ten months after cleanout, the average sediment depth was 3.6 inches feet and floatables covered about 25% of the water surface (Table 8). Oil sheen was observed every time.

Table 8 - Accumulated sediment, floatables and oil
in Downstream Defender® unit (RU18-01)

Monitoring Date	09/27/2011	12/27/2011	03/20/2012
Sediment Depth (in)	3	3.36	3.6
Covered Area of Floatables	10%	25%	33%
Oil Level	Some oil sheen	Some oil sheen	Some oil sheen

F. Characterization of Oil and Floatables

Oil and Grease

The amount of oil in the devices was measured using oil-only absorbents. 1.8 pounds of oil were measured at RU15-01 and 3.4 pounds at RU18-01. However, due to the dry condition of RU15-01 and to a large amount of litter, oil absorbents could not be placed correctly to cover the whole area. The reported value might be lower than the actual oil content in the device.

Floatables

In RU15-01 (Downstream Defender), most floatables were comprised of plastic (Table 9), and they were difficult to skim off due to the dry condition and design of the device. In RU18-01 (Aqua-Swirl), most floatables were comprised of Styrofoam products (Table 9).

Table 9 - Types and amount of litter collected (ft^3)

	Aluminium	Cigarette Butts	Fabric	Glass	Paper	Misc	Plastic	Styrofoam	Wood & Debris
RU15-01	0.11	0.07	0.04	0.18	ND	0.18	1.24	0.5	0.18
RU18-01	ND	0.04	ND	0.07	0.018	0.07	0.18	0.53	0.28

G. Sediment Sample Analysis

Sediment Particle Size Using Sieve Analysis

MTDs are designed to remove litter and large sized particles from stormwater. 20% of sediment from RU15-01 and 5% of sediment from RU18-01 were found to be larger than 4.75 mm. 3% of sediment from RU15-01 and 6% of sediment from RU18-01 were found to be smaller than 75 microns.

Chemical Analysis for Sediment Samples

The results of the analysis concluded that concentrations of Arsenic, Cadmium, Copper, Lead and Zinc were well below the regulated levels (Table 10). The Total Kjeldahl Nitrogen and Total Phosphorus concentrations were compared to forest (pine barren) soil quality from Rutgers pinelands field station data (Tuininga et al. 2002). The Total Kjeldahl Nitrogen and Total Phosphorus concentrations (Table 10) found in the sediment samples were higher than those for forest (pine barren) soil quality.

Table 10 - Chemical analysis for sediment samples (mg/kg)

	Arsenic	Copper	Lead	Zinc	Cadmium	TKN	TP
RU15-01	1.96	50.00	30.75	99.95	ND	118.5	146.5
RU18-01	1.41	8.94	9.26	24.80	ND	91.0	39.5

Percent Organic Matter of Sediment

The organic content of the sediments was 8.6% for RU15-01 (located in an urban area) and, 17.2 % for RU 18-01 (located in a suburban area).

Table 11 - Measurement of organic content in bottom sediments

ID	Weight of aluminum pan (mg)	Weight of residue + pan before ignition (mg)	Weight of residue + pan after ignition (mg)	Organic content(%)
RU15-01	15.01	210.00	191.98	8.6
RU18-01	13.46	205.13	170.01	17.2

REFERENCES

1. *New Jersey Stormwater Best Management Practices Manual*. New Jersey Department of Environmental Protection, Division of Watershed Management, April 2004 (revised September 2009). Available at: http://www.njstormwater.org/bmp_manual2.htm

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Appendix A-I: MTD Location Table

The Excel spreadsheet is included in the CD-ROM.

Appendix A-II: MTD Location Maps

The image files are included in the CD-ROM.