

EAST OF HUDSON
WATERSHED CORPORATION



Stormwater Retrofit Project

Design Manual

Project Years 6-10

Table of Contents

1.0	Design Standards	3
1.1	Water Quality Volume and Retrofit Sizing	3
1.2	Phosphorus Loading and Reduction Calculations	3
1.3	Channel Stabilization	6
1.4	Acceptable Variances from the SMDM	7
2.0	Standard Services & Deliverables	8
2.1	List of Deliverables	8
2.2	Detailed Project Schedule	8
2.3	Survey	10
2.4	Field Investigation	10
2.5	Design Submittals	11
2.5.1	30% Engineering Design with Alternatives	11
2.5.2	60% Engineering Design	12
2.5.3	100% Engineering Design & Draft Contract Documents	13
2.5.4	Final Contract Documents & Operation and Maintenance Documents	14
2.5.5	Easement Documents	14
2.5.6	Construction Phase Services (CPS)	14
2.5.7	Record Documents	15

Appendix A - The BANCS Model to Predict Streambank Erosion

1.0 DESIGN STANDARDS

1.1 Water Quality Volume and Retrofit Sizing

Stormwater Retrofit Projects (SRP) shall be designed to comply with the New York State Department of Environmental Conservation (NYSDEC) Stormwater Management Design Manual (SMDM) most recent edition, except as set forth in Section 1.3 below. The SRP's shall be designed to treat runoff from the 90th percentile design storm and not the 1-year, 24-hour design storm that is required by Chapter 10 of the SMDM.

The following precipitation intensities correspond to the 90th percentile rainfall event:

Table 1: 90th Percentile Rainfall Event Number (P)

County	P (in)
Dutchess	1.2
Putnam	1.2
Westchester	1.3

SRP's shall be designed as off-line practices, diverting the water quality volume to the proposed SRP and the water quantity storms (e.g. 10 and 100 year design storms) to bypass the SRP. All designs shall demonstrate sufficient capacity of the proposed drainage structures to convey runoff associated with the water quantity storms, or at a minimum match the capacity of the existing stormwater drainage system into which the proposed retrofit discharges.

Hydraulic calculations shall be prepared for each proposed stormwater retrofit. Calculations shall be based on TR-20 and TR-55 methods as provided by the United States Department of Agriculture (USDA), most recent edition. The calculations shall be provided to EOHWC with the design plans for review and approval.

1.2 Phosphorus Loading and Reduction Calculations

The Engineer shall calculate phosphorus loading and reduction estimates for each SRP. The phosphorus loading and reduction estimates shall be prepared using the Simple Method (SM), incorporating the loading coefficient ("C") values provided in Table 2 for various types of land use and the SRP removal efficiency values applicable to the East of Hudson Watershed. The design of each SRP shall maximize the phosphorus reduction that may be achieved by the proposed retrofit method.

Simple Method: $L = 0.103(R)(C)(A)$

Where:

- L = Annual load (kg/yr)
- R = Annual Runoff (inches)
- C = Pollutant Concentration (mg/l)
- A = Contributing Area (acres)
- 0.103 = Unit Conversion factor

And where:

- $R = (P)(P_j)(R_v)$
- P = Annual Rainfall (inches)
- $P_j = \text{Fraction of rainfall producing Runoff} = 0.9$
- $R_v = \text{Runoff Coefficient where } R_v = 0.05 + 0.9(I_a)$
- Where $I_a = \text{Impervious fraction}$

Table 2: Phosphorus Loading Coefficients (C)

Land Use	Phosphorus Concentration (C) (mg/L)
Residential	0.41
Impervious	0.50
Commercial	0.34
Industrial	0.45
Actively Grazed Pasture	0.40
Forest	0.15
Developed Open Space*	0.59

* e.g. golf courses, parks, cemeteries, single houses with large lawns.

Table 3: Annual Rainfall Depth (P)

County	P (in)
Dutchess	45
Putnam	45
Westchester	48.6

The engineer shall use the following reduction values to determine the estimated phosphorus removal associated with the proposed retrofit practice:

Table 4: SRP Phosphorus Removal Efficiency

Retrofit Type	Phosphorus Reduction (%)
Micropool Extended Detention Pond	40
Wet Pond	49
Wet Extended Detention Pond	55
Multiple Pond System	76
Pocket Pond	67
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Shallow Wetland	43
ED Shallow Wetland	39
Pond/Wetland System	56
Pocket Wetland	57
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Infiltration Trench	68
Infiltration Basin	50
Dry Well	50
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Surface Sand Filter	59
Underground Sand Filter	59
Perimeter Sand Filter	41
Organic Filter	61
Bioretention	65
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Dry Swale	50
Wet Swale	28
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Green Infrastructure*	*See Below
Cartridge System	40
StormBasin (CB Insert)	50
Hydrodynamic Separators**	10
Channel Stabilization	See Channel Stabilization Below

*Green Infrastructure (GI) practices are to be designed in accordance with the NYSDEC Stormwater Management Design Manual and other design criteria provided by EOHWC. The phosphorus removal efficiency for GI SRP's (including subsurface infiltration) is equal to the percentage of the WQv being treated in the SRP. Thus, 100% treatment of the WQv yields 100% phosphorus removal efficiency for the SRP.

**Hydrodynamic Separators are not a preferred SRP based on the low phosphorus removal efficiency.

1.3 Channel Stabilization

Phosphorus removal for the channel stabilization SRP is no longer calculated using the Channel Enlargement Method. The Alternate Channel Stabilization Method (Alt CSM) for phosphorus loading (P-load) calculation was approved by the NYSDEC in December of 2015 and provides 100% P-Reduction credit for the calculated P-load. The Alt CSM is based on a channel assessment process known as the Bank Erosion Hazard Index (BEHI).

The BEHI is a systematic approach developed to calculate the average annual depth of soil erosion from a streambank. This annual soil depth is then applied over the surface area of the unstabilized channel. The BEHI method for the channel erosion assessment methods are contained within the research document, "*The BANCS Model to Predict Streambank Erosion*" which is shown in Appendix A. The procedure required to calculate the P-load is as follows:

- 1) Using the contributing drainage area (CDA), site conditions and the existing channel dimensions, create a hydraulic/hydrological model to determine runoff volumes and velocities for the following storm events: WQv, 10 yr, 25 yr and 100 yr. The EOHWC recommends HydroCAD 10.0 as a minimum for the modeling software, as this model provides results that have been approved by the NYSDEC for use within our P-load calculations.
- 2) Utilize site data and the BEHI assessment process to determine the annual channel erosion depth (**D**) in ft/yr. Once D is determined, the annual volume of eroded soils is calculated over the surface area of the channel in square feet (ft²)
- 3) The P-load is then calculated using the following relationship:

$$\text{Alt CSM P-Load} = (\text{Channel Surface Area} \times \mathbf{D}) \times \text{BD} \times \text{Ptest} = \text{P-Load.}$$

Where: BD = bulk density (typ. 95 lb/ft³).

Ptest = phosphorus level in soil (typ. 300 mg-P/Kg-soil).

The channel surface area noted above represents the existing channel conditions and dimensions. The stabilized channel design represents the proposed stabilized channel geometry.

The NYSDEC approval of the Alt CSM also provides for phosphorus removal credit from the treatment of the WQv as part of the proposed design. This WQv can be treated using any of the approved SMP's. The procedure required to calculate this P-load is as follows:

- 1) Calculate P-load and WQv for the CDA using the Simple Method (SM).
- 2) Determine the percent of WQv that can be treated (Vt) as part of the project.
- 3) Calculate the Total P-Reduction for the project using the following relationship:

$$\text{P-Reduction Total} = \text{Alt CSM P-Load} + [(\text{SM P-Load} \times Vt) \times \text{SMP Efficiency (\%)}].$$

The total phosphorus reduction credit is equal to the mathematical relationship shown above. The total phosphorus loading is equal to the percent of the WQv that is treated, calculated by the Simple Method, in addition to the P-Load calculated by the Alt CSM.

1.4 Acceptable Variances from the SMDM

The following variances from the design standards presented in the SMDM are acceptable for EOHWC SRP's only:

- EOHWC SRPs need to hold to the updated rainfall standards set forth in the most recent SWDM version 2015.
- Pocket Ponds: Tributary area up to seven (7) acres is permitted.
- Two (2) foot separation from bottom of SRP to bedrock and/or seasonal high groundwater table is permitted.
- Infiltration tests at less frequent intervals than that specified in the SMDM may be acceptable on a site-specific basis. The selected engineer shall provide design details and soil test results to EOHWC when making a request for an exception to the requirement.
- The minimum planting soil bed depth for filtration practices is 2.5 feet.
- New York State Verified Proprietary Practices as identified by the NYSDEC that have been accepted for phosphorus removal efficiency using one of the listed SMP evaluation systems, may be acceptable for use in retrofits. Proprietary practices must meet the performance standards for new practices. Choice of such proprietary practices shall be accompanied by an analysis of the cost

effectiveness of a proprietary practice (both for the initial capital cost and ongoing operation and maintenance) versus constructed practices.

- Additional variances may be added by EOHWC.

2.0 STANDARD SERVICES & DELIVERABLES

The following standard services and deliverables are mandatory for all EOHWC SRP's. EOHWC may modify services and deliverables as required. The following deliverables shall be provided in electronic format as a .PDF file, with additional requirements for electronic and printed formats as described below.

2.1 List of Deliverables

1. Engineering project schedule.
2. 30% engineering design with alternatives.
3. 60% engineering design including the Engineer's Opinions of Probable Costs.
4. 100% engineering design and draft contract documents.
5. Final contract documents.
6. Temporary and Permanent Easement documents.
7. Construction bid evaluation and recommendation of bid award.
8. Construction Phase Services (CPS) including all construction submittal reviews and approvals.
9. Site Inspection as required to verify engineering design.
10. Produce Record Documentation including "As-built" construction plans.
11. Other deliverables as may be noted in the specific EOHWC project RFP.

The standard services and deliverables are further described below, and may be modified in writing by EOHWC.

2.2 Detailed Project Schedule

Within ten (10) working days of receipt of the Notice of Award and the Professional Services Agreement (PSA), the Engineer shall provide a detailed project schedule for completion of the work. The schedule shall be a Gantt-style chart or other EOHWC approved format. The Engineer shall modify the schedule in a timely manner as needed to reflect changes to the work. Schedule modifications shall be completed by the Engineer without additional compensation. The schedule shall become part of the Engineer's Contract. At minimum, the schedule must include the necessary descriptions and completion dates for the required information and Tasks noted below:

Required Information

1. Engineer's Name.
2. Original Date.
3. Contract and Task Order Number.
4. Project Number and Name.
5. Revision Number and Date.

Required Tasks

1. Project Task List with Construction Durations.
2. Project Due Diligence:
 - a. Project Site Review
 - i. FEMA Flood Plain Assessment (FIRM).
 - ii. USDA Web Soil Survey (WSS).
 - iii. State Wetland Mapping (NYSDEC ERM).
 - iv. US Wetland Mapping (USFWS NWI).
 - v. Endangered Species Review (NYSDEC ERM).
 - vi. Historic Site Determination (NYSHPO)
 - vii. SEQR Determination (NYSDEC)
 - b. Permit Identification;
 - i. NYSDEC.
 - ii. NYSDOT.
 - iii. NYCDEP.
 - iv. USACOE.
 - v. Local Municipality.
 - c. Survey review and verification.
 - i. Utility Verification
 - ii. Benchmark Location
 - iii. Deed Review.
 - iv. Topographic Analysis
 - v. Existing Easements
 - vi. Additional Site Features (upon request).
3. Pre-Design Engineering Kick-off Meeting for Concept Design Review.
4. Design Document Submittal:
 - a. 30% Design. (One week review period by EOHWC)
 - b. 60% Design. (One week review period by EOHWC)
 - c. 100% Design. (One week review period by EOHWC and NYSDEC)
 - d. Draft Contract Documents. (One week review period by EOHWC)

- e. Final Contract Documents. (One week review period by EOHWC)
5. Advertisement of Request for Construction Bids (by EOHWC; typically a 2 week duration)
6. Contractor Bid Evaluation (One week review period by Engineer)
7. Notice of Award (by EOHWC, within 1 weeks of completing Bid Evaluation)
8. Notice to Proceed (by EOHWC, within 1 weeks of Notice of Award)

Further details describing the components of the various design submittals are discussed in Section 3.5 of this document.

2.3 Survey

The Engineer must obtain the survey information required to complete the project design and construction. The EOHWC retains the right of approval for the Engineers selection of the proposed surveying firm.

Field surveying shall be limited to the area that may be affected by construction of a practice, plus 20 feet of undisturbed areas surrounding the practice, unless otherwise approved by the EOHWC. Topography shall be shown at not less than two (2) foot contours, referenced to North American Vertical Datum of 1988 (NAVD88). The horizontal coordinate system shall be the NYS Plane Coordinate System, East Zone, North American Datum (NAD83). All onsite utilities will be located including; electrical service, water/well service, phone/cable service, sanitary sewer service.

A full boundary survey may not be required for each stormwater retrofit project. The Engineer may require additional data if the project limit of disturbance (LOD) is located within 10 feet of a property boundary, wetland buffer, stream buffer, or grading setback. Additional survey data may be provided if required. Two permanent reference points shall be provided on the plans, providing coordinates and elevations in the required datum.

2.4 Field Investigation

The Engineer shall perform field investigations sufficient to determine if site conditions (e.g. groundwater or bedrock test pits) exist that would preclude, hinder, or cause unnecessary design modification during construction.

The Engineer shall identify and delineate project constraints (e.g. wetlands) that may affect the SRP design and permitting. The Engineer shall perform field investigations

(e.g. percolation testing) sufficient to verify that the proposed stormwater retrofit is designed properly and accurately represented in the initial evaluation.

2.5 Design Submittals

2.5.1 30% Engineering Design with Alternatives

The Engineer shall provide an Engineering Design of the SRP proposed by the EOHWC that shall not exceed a 30% engineering design. At a minimum, the 30% Engineering Design Report shall include:

1. Cover Page
2. Executive Summary/Introduction
3. Project Objective(s)
4. Existing Conditions
 - a. Project Location Mapping
 - b. Current Land Use
 - c. USGS Soil Classification Mapping
 - d. Site Soil Investigation (Deep Test pits, perc testing, soil borings, etc.)
 - e. Site Topography (per design requirements)
 - f. Identify stormwater flow path and Time of Concentration (Tc).
 - g. Identify nearest receiving waterbody
 - h. Other site conditions (state/federal wetlands, brownfield projects, etc.)
5. Project Description
 - a. Recommended SRP
 - b. Feasibility analysis of selected stormwater management practice (SMP)
 - i. Delineated drainage area (determine site specific areas, Impervious, Forested, etc.)
 - ii. Preliminary site grading
 - iii. Stormwater flow path showing post Tc.
 - iv. Design Considerations
 - v. Phosphorus Loading Calculation and WQv treatment sizing
 - c. Feasible Alternative(s)
6. Proposed Project Schedule
7. Anticipated Regulatory Approval and Permits
8. Project Cost Estimate
 - a. Engineer's opinion of probable construction cost (only to be prepared for the alternatives upon request by EOHWC)

- i. Construction
 - ii. Equipment
 - iii. Contingency
- 9. Conceptual Site Plan
 - a. Engineer Name, Date, Project Title
 - b. North Arrow/Legend
 - c. Graphical Scale
 - d. All Site Features (wetlands, nearest waterbody, streets, etc.)
 - e. SRP location and layout
 - f. Location Map
 - g. Sheet Legend

If the SRP proposed by EOHWC is not feasible, the 30% Engineering Design shall identify the issues which render the proposed SRP infeasible and recommend an alternative SRP. If requested by EOHWC, the Engineer shall make every reasonable effort to develop an alternative SRP which provides a phosphorus removal greater than or equal to the EOHWC proposed SRP, does not add permitting and/or easement requirements, increase the complexity of constructing the SRP, or increase the engineer's design fees. EOHWC will review the Engineer's proposed SRP and calculations and may accept the revision or request additional information from the Engineer. The Engineer shall provide a Change Order Request including revised project schedule, if required, to complete the Scope of Services as described in the solicitation for the alternative SRP

EOHWC will review the alternative (if presented) and may require proceeding with the original SRP, or authorize a modification to proceed with the alternative SRP.

Prior to field work, the Engineer shall prepare a general Health and Safety Plan (HASP) for their field activities, and include any site-specific concerns, if applicable. The HASP shall be provided to the EOHWC for information purposes only.

2.5.2 60% Engineering Design

The Engineer shall prepare an engineering design with the level of detail commensurate with similar engineering projects. The plans shall be technically complete, with sufficient detail and information to facilitate a discussion between EOHWC and the property owner (private or public) regarding impacts/encumbrances to the property and/or use of the property. The plans shall include sufficient detail and information to

submit with regulatory permit applications. Includes completed regulatory permit applications (excluding fees), for signature by EOHWC and/or the Owner.

The Engineer shall respond to and incorporate any comments received from the EOHWC and other review agencies on the plans, calculations, and reports. The Engineer shall prepare all plans at a scale and detail sufficient for construction of the SRP. Scale shall not be less than one inch equals thirty feet, however the scale may be reduced at the discretion of the Engineer where it is necessary to show sufficient detail to construct the retrofit. The minimum paper size for full-size plans is 24-inches by 36-inches. The minimum paper size for half-size plans is 11-inches by 17-inches.

2.5.3 100% Engineering Design & Draft Contract Documents

The Engineer shall prepare an engineering design with the level of detail commensurate with similar engineering projects, including final phosphorus loading and removal calculations. The level of detail and completeness for plans and calculations shall be sufficient such that the NYSDEC can review and accept the project design as technically complete. This submittal shall include the 100% Engineer's Opinion of Possible Construction Costs (EOPCC).

The Draft Contract Documents (CDs) shall be developed for the SRP(s), based on the standard CDs provided by EOHWC. The primary purpose of the Draft CDs is to identify any variance from the EOHWC standard CDs, incorporate Owner requirements, and allow sufficient review.

The Engineer shall respond to and/or incorporate any EOHWC and other review agencies comments received on the plans, calculations, and/or reports. The Engineer shall prepare all plans at a scale and detail sufficient for construction of the stormwater retrofit. Scale shall not be less than one inch equals thirty feet, however the scale may be reduced at the discretion of the Engineer where it is necessary to show sufficient detail to construct the retrofit. The minimum paper size for full-size plans is 22-inches by 34-inches. The minimum paper size for half-size plans is 11-inches by 17-inches.

2.5.4 Final Contract Documents & Operation and Maintenance Documents

The Final CDs shall be of sufficient completeness and detail to issue for the solicitation of construction bids without the need for addenda, and shall include the 100% Design Plans (with any review comments addressed and incorporated), and the Final Administrative and Technical Specifications. This deliverable includes the EOPCC, Bid Evaluation, and preparing a Recommendation of Award letter.

The Engineer shall do all things necessary and proper to construct and procure construction bids for the SRPs in this Solicitation, any Addenda, Task Order, and/or Change Orders.

The final submittal to EOHWC shall include four printed copies of the full-size plans and specifications bearing the Engineer's Professional Engineer seal, one printed copy of the half-size plans, and two electronic versions of the plans: one as a PDF file and the second as an AutoCAD 2010 compatible DWG file.

The Engineer shall prepare the Operation and Maintenance (O&M) manual for the SRP based on the forms provided in the SMDM and supplemented as necessary, and the Engineer's Opinion of Probable O&M Costs, developed as an annual cost beginning at the completion of construction and including a period of five years following completion of construction.

2.5.5 Easement Documents

If the SRP is located on non-municipally owned property, EOHWC expects that easements (permanent O&M easement and temporary construction easement) will be required between EOHWC, the Host Municipality and the property owner. The Engineer shall prepare sketches of the easements and provide the sketches to EOHWC for use in negotiations with the property owner. The Engineer shall provide a survey drawing and legal descriptions of the final easements to EOHWC, for EOHWC's use in preparing and executing the easements within the Installation Agreement.

2.5.6 Construction Phase Services (CPS)

Prepare and provide the documentation required to complete CPS. This typically includes, but is not limited to: meeting schedules/agendas/minutes, site visit notes and photographs, invoice reviews, shop drawing reviews, etc.

The Engineer shall provide CPS, including a pre-bid meeting, construction observation for general compliance with the Contract Documents, reviewing shop drawings, responding to the contractor's requests for information/interpretation/clarification, preparing change orders, reviewing contractor payment requests, review and finalizing record documents, and contract close-out. The Engineer shall perform construction observation to duration and frequency to support the CPS requirement, and shall describe the CPS duration and frequency in their proposal.

2.5.7 Record Documents

Prepare and provide Record Documents of the completed SRP, including following:

1. Approved Operation and Maintenance Manual
2. Approved O&M cost estimate
3. Engineering Certification Letter
 - a. Signed and sealed by the design engineer certifying the project was constructed according to the approved plans
4. As built drawings
 - a. Four (4) hard copies and one (1) electronic ACAD format copy
5. Notice of Termination
6. Closeout of any opened regulatory permit for the constructed SRP
7. Any easements filed with the County
8. Final phosphorus removal credit
 - a. Signed and sealed by the design engineer
9. Prevailing Wage Schedule – Notice of Completion

Record document plans shall include surveyed information to accurately describe the key components of the SRP. Typical key components include but are not limited to:

- Top of berm/bottom of basin
- Structure rims/ weir inverts
- Rip-rap limits
- Pipe inlet/outlet inverts, diameter, material
- Swale/channel centerline.