ANNUAL STANDARDS AND SPECIFICATIONS FOR PROJECTS IN VIRGINIA

Submitted by:

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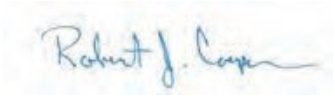
Certification Statement

I certify under penalty of law that all documents and all attachments included in the submission and update of Mountain Valley Pipeline, LLC's Annual Standards and Specifications for Projects in Virginia have been prepared under my direction or supervision in a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is to the best of my knowledge and belief true, accurate and complete. I am aware that there are significant penalties for submitting false information including the possibility of a fine and imprisonment for knowing violations.

Name: 

Title: Senior Vice President, Construction Services

Date: July 18, 2023

TABLE OF CONTENTS

APPENDICES

ACRONYMS AND DEFINITIONS

ATWS	Additional Temporary Workspace
BSRF	Belted Silt Retention Fence
BMP	Best Management Practices
Commonwealth	Commonwealth of Virginia
EI	Environmental Inspector
E&ISC	Exotic and Invasive Species Control
ESC	Erosion and Sedimentation Control
FERC	Federal Energy Regulatory Commission
HDD	Horizontal Directional Drilling
LDA	Land-Disturbing Activity
LEI	Lead Environmental Inspector
LOD	Limits of Disturbance
MOUNTAIN VALLEY	Mountain Valley Pipeline, LLC
MS4	Municipal Separate Storm Sewer System
PLAN	FERC Upland Erosion Control Revegetation and Maintenance Plan
PROCEDURES	FERC Wetland and Waterbody Construction and Mitigation Procedures
RLD	Responsible Land Disturber
ROW	Right-of-Way
SPCC	Spill Prevention, Containment and Countermeasure
SWM	Stormwater Management
SWMA	Stormwater Management Act
SWPPP	Stormwater Pollution Prevention Plan
TMDL	Total Maximum Daily Load
VADEQ	Virginia Department of Environmental Quality
VDOT	Virginia Department of Transportation
VESCH	Virginia Erosion and Sediment Control Handbook
VESCP	Virginia Erosion and Sediment Control Program
VRRM	Virginia Runoff Reduction Method
VSMP	Virginia Stormwater Management Program
WLA	Wasteload Allocation

INTRODUCTION

Mountain Valley Pipeline, LLC (MOUNTAIN VALLEY) is a joint venture in which EQM Midstream Partners, LP, and NextEra US Gas Assets, LLC, are the primary partners. MOUNTAIN VALLEY constructs, operates, and maintains interstate natural gas transmission projects and related infrastructure in the Commonwealth of Virginia and surrounding states.

MOUNTAIN VALLEY has prepared these Annual Standards and Specifications (Standards and Specifications) for submission to the Virginia Department of Environmental Quality (VADEQ). These Standards and Specifications document the erosion and sediment control (ESC) and stormwater management (SWM) practices MOUNTAIN VALLEY will implement for regulated land disturbance and related activities in the Commonwealth associated with its natural gas transmission infrastructure.

These Standards and Specifications meet the applicable requirements of the following:

- Virginia Erosion and Sediment Control Program (VESCP) Regulations (9VAC25-840);
- Virginia ESC and SWM Certification Regulations (9VAC25-850);
- Virginia Stormwater Management Act (SWMA) (Va. Code § 62.1-44.15:24 et seq.);
- Virginia Erosion and Sediment Control Law (Va. Code § 62.1-44.15:51 to 66);
- Virginia Stormwater Management Program (VSMP) Regulation (9VAC25-870);
- Federal Energy Regulatory Commission (FERC) Upland Erosion Control, Revegetation and Maintenance Plan (PLAN); and
- FERC Wetland and Waterbody Construction and Mitigation Procedures (PROCEDURES). [*]

MOUNTAIN VALLEY and its construction contractors will implement these Standards and Specifications for all regulated land disturbance activities in the Commonwealth. Project-specific information along with figures illustrating the ESC and SWM devices to be implemented in accordance with these Standards and Specifications will be included in the site-specific ESC and SWM plans submitted to DEQ for approval, when required. The Virginia Erosion and Sedimentation Control Handbook (VESCH), 3rd Ed., 1992 will also be referenced as an approved source of ESC devices available for implementation.

GENERAL REQUIREMENTS

These Standards and Specifications have been prepared by MOUNTAIN VALLEY for use by its employees and contractors to identify the means and methods for controlling erosion of surface soils, and to reduce the runoff of sediment to the greatest extent reasonably achievable during and after construction of energy infrastructure projects.

Unless specifically stated, the BMPs and specifications from the VESCH, along with accompanying technical documents and guidance, have been adopted and are accepted for use.

The Minimum Standards and Specifications (STD & SPECS) from the VESCH typically employed for the construction of natural gas facilities are referenced by number throughout these Standards and

[*] MOUNTAIN VALLEY does not, and has no plans to, conduct land-disturbing activities in areas subject to the Chesapeake Bay Preservation Act, Va. Code § 62.1-44.15:67. These Standards and Specifications therefore have not been developed to comply with the requirements of that Act.

Specifications. FERC requirements are also referenced by section. Additional ESC measures in Chapter 3 of VESCH may be implemented if site-specific conditions warrant.

Implementation of these Standards and Specifications will be overseen by one or more Program Administrators employed by MOUNTAIN VALLEY who possess the requisite program administrator certification(s) from VADEQ as listed in 9 VAC 25-850-40.A.

2.1 PLAN DEVELOPMENT AND REVIEW

MOUNTAIN VALLEY will implement the following steps for the development and review of ESC, SWM, and SWPPP plans.

- A Program Administrator who has completed the “Program Administrator for Erosion and Sedimentation Control” and “Program Administrator for Stormwater Management” will oversee the development and implementation of the ESC, SWM, and SWPPP plans in accordance with these Standards and Specifications.
- Site-specific ESC plans will be prepared for any regulated land-disturbing activity that disturbs 10,000 square feet or greater. For the purposes of the ESC plan requirements, land-disturbing means any man-made change to the land surface that may result in soil erosion from water or wind and the movement of sediments into state waters or onto lands in the Commonwealth, including, but not limited to, clearing, grading, excavating, transporting, and filling of land, except those activities exempted by Va. Code § 62.1-44:51.
- Site-specific SWM plans and a Stormwater Pollution Prevention Plan will be prepared for any regulated land-disturbing activity that disturbs 1 acre or greater. For the purposes of the SWM plan requirements, land disturbance" or "land-disturbing activity" means a manmade change to the land surface that potentially changes its runoff characteristics including clearing, grading, or excavation, except that the term shall not include those exemptions specified in Va. Code §62.1-44.15:34.
- Plans will be developed under the supervision of a professional engineer licensed to practice engineering in the Commonwealth of Virginia. The plans will comply with all applicable requirements of the Virginia ESC Regulations (9VAC25-840-40), Virginia Stormwater Management Program (VSMP) Regulation (9VAC25-870), Virginia ESC and SWM Certification Regulations (9VAC25-850-50), FERC PLAN and PROCEDURES, and these Standards and Specifications.
- The ESC, SWM, or SWPPP plans will be submitted to one or more Plan Reviewers who have completed the VADEQ certification process for “Plan Reviewer for Erosion and Sediment Control” and “Plan Reviewer for Stormwater Management.”
- MOUNTAIN VALLEY and the Plan Reviewer(s) will conduct a completeness review to verify each project plan is complete.
- Any deficiencies identified by the Plan Reviewer(s) will be addressed and followed by further review by the Plan Reviewer(s). This process will continue until the Plan Reviewer(s) is satisfied that the plans meet the standards described in this document and thereby approves the plans.
- The Program Administrator will document approval of the plan set by stamping them and issuing a written approval letter on MOUNTAIN VALLEY letterhead. Minor redline changes to plans made in the field will be reviewed and approved by the Program Administrator in the same manner.
- The Program Administrator will submit variance requests, if any, to VADEQ for review and approval in accordance with 9VAC25-840-50.

2.2 VADEQ SITE-SPECIFIC PLAN REVIEW AND OVERSIGHT

In addition to the plan development and review requirements set in Section 2.1, the following additional site-specific plan review and oversight measures will be implemented if required by Va. Code § 62.1- 44.15:81.D or as otherwise requested by VADEQ within its authority. It is understood that these additional measures may be implemented for large pipeline construction projects but are not intended to apply to smaller-scale projects, such as routine maintenance and repair of previously constructed infrastructure.

- The Program Administrator(s) will act as the point of contact for VADEQ throughout the project.
- After completing the plan review and approval process outlined in Section 2.1, the Program Administrator will submit its ESC and SWM plans and related/supporting documentation, including any variance requests, and SWPPPs for a project to VADEQ for review and approval in accordance with this section.
- As authorized by law, the State Water Control Board and VADEQ may charge fees sufficient to cover the costs associated with plan reviews. Costs associated with the VADEQ review process may include third party plan review.
- Following completion of the technical review of the plans by VADEQ and determination the submission meets the requirements outlined in these Standards and Specifications, VADEQ will issue an approval letter as well as record stamp the approved plan documents.
- As authorized by law, the State Water Control Board and VADEQ may enforce approved specifications and charge fees equal to the lower of (i) $1,000 or (ii) an amount sufficient to cover the costs associated with standard and specification review and approval, project inspections, and compliance. Costs associated with the VADEQ review process may include third-party plan review.
- VADEQ will perform pre-scheduled as well as random site inspections for the project. Random site inspection or inspections in response to a complaint may be conducted without prior notification to MOUNTAIN VALLEY, its contractors and/or inspection staff. Inspections are intended to ensure compliance with the SWMA, the ESC Law and regulations adopted thereunder. The VADEQ may take enforcement actions if areas of non-compliance are identified during the routine inspection or in response to a complaint report.

MOUNTAIN VALLEY shall notify VADEQ before commencing any land-disturbing activity (as that term is defined in Va. Code § 62.1- 44.15:51 and/or 9VAC25-870-10 and summarized in Section 2.1)) or project subject to these Standards and Specifications. Such notification shall be provided to allow VADEQ to determine if it will exercise its discretion to provide site-specific oversight to an activity or project in accordance with this Section 2.2.

2.3 PRECONSTRUCTION NOTIFICATION

The following information is required to be included in the e-notification StandardsandSpecs@deq.virginia.gov two weeks prior to initiating a regulated land-disturbing activity (LDA) (refer to Section 2.1 for definitions of land-disturbing activity):

- Project **name** or project number;
- Project location (including nearest intersection, latitude and longitude, access point);
- On-site project manager name and contact information;
- Responsible Land Disturber (RLD) name and contact information;
- Project description;
- Acreage of disturbance for project;

- Project start and finish date; and
- Any variances/exceptions/waivers associated with this project.

The project's Pre-Construction kickoff meeting date, time and location will be provided in the e-notification. During the project's Pre-Construction kickoff meeting, MOUNTAIN VALLEY staff will present the project's Safety Environmental Awareness Program (SEAP) training. FERC requires that all visitors, agency representatives, contractors and company staff attend the project specific SEAP training prior to entering the project work limits. SEAP training will be conducted throughout the project to facilitate staff additions and visitors as needed.

Copies of the project permit authorizations will be maintained at each construction spread job trailer/yard in a dedicated project permit mailbox. The location of the mailbox will be identified during the project's Pre-Construction kickoff meeting held for each construction spread.

2.4 PRECONSTRUCTION REQUIREMENTS

A VADEQ-Certified Responsible Land Disturber (RLD), holding a valid RLD Certification, shall be named for each project (or per construction spread for large linear projects) involving regulated LDA. MOUNTAIN VALLEY will require, at minimum, one Environmental Inspector per project/construction spread to obtain/maintain a valid RLD Certification throughout the project construction and restoration activities.

A copy of the approved plans will be maintained in a project mailbox established for each project or construction spread, as applicable. All redline changes will be maintained on this official copy of the plan drawings and presented upon request to VADEQ inspectors during routine inspections.

2.5 REVISIONS TO ESC, SWM, & SWPPP PLANS

For revisions to the approved ESC Plans:

- Minor field-approved revisions that do not increase the LOD or that will increase the effectiveness of ESC and SWM BMPs will be "redlined" on a set of plans that will remain on site for the duration of the project to allow MOUNTAIN VALLEY and VADEQ to ensure compliance with the approved plan and applicable regulatory requirements:
    - MOUNTAIN VALLEY will maintain a log documenting all red-line changes per construction spread. The log will be presented to the VADEQ Inspector upon request for signoff. Minor redline revisions include (but are not limited to) the following:
        - Adjustment of BMP orientation to ensure proper function and protection of the adjacent resources;
        - Implementation of additional measures to meet changing site conditions or to address areas of potential concern;
        - Adjusting the location of the pipeline centerline within the permitted LOD;
        - Adjusting/lengthening the Temporary Stone Construction Entrance to address weather conditions; and
        - Additional reduction of LOD where necessary.

        - On a regular basis (at least every two weeks), the Program Administrator will review and approve minor redline changes made in the field in accordance with Section 2.1 to ensure consistency with the Standards and Specifications.
- Major revisions that exit the permitted LOD will be submitted by the MOUNTAIN VALLEY Program Administrator (after the following the plan review and approval process outlined in Section 2.1) to VADEQ for review and approval prior to implementation of the change for projects for which VADEQ has conducted individual plan review. Major revisions include (but are not limited to) the following:
    - Reroutes;
    - Proposed access road additions; and
    - Proposed additional temporary workspace (ATWS) areas.

The revision log documenting redline changes as well as the redline markup of ESC/SWM drawings will be located in each construction spread permit mailbox. An errata sheet will be maintained on the Project website documenting all major plan approvals, additions, changes, modifications, and revisions along with their corresponding DEQ approval dates.

2.6 INSPECTION STAFF REQUIREMENTS

- Inspection Staff Requirements for Pipeline Construction Activities.
    - A project will have one Lead Environmental Inspector (LEI) and at least one Environmental Inspector (EI) per construction spread. Inspection staff requirements will be determined by MOUNTAIN VALLEY based on the construction activities being undertaken and accessibility to the active areas while providing appropriate coverage to maintain environmental compliance. The LEI and EI will be required to be knowledgeable of environmental permit compliance requirements, be experienced in ESC and SWM BMP installation, operation and maintenance requirements, project permit conditions, and experienced with the FERC's PLAN and PROCEDURES. The LEI/EI will review the implementation of the Standards and Specifications and any applicable environmental permits, resolve apparent conflicts between permits and the Standards and Specifications, and coordinate with the Construction Supervisor about additional measures which may be needed to address erosion and sedimentation. The LEI will also keep a daily log of activity documenting project activities related to environmental permit compliance and corrective measures implemented, site visitors (i.e. non-project staff), waterbody and wetland crossing log and ESC installation and maintenance activities.
    - MOUNTAIN VALLEY will require all LEI and EI staff working on projects in the Commonwealth to obtain the dual ESC and SWM Inspector Certification (to function in these roles. In addition, MOUNTAIN VALLEY may retain a VADEQ-Certified ESC and SWM Inspector from a third-party contractor as needed to provide additional staff support. MOUNTAIN VALLEY may also enter into agreements or contracts with soil and water conservation districts, adjacent localities, or other public or private entities to carry out or assist with these responsibilities.
    - For activities regulated by FERC, MOUNTAIN VALLEY will also have a FERC third-party inspector assigned to each construction spread. This inspector will have peer status with all other activity inspectors and shall have the authority to stop activities that violate the environmental conditions of the FERC certificate or other authorizations and order corrective action once approval has been granted by the MOUNTAIN VALLEY Project Manager.

- The Environmental inspection staff's responsibilities include (but are not limited to):
    - Managing the spread punchlist for ESC controls that are in need of routine maintenance/repair/replacement due to (but not limited to the following):
        - construction activities;
        - storm events;
        - third party related impacts (including but not limited to: livestock/wildlife, landowner, agricultural activities, unauthorized traffic, vandalism, etc.);
        - degradation due to age; or
        - ineffectiveness.
    - Prioritizing punchlist items, as necessary, that have a higher potential to result in impacts to sensitive resources or off ROW areas if measures are not corrected in advance of the next precipitation event;
    - Verifying punchlist items are completed;
    - Ensuring compliance with Mountain Valley's federal and state permit conditions including those contained in these Standards and Specifications;
    - Verifying construction limits prior to initiating construction activities;
    - Identifying ESC/SWM and soil stabilization needs in all project areas;
    - Inspecting installation, operation, and function of all ESC/SWM devices to ensure compliance with the typical details and that controls are functioning properly to prevent loss of sediment in accordance with the requisite inspection frequency;
    - Identifying ESC/SWM controls that are in need of maintenance, repair and replacement, and entering items into the punchlist;
    - Tracking of installation, maintenance, repair, replacement and removal of all ESC/SWM controls;
    - Conducting routine inspections, including daily (as appropriate), SWPPP, and post-storm event;
    - Coordinating with agency and third-party monitors regarding project activities and identifying areas where corrective measures are needed;
    - Providing monitoring and oversight of all stream and wetland crossings, including by conducting pre- and post-crossing inspections; and
    - Investigating ESC/SWM complaint notification.

- The LEI and EI shall be responsible for submitting requests to VADEQ field coordinator or their designee, where necessary, for extension of the applicable timeframe to repair or maintain a deficient ESC measure identified by an inspector. Requests shall be submitted in writing and include sufficient information to demonstrate to VADEQ's satisfaction that compliance with the default timeframe would result in greater environmental impacts under the present conditions or that other circumstances beyond MOUNTAIN VALLEY'S control warrant an extension. Conditions that warrant an extension of the default timeframe include, but are not limited to:

    - Saturated soil conditions prevent the deployment of equipment to the location of the ESC control without causing greater damage to other controls and/or causing excessive disturbance to right-of-way areas that are otherwise stabilized;

- Where the potential damage to stabilized areas of the right-of-way, particularly where permanent vegetative stabilization is in progress, outweighs the likely benefit of deploying equipment to the location of the ESC control;

- Following severe storm events, if complying with the default timeframe for a particular ESC measure or measures would divert necessary resources from other post-storm response actions with greater environmental benefit;

- Where landowner permissions and/or other external requirements must be satisfied to complete an activity;

- Where adverse weather conditions prevent safe working conditions.

- Extensions shall be requested for the period of time reasonably necessary for the conditions justifying the extension to abate. Further extensions may be requested upon a demonstration that the conditions necessitating the extension remain. In the event a request for extension is denied, an appeal may be made via email to VADEQ project management with supporting documentation. Within 24 hours following submittal, a conference call may be necessary to discuss MOUNTAIN VALLEY/Agency concerns regarding the request and to finalize plans for resolution.

At VADEQ's discretion, MOUNTAIN VALLEY will have dedicated VADEQ inspection staff onsite throughout the week as well as VADEQ third-party inspection/monitoring staff onsite daily until a pipeline construction project is completed. For such projects, hard copies of all SWPPP inspection reports will be provided to the VADEQ inspection staff to be reviewed onsite by agency staff.

2.7 INSPECTION FREQUENCIES AND REQUIREMENTS

MOUNTAIN VALLEY will adhere to the following minimum schedules and requirements for conducting inspections of all temporary erosion and sediment controls and stormwater management BMPs for all areas of a project in the Commonwealth. MOUNTAIN VALLEY is subject to varying inspection frequencies consistent with the respective requirements of the Construction General Permit, VESCP, and VSMP. If adverse weather causes the safety of the inspection personnel to be in jeopardy, the inspection may be delayed until the next business day on which it is safe to perform the inspection. Any time inspections are delayed due to adverse weather conditions, evidence of the adverse weather conditions shall be included in the SWPPP with the dates of occurrence. The frequencies and requirements outlined below consolidate these requirements.

ESC Inspections (DEQ-Certified ESC Inspector)

- Inspection Frequencies.

  - In non-TMDL watersheds:

    - During or immediately following initial installation of erosion and sediment controls;

- At the completion of the project prior to the release of any performance bond; and
- Either of the following:
  - At least once every five business days; or
  - At least once every 10 business days and no later than 48 hours following a measurable storm event (or on the next business day if the storm event occurs when there are more than 48 hours between business days).

- In TMDL watersheds:
  - During or immediately following initial installation of erosion and sediment controls;
  - At the completion of the project prior to the release of any performance bond; and
  - Either of the following:
    - At least once every four business days; or
    - At least once every five business days and no later than 24 hours following a measurable storm event (or on the next business day if the storm event occurs when there are more than 24 hours between business days).

- Inspection Requirements.

  - Record the date and time of the inspection and, when applicable, the date and rainfall amount of the last measurable storm event;

  - Record the information and a description of any discharges occurring at the time of the inspection or evidence of discharges occurring prior to the inspection;

  - Record any land-disturbing activities that have occurred outside of the approved ESC plan;

  - Inspect the following for installation in accordance with the approved ESC plan, identification of any maintenance needs, and evaluation of effectiveness in minimizing sediment discharge, including whether the control has been inappropriately or incorrectly used:
    - All perimeter erosion and sediment controls, such as silt fence;
    - Soil stockpiles, when applicable, and borrow areas for stabilization or sediment trapping measures;
    - Completed earthen structures, such as dams, dikes, ditches, and diversions for stabilization and effective impoundment or flow control;
    - Cut and fill slopes;
    - Sediment basins and traps, sediment barriers, and other measures installed to control sediment discharge from stormwater;
    - Temporary or permanent channels, flumes, or other slope drain structures installed to convey concentrated runoff down cut and fill slopes;
    - Storm inlets that have been made operational to ensure that sediment laden stormwater does not enter without first being filtered or similarly treated; and
    - Construction vehicle access routes that intersect or access paved or public roads for minimizing sediment tracking.

- Inspect areas that have reached final grade or that will remain dormant for more than 14 days to ensure:
    - Initiation of stabilization activities have occurred immediately, as defined in 9VAC25-880-1; and;
    - Stabilization activities have been completed within seven days of reaching grade or stopping work.

- Inspect for evidence that the approved ESC plan has not been properly implemented. This includes:
    - Concentrated flows of stormwater in conveyances such as rills, rivulets, or channels that have not been filtered, settled, or similarly treated prior to discharge, or evidence thereof;
    - Sediment laden or turbid flows of stormwater that have not been filtered or settled to remove sediments prior to discharge;
    - Sediment deposition in areas that drain to unprotected stormwater inlets or catch basins that discharge to surface waters. Inlets and catch basins with failing sediment controls due to improper installation, lack of maintenance, or inadequate design are considered unprotected;
    - Sediment deposition on any property (including public and private streets) outside of the construction activity covered by this general permit;
    - Required stabilization has not been initiated or completed or is not effective on portions of the site;
    - Sediment basins without adequate wet or dry storage volume or sediment basins that allow the discharge of stormwater from below the surface of the wet storage portion of the basin;
    - Sediment traps without adequate wet or dry storage or sediment traps that allow the discharge of stormwater from below the surface of the wet storage portion of the trap; and
    - Land disturbance or sediment deposition outside of the approved area to be disturbed.

- Inspect pollutant generating activities identified in the pollution prevention plan for the proper implementation, maintenance, and effectiveness of the procedures and practices.

- Identify any pollutant generating activities not identified in the pollution prevention plan.

- Identify and document the presence of any evidence of the discharge of prohibited pollutants.

- Inspectors should be familiar with and implement any other inspections requirements assigned by the Program Administrator to comply with any permit, consent decree, agency agreement, or voluntary measure.

- Inspection Reports.

    - Inspectors shall complete an inspection report for each inspection using the form provided by MOUNTAIN VALLEY.

- Inspection reports shall be appended to the SWPPP no later than four business days after the inspection is complete.

- Inspection reports and any actions taken in response shall be retained as part of the SWPPP for at least three years from the date the relevant project is completed. The inspection report shall identify any incidents of noncompliance. Where an inspection report does not identify any incidents of noncompliance, the report shall contain a certification that the construction activity is in compliance with the SWPPP. All elements of the SWPPP will be made publicly available in a reasonable manner.

SWM Inspections (DEQ-Certified SWM Inspector)

- During Project Construction.

  - Inspectors shall inspect any SWM measures installed during the period of project construction utilizing the inspection frequency and applicable requirements outlined above for ESC inspections.

  - Inspectors may require monitoring and reports from the person(s) responsible for meeting the SWM plan requirements to ensure compliance and to determine whether the measures required provide effective stormwater management.

  - Inspectors shall conduct such investigations and perform such other actions as are necessary to carry out the provisions of these Standards and Specifications and the approved SWM plans.

  - SWM inspectors are responsible for ensuring:
    - Compliance with the approved ESC plan;
    - Compliance with the approved SWM plan;
    - Development, updating, and implementation of a pollution prevention plan; and
    - Development and implementation of any additional control measures necessary to address a TMDL.

- After Project Construction.

  - The post-construction inspection frequency will commence for a construction spread when all restoration activities outlined in Sections 2.18.1 through 2.18.6 have been completed for disturbed areas of the spread.

  - SWM measures installed in accordance with approved SWM plans shall be periodically inspected and maintained as necessary. The inspection frequency, inspection requirements, and maintenance activities shall be in accordance with these Standards and Specifications and any applicable Stormwater Management Facility Maintenance Agreements entered into between MOUNTAIN VALLEY and VADEQ or other appropriate governmental authority.

2.8 EMERGENCY RESPONSE

In an emergency, MOUNTAIN VALLEY will respond as needed to prevent or minimize harm to persons or property and will contact (via phone and email) the appropriate agencies as soon as practicable under the circumstances. MOUNTAIN VALLEY will immediately implement stabilization and containment measures upon identification of a hazard and develop corrective measures in coordination with the appropriate agencies (including VADEQ). Conducting LDAs in response to a public emergency where the related work requires immediate authorization to avoid imminent endangerment to human health or the environment is not considered a regulated LDA. In such situations, VADEQ shall be advised of the disturbance within seven (7) days of commencing the land-disturbing activity, and compliance with the administrative requirements of subsection A of § 62.1-44.15:34, which is required within 30 days of commencing the LDA. If the land-disturbing activity would have required an approved erosion and sediment control plan or the activity were not an emergency, then the land area disturbed shall be shaped and stabilized in accordance with the requirements of the VADEQ.

2.9 SPCC PLAN

MOUNTAIN VALLEY projects will be implemented in accordance with a Spill Prevention, Containment, and Countermeasure (SPCC) Plan that meets the requirements of the Commonwealth and federal agencies. A copy of the SPCC plan will be maintained and updated onsite for implementation during project activities.

2.10 GENERAL DESCRIPTION OF PIPELINE CONSTRUCTION ACTIVITIES

Pipeline and related facility construction activities include all activities associated with the project from the initial planning stages to the final restoration and maintenance of the right-of-way (ROW), as shown in the Construction Sequence typicals in Appendix C. Daily activities will be planned and managed in advance to provide sufficient resources and manpower for the work effort to be accomplished in a timely manner. The primary construction activities undertaken by MOUNTAIN VALLEY are the construction of natural gas pipelines and facilities along with their associated continued maintenance. Other construction activities to be undertaken in accordance with these Standards and Specifications include the construction of access roads, laydown yards, mainline valves, and compressor stations necessary for the construction, maintenance, or operation of MOUNTAIN VALLEY's pipeline facilities.

Cross-country pipeline construction typically proceeds in an assembly line fashion, with multiple stages of construction occurring simultaneously at different locations to minimize the time needed to complete the project. The stages of construction include: survey and planning, mowing and clearing, grubbing and grading, trenching, pipe assembly (including stringing, bending, welding, testing, coating, and lowering-in), backfilling, final grading, and restoration. The ESC measures to be installed for each of these stages are described below. If any denuded area will remain idle for more than 14 days, temporary stabilization (temporary seed or mulch, as directed by the Environmental Inspector) will be applied within seven (7) days (unless otherwise noted) to that area.

Specific areas (e.g. wetland/water body crossings, residential areas, road or railroad crossings, etc.) requiring specialized construction measures (e.g. boring or directional drilling) will be treated as separate construction entities. Environmentally sensitive areas such as stream and wetland areas, ponds, water supply areas (springs, wells, public water intakes), karst features, threatened and endangered species areas, culturally significant areas (cemeteries, historical or archaeological resources), or areas identified by landowners as being of concern may require additional ESC Procedures, as described in Section 3.0 Temporary Erosion Controls and outlined in the project's ESC plan drawings. Specialized construction

techniques often combine several construction stages into one. This reduces the duration earth disturbing activities occur in a specific area and in many cases, reduces the LOD required for implementation in these specific areas. Final testing (see Section 2.15.1 Hydrostatic Testing) of facilities will be completed after tie-ins are completed.

2.10.1 Construction Work Areas

Construction work areas include all facilities, access roads, staging areas, temporary pipe yards, contractor yards, and the construction ROW. To the extent possible, previously disturbed areas will be used for construction to minimize new impacts. Landowner agreement and appropriate permits will be obtained prior to the use of any area for project construction activities. These ESC and SWM specifications apply to all construction work areas utilized by MOUNTAIN VALLEY.

Temporary workspace is typically reduced at waterbody and wetland crossings to the extent feasible. ATWS may be required at specific locations to accommodate road and utility crossings, waterbody and wetland crossings and in steep slope areas, etc. Variations may occur based on the type of facility under construction, landowner conditions, permit conditions, or topographic conditions.

The construction ROW may be widened (subject to compliance with all applicable survey and mitigation requirements, landowner agreements and all other necessary approvals) in areas such as steep slopes and topsoil conservation areas to ensure safe construction and for storage of excess spoil.

After construction is completed, all work areas will be restored with a perennial vegetative cover, unless specifically directed otherwise by the landowner or permit conditions. Following permanent stabilization, temporary work areas will be returned to pre-construction land uses.

Consistent with the 2019 Construction General Permit, MOUNTAIN VALLEY will minimize the exposure of waste materials to precipitation by closing or covering waste containers during precipitation events and at the end of the business day or implementing other similarly effective practices. Minimization of exposure is not required in cases where the exposure to precipitation will not result in a discharge of pollutants.

2.10.2 Construction Line List and Permits

MOUNTAIN VALLEY will provide the contractor with a Construction Line List that describes special requirements (e.g., timber salvage, topsoil segregation, restoration measures, and fencing requirements) requested by landowners. The contractor will comply with these special requirements so long as they do not conflict with the requirements of these Standards and Specifications or any other federal or state permit requirements.

When constructing a FERC-regulated project, landowner contact information is considered privileged and confidential and is not available for public review, including under Freedom of Information Act requests. As a result, parcel identification numbers are provided on site-specific ESC and SWM plan drawings. Information regarding landowners will be maintained by each construction spread EI as well as in the project job trailer located at each construction spread yard. This information will be available to the VADEQ during site inspections and as needed throughout construction and restoration activities.

Per Minimum Standard (MS)14 of Virginia ESC Law and Regulations, MOUNTAIN VALLEY will obtain all applicable federal, state and local permits pertaining to working in wetlands or crossing live watercourses. In the event permit requirements are more stringent than the requirements of these Standards and Specification, the more restrictive requirements will be implemented.

It will be the construction contractor's responsibility to obtain permits that may be required for specialized activities such as burning, blasting, and transportation activities associated with the project. This

responsibility shall be a condition of each contractor's contract. Per MS-14, all applicable federal, state and local regulations pertaining to working in or crossing live watercourses shall be met. These may include, for example, the following:

- United States Army Corps of Engineers Nationwide Permit 12
- Virginia Marine Resources Commission Submerged Lands Agreement
- VADEQ 401 Water Quality Certification

2.11 SURVEY AND PLANNING

To the extent practicable, construction work areas will be selected in advance and included in all surveys, landowner negotiations, and permitting. Any new work areas selected by the contractor must receive appropriate review, permitting and applicable agency approval prior to their use. In the event additional workspace (including access roads, expanded temporary ROW, ATWS, etc.) is needed, MOUNTAIN VALLEY will submit additional information to VADEQ for review and approval prior to initiating use of these areas (provided VADEQ is exercising site-specific oversight for the activity or project in accordance with Section 2.2). The limits of the approved work areas, boundaries of environmentally sensitive areas and the location of the facilities will be marked in the field and verified prior to the start of mechanized activities.

2.12 MOWING AND CLEARING

The initial mechanized stage of construction involves the clearing of brush, trees, and vegetation from the ROW. Where mowing and clearing operations result in denuding of soil, stabilization, erosion control or sediment trapping measures shall be installed as soon as practicable, but no later than seven days after soil exposure, to prevent erosion and deposition of sediment on roadways, properties and waterways located off of the LOD. Vegetation will be cut off at ground level, and un-merchantable timber (e.g., brush, stumps, slash and tree tops) will be disposed of by chipping and blowing chips off LOD in upland areas (landowner approval required), windrowing, or by burning (if allowed). Burning will only be conducted if appropriate permit approvals are received and activity is authorized by MOUNTAIN VALLEY. Merchantable timber will be cut and stacked along the outboard edge of the construction LOD in upland areas as directed by the landowner ROW agreements and approved by the MOUNTAIN VALLEY Construction Supervisor. Tree tops and brush may be chipped and spread (blown) uniformly onto undisturbed forest land adjacent to the disturbed ROW if allowed per landowner agreement. Alternately, if wood chips generated from land clearing activities are scattered along the edge of the ROW, the chips will be spread to a maximum of 1 ton/acre and an additional application of 1 pounds of nitrogen per 1,000 square feet of wood chips will be made to affected areas. MOUNTAIN VALLEY will never apply more than one (1) pound of nitrogen per 1,000 square feet within a 30-day period. Annual limits for total nitrogen application will vary based on the solubility of the nutrient, therefore MOUNTAIN VALLEY will reference the most current VADEQ technical bulletin for the application rates in certain seasons and habitats.

Clearing of vegetation in wetlands will be limited to trees and shrubs, which will be cut flush with the surface of the ground and removed from the wetland. Stump removal, topsoil segregation, and excavation will be limited to the area immediately over the trench line within the permanent easement per, as applicable, permit requirements from the U.S. Army Corps of Engineers, FERC PROCEDURES, and/or a project's FERC Certificate conditions. Trees located within 15 feet of the pipeline with roots that could compromise the integrity of the pipeline coating may be selectively cut and removed from the permanent ROW. Limited stump removal and grading may be conducted within the permanent easement in wetlands to ensure a safe working environment.

Where requested by the affected landowners, trees of special concern (i.e. located within or immediately

adjacent to construction LOD) will be protected by fencing and armoring in accordance with VESCH STD & SPEC 3.38 Tree Protection and Preservation, as necessary. Trees and shrubs that are not required to be cleared to facilitate construction activities will not be unnecessarily damaged during construction (Plates 3.38-1, -2, -7, -8, -9).

2.12.1 Fence Crossings

Where it is necessary to remove existing fences in the ROW, adequate temporary fences and gates will be installed around the construction area, if required by the landowner. Temporary fences or gates will be provided with suitable fasteners and will be kept closed, except when necessary to be opened for construction purposes. Existing fences will be replaced in kind or as agreed upon with the landowner upon completion of work.

2.13 GRUBBING AND GRADING

The grading operation involves grubbing of stumps, stockpiling topsoil where applicable, and leveling the construction ROW to create a safe operating area for equipment, employees and vehicles. Where required (see Section 2.13.1), topsoil and subsoil disturbed during grading operations will be stored separately and will not be mixed together or with foreign material (e.g., stumps, slash, or wood chips). Soil stockpiles resulting from grading operations shall be stabilized or provided with sediment trapping measures. The disposal methods described in Section 2.12 Mowing and Clearing for clearing debris also apply to stumps. Grading and grubbing will be conducted as a separate construction activity at waterbody and wetland crossings which will be treated as separate construction areas until the contractor is prepared to complete all other construction activities at that site in the shortest practicable time. Because grubbing and grading involve ground disturbance, down-gradient temporary ESC devices shall be installed and functioning prior to conducting these activities.

ESC measures will be installed as a first step in any LDA and will be made functional before upslope land disturbance takes place.

Specifications for temporary ESC measures are discussed below in Section 3.0 Temporary Erosion Control.

2.13.1 Topsoil Conservation (MVP-ES46)

Topsoil will be segregated in pastureland, upland forested areas, residential areas, meadowlands, wetlands without standing water or saturated soil, areas requested by the landowner, and where directed by the EI. The topsoil will be stored separately from trench subsoil and replaced on top of the subgrade during final grading. Topsoil will be stored along the edge of the temporary LOD, maintaining a minimum 10-foot setback from waterbody and wetland boundaries. In non-saturated/non-standing water wetland areas, the top 12 inches of wetland soil will be segregated from the trench line during trenching activities to be used during restoration.

In agricultural lands and upland forested areas, topsoil will be stripped from either the full LOD (using additional temporary ROW to store the topsoil in this case) or from the trench line and subsoil storage area. During construction, topsoil storage piles shall be stabilized or protected with sediment trapping measures.

At least 12 inches of topsoil (where available) will be segregated in deep soils. Where soils are shallow, every effort will be made to segregate the entire topsoil layer. In residential areas, topsoil replacement (i.e., importation of topsoil) is an acceptable alternative to topsoil segregation. Topsoil may not be used to fill sandbags or to pad the pipe.

2.13.2 Drain Tiles

The following procedures apply to locations where existing drain tiles are encountered:

1. Mark drain tile locations identified prior to and during construction.
2. Inspect all drainage tile systems exposed within the area of disturbance to check for damage.
3. Repair drain tiles damaged during construction activities to their original condition. Drain tile repair will be limited to the area damaged within the construction LOD. Do not use filter covered drain tiles without agreement of the local soil conservation authorities and the landowner. The construction contractor, overseen by the EI or construction inspector, will be responsible for testing and repairs.
4. For new pipelines in areas where drain tiles exist or are planned, ensure that the depth of cover over the pipeline is sufficient to avoid interference with drain tile systems. For adjacent pipeline loops in agricultural areas, install the new pipeline with at least the same depth of cover as the existing pipeline(s).

2.13.3 Irrigation

Water flow will be maintained in crop irrigation systems, unless shutoff is coordinated with affected parties.

2.13.4 Access Roads

MOUNTAIN VALLEY will utilize existing roads and newly constructed roads to facilitate construction. Typical road widths will be 25 feet but may require additional temporary widening to facilitate use by large equipment and pipe delivery trucks. Existing roads will be maintained with minor grading and gravel dressing (as needed) to maintain the road surface. Temporary ESC BMPs will be installed in accordance with the ESC plan. For existing roads that require waterbody crossing culverts to be replaced due to condition or temporary widening for use, MOUNTAIN VALLEY will either span the waterbody to avoid impact or permit the culvert replacement as an impact under an appropriate permit from the U.S. Army Corps of Engineers and/or Virginia Water Protection permit.

Following installation of a project, existing roads that required temporary widening will be returned to pre-existing contours and conditions. Any drainage culverts damaged will be repaired as needed and returned to pre-existing conditions. Areas of temporary widening will have the temporary road surface reclaimed and the disturbed areas revegetated. The road surface will be returned to the pre-existing width and a top coat of gravel applied (where necessary). Once disturbed areas are permanently stabilized with vegetation or other measures (i.e. gravel, where applicable), temporary ESC BMPs will be removed and properly disposed of at an approved waste disposal site.

Newly constructed temporary access roads will be installed in accordance with the ESC plans. Following completion of the project, temporary access roads will be returned to pre-existing contours and stabilized with permanent vegetation. Temporary ESC BMPs will be maintained on temporary access roads throughout the project until the disturbed area is restored and permanently stabilized with vegetation. Once the area has been permanently stabilized, the temporary ESC BMPs will be removed and properly disposed. Existing dirt roads, logging roads, and two-track or vegetated agricultural roads will be returned to their pre-construction conditions. Roads with a pre-construction dirt surface will be temporarily stabilized with seed and mulch upon restoration. No new roads will be constructed unless prior approval has been received from the appropriate agencies (including VADEQ and FERC).

Newly constructed permanent access roads that are required for operation of a project will be installed in accordance with the project's ESC plan terms and conditions. Permanent roads will be installed for

construction use and will remain in-place for operation of the facilities. Permanent stormwater controls (as needed) will be designed in accordance with the terms and conditions outlined under Appendix B—Stormwater Methodology of these Standards and Specifications and approved by VADEQ.

2.14 TRENCHING

Trenching consists of excavating the trench for the pipeline and is typically accomplished with an excavator or a rotary wheel-ditching machine. In areas where soft rock or hard pans are present, a tractor-mounted ripper or excavator mounted hammer can be used to break and loosen consolidated material. Loosened material will then be removed with an excavator. Spoil piles from trenching activities that will remain undisturbed for seven days or longer shall be stabilized or provided with sediment trapping measures. The ditch will be excavated to a minimum practicable width for excavation stability; additional width will be excavated to meet safety standards when work will occur within the excavation such as at tie-ins, bore pits, valve settings, etc. In areas where mechanized means of rock removal is unsuccessful, blasting may be used as needed. Projects will prepare a general blasting plan for use during activities. As necessary, a site-specific blasting plan may also be prepared by the construction contractor for MOUNTAIN VALLEY's review and approval. Any site or project-specific blasting plans can be found in the project-specific appendices.

2.14.1 Trench Breakers

Temporary trench breakers will be installed in the open trench during trenching, just upslope of every interceptor diversion (at a minimum), to reduce the velocity of storm water flow along the trench and decrease erosive velocity. Trench breakers are not employed in trenchless construction such as conventional boring or horizontal directional drilling, or in non-linear excavations (such as work within a station yard). Temporary trench breakers are typically made of sandbags but may consist of native materials except topsoil. Topsoil shall not be used for trench breakers. Trench breakers will be inspected prior to final back filling of the trench.

MAXIMUM RECOMMENDED SPACING AND MATERIALS FOR PERMANENT TRENCH BREAKERS

Trench Slope	Distance (feet)	Plug Material
0-5%	See Note 1	Concrete Filled Sacks
5-15%	500	Sandbags or Concrete Filled Sacks
15-25%	300	Sandbags or Concrete Filled Sacks
25-35%	200	Sandbags or Concrete Filled Sacks
35-100%	100	Sandbags or Concrete Filled Sacks
>100%	50	Concrete Filled Sacks (Wetted)

NOTE 1: Trench Breakers are required at all waterbody crossings regardless of trench slope. Otherwise, not required at slopes <5%.

Following pipe installation, the temporary trench breakers are replaced with permanent trench breakers to inhibit piping and subsurface erosion in the trench. Materials appropriate for use as permanent trench breakers include sandbags, concrete filled sacks, or VADEQ approved alternative. On steep slope areas, the MOUNTAIN VALLEY Construction Supervisor may require that permanent trench breakers be made with wetted cement bags, mortared stone, or other impervious material approved by VADEQ. Permanent trench breakers must be installed at stream banks, at the edge of wetlands, and in road and railroad embankments to minimize the chance of subsidence. Permanent trench breaker installations at waterbody and wetland crossings must be constructed with impervious materials to prevent the trench line from serving as a conduit to convey groundwater away from the resource.

2.15 PIPE ASSEMBLY

Most pipe assembly activities do not require any additional ESC measures; however, all ESC measures will be maintained in good working order where pipe assembly is being conducted.

2.15.1 Hydrostatic Testing

A pipeline must be pressure tested after backfilling and before placing it into operation in order to establish the Maximum Allowable Operating Pressure (MAOP). Pressure testing may also be conducted on a pipe segment prior to lowering-in as directed by the Construction Supervisor. Pressure testing, or hydrostatic testing as it is called when the test is conducted with water, is often conducted while clean-up activities are on-going. The test manifold locations may be restored out of sequence with the rest of the ROW. If portions of the restored ROW must be disturbed again in order to complete pressure testing, ESC measures will be implemented as applied during the rest of construction and as described in these Standards and Specifications.

Hydrostatic test water will be released to upland areas through an energy dissipating dewatering device in accordance with VESCH STD & SPEC 3.26 Dewatering Structure and Typical Construction Detail MVP-ES2 Pumped Water Filter Bag. The dewatering structures will be sized to accommodate the rate and volume of release. These activities will be monitored and regulated to prevent erosion and over pumping of the dewatering structures. Releases will be stopped when necessary to perform maintenance of the dewatering structures and ensure they remain in good working order. No hydrostatic test releases will occur directly to waterbodies, wetlands or other identified environmentally sensitive areas.

Because MOUNTAIN VALLEY does not intend to release any hydrostatic test water to waterbodies, coverage under a Virginia Pollutant Discharge Elimination System (VPDES) permit is not required. Nevertheless, as an additional BMP, all upland releases of hydrostatic test water will be conducted in accordance with the sampling, monitoring, and effluent limit conditions (pH of 6.0-9.0, no more than 15.0 mg/l petroleum hydrocarbons and 0.011 mg/l total residual chlorine) of the General VPDES Permit for Discharges from Petroleum Contaminated Sites, Groundwater Remediation, and Hydrostatic Tests, VAG83, 9 VAC 25-120-80, applicable to discharges of hydrostatic test water.

2.15.2 Trench Dewatering

The trench will be cleared of debris and dewatered prior to lowering in pipe or equipment. Water from dewatering operations will be filtered through an approved filter bag that will comply with manufacturer's recommendations for inspection and maintenance, passed through a VADEQ standard dewatering structure, and discharged in a manner that does not result in accelerated erosion or adversely affect off-site property. Trench dewatering will be conducted through a filter bag (MVP-ES2) and placed within a

dewatering structure (i.e. VESCH STD & SPEC 3.26-3 or other approved alternative). Pumped Water Filter Bags should be replaced as often as necessary to maintain function and prevent a failure of the filter bag. Pumps used in the dewatering activity will be placed in a secondary containment to prevent spills of fuel or oil to the ground surface in accordance with the SPCC Plan. Dewatering structures will be constructed in a well vegetated stabilized area away from waterbodies and wetlands and sized according to the intended use. Discharge will be monitored and controlled to prevent erosion and sedimentation from occurring to adjacent areas as well as to prevent over pumping of the dewatering structure. The discharge will be directed away from any waterbody, wetland or other environmentally sensitive areas. The discharge point will be monitored during the activity to ensure that the discharge is thoroughly filtered, and no erosion or sedimentation occurs at the discharge point.

If directed or authorized by MVP, anionic polymers may be used as a flocculent on a case-by-case basis to supplement the approved treatment methods. These products may be considered for use during trench dewatering in upland areas, during road or stream bores where high volumes of pit water are anticipated, during the dry-ditch open-cut resource crossings, and other areas where necessary. Polymer use is not intended for replacement of traditional methods but should be used in conjunction with the traditional methods. USE OF CATIONIC POLYMERS ARE PROHIBITED. All polymer products will be submitted to VADEQ for review prior to use.

2.16 BACKFILLING

Backfilling follows pipe installation and generally consists of replacing the material excavated from the trench. In areas where topsoil has been segregated, the subsoil will be replaced first, and the topsoil will be replaced during final grading. Backfilled trench material will be compacted to stabilize the trench. Excess rock, including blast rock may be used to backfill the trench to the top of the existing bedrock profile.

As specified above, permanent trench breakers will be installed in accordance with the specifications identified under Section 2.14.1 Trench Breakers to prevent the backfill from sliding or washing on sloping ground.

2.17 FINAL GRADING

Final grading will be completed no later than 20 calendar days after backfilling (10 calendar days in residential areas), soil and weather conditions permitting. These durations may be extended in locations where it is necessary to maintain a travel lane for access to other portions of the Project.

The ROW will be cleared of construction debris, re-graded to pre-construction contours, and segregated topsoil will be replaced. ROW diversions will be installed in accordance with Typical Construction Details MVP-17 through MVP-17.9 -Temporary Slope Breakers/Temporary Right-of-Way Diversion. All temporary ESC perimeter controls will remain in place until replaced by permanent ESC measures or when a ground cover that is uniform, mature enough to survive, and will inhibit erosion is achieved. In rotated and permanent cropland and pastures, residential areas, and other areas as stipulated by the Construction Supervisor, excess rock greater than four (4) inches in diameter will be removed from at least the top 12 inches of soil to the extent practicable. After final grade is achieved, the size, density, and distribution of rock on the construction work area should be similar to adjacent areas not disturbed by construction. The landowner may approve other rock size provisions in writing.

In areas where establishing pre-construction contours and conditions are not feasible (i.e. valve locations, meter sites, new access road locations, etc.), MOUNTAIN VALLEY will address these areas in the site-specific ESC and SWM plans. These areas will be addressed specifically in the plan sets with the specific sheets identified in the cover letter when submitted to DEQ for review. In the event additional areas are

identified (i.e. temporary access roads, etc.), MOUNTAIN VALLEY will contact VADEQ to discuss changes.

2.17.1 Temporary Stabilization

When acceptable final grade cannot be achieved (e.g., during winter or early spring construction), when permanent seeding (see Section 2.18.2 – Permanent Seeding) cannot be applied due to adverse soil and weather conditions, or any time a denuded area will remain idle for more than 14 calendar days, temporary stabilization measures will be implemented. Temporary seeding (VESCH STD & SPEC 3.31) will be applied to the rough graded area in accordance with Table 3.31-B in the VESCH STD & SPEC. Following seed application, mulch will be applied to help the seed stay in place, to hide the seed from animals, and to retain soil moisture. Mulch can consist of straw, erosion control fabric, hydraulically applied blanket, or some functional equivalent. ESC measures will be monitored and maintained until conditions improve and final cleanup can be completed in the next recommended planting window. As described in section 2.18.3, erosion control fabric, such as jute matting or bonded fiber blankets, may be used as temporary stabilization. Fiber matrix or polyacrylamide-based erosion control products (MVP-ES40 and MVP-ES40-1) will be substituted for erosion control blanket in agricultural areas. Additionally, slopes in excess of 30% will be stabilized with steep slope soil stabilization blankets and matting techniques identified in the VESCH - STD & SPEC 3.36 Soil Stabilization Blankets and Matting. In addition to VESCH STD & SPEC 3.36 Soil and Stabilization Blankets and Matting, MOUNTAIN VALLEY will utilize hydraulically applied soil stabilization blankets and matting (i.e. EarthGuard, Flexterra or equivalent) as an alternative to the rolled ESC blanket material identified under VESCH STD & SPEC 3.36. Plastic covering may also be used as temporary protection for soils, slopes, and stockpiles where soil conditions do not allow traditional mulching/seeding or soil stabilization blanket to be installed. Plastic covering shall be limited to stockpiles or small areas requiring urgent protection and only remain in place until traditional measures (mulching/seeding or soil stabilization blanket) can be installed. As per MS-1, permanent or temporary soil stabilization shall be applied to denuded areas within seven days after final grade is reached on any portion of the site. Temporary soil stabilization shall be applied within seven days to denuded areas that may not be at final grade but will remain dormant for longer than 14 days. Permanent stabilization shall be applied to areas that are planned to be left dormant for more than one year.

2.17.2 Permanent Slope Breakers (Right-of-Way Diversions/Waterbars)

Permanent slope breakers (also commonly called right-of-way diversions or waterbars) are intended to reduce runoff velocity and divert water off the construction ROW. Permanent slope breakers will be constructed in accordance with Typical Construction Detail MVP-17 and MVP-18. Permanent slope breakers will be constructed and maintained in all areas, except cultivated areas and lawns, using the maximum spacing recommendations in the following table.

RECOMMENDED MAXIMUM SPACING FOR

PERMANENT SLOPE BREAKERS

Pipeline Grade	Distance (feet)
<2%	- [1, 2]
2-5%	400
6-15%	200
16-30%	100
>31%	50 [3]

[1] Permanent Slope Breakers will be installed as needed based on field conditions.
[2] Permanent Slope Breakers will be installed 25 feet from each waterbody boundary regardless of slope conditions.
[3] Slopes greater than 65% may require site specific stabilization measures based on field conditions as approved by MOUNTAIN VALLEY Design Engineering and MOUNTAIN VALLEY Environmental Inspector.

Permanent slope breakers will be constructed with a 2-5 percent out-slope to divert surface flow to a well-vegetated stable area. In the absence of a well-vegetated stable area, appropriate energy-dissipating devices will be constructed off the construction ROW (MVP-ES42).

2.17.3 Soil Compaction Mitigation

During preparation of the LOD and trench excavation, topsoil will be segregated and stockpiled separately from excavated subsoil as provided in Section 2.13.1-Topsoil Conservation. During backfill and final grading, topsoil and subsoil will be returned to their original profile. MOUNTAIN VALLEY will disc areas disturbed during construction activities to facilitate revegetation of the ROW. This will include discing subsoil to a depth of 4-6” prior to returning topsoil to the ROW. Topsoil will then be disced prior to seed and mulch application. Severely compacted areas may require additional de-compaction activities to be employed on an as needed basis using a plow or other deep tillage implement.

Following discing, seed and mulch will be applied to the prepared seedbed. In lieu of anchoring mulch to the topsoil using tracked equipment, MOUNTAIN VALLEY will utilize an agricultural crimper to minimize potential for excessive compaction to occur. As an alternative option in agricultural areas, arrangements can be made with the landowner to plant and plow under a "green manure" crop, such as alfalfa, to decrease soil bulk density and improve soil structure. If subsequent construction and cleanup activities result in further compaction, additional tilling may be required.

Restored soils will be tested for compaction throughout the project as necessary in areas disturbed by construction activities. Compaction testing locations will be determined by the MOUNTAIN VALLEY LEI/EI during restoration activities. Tests will be conducted on the same soil type under similar moisture conditions in undisturbed areas immediately adjacent to the Project site to identify approximate pre-construction conditions. A cone penetrometer or other appropriate devices will be used to conduct tests as necessary. Excess rock will be removed from at least the top 12 inches of soil to the extent practicable in all rotated and permanent cropland, hayfields, pastures, residential areas, and other areas at the landowner's request. The size, density, and distribution of rock on the construction work area should be similar to adjacent areas not disturbed by construction. Diligent efforts will be made to remove stones greater than four (4) inches if the off-ROW areas do not contain stones greater than (4) inches. The landowner may approve other rock size provisions in writing.

2.18 RESTORATION

Restoration includes permanent soil stabilization measures, both vegetative and non-vegetative (e.g., rip rap or gabions). A permanent vegetative cover will be established on all disturbed areas of the ROW not otherwise permanently stabilized. Restoration will promptly follow final grading to take advantage of soil scarification resulting from grading and will be completed within seven (7) calendar days of final grading, weather and soil conditions permitting.

2.18.1 Cleanup

Final cleanup of an area (including final grading and installation of permanent ESC structures) will be completed within 20 calendar days after backfilling the trench in that area (10 calendar days in residential areas). These durations may be extended in locations where it is necessary to maintain a travel lane for access to other portions of the Project. If this schedule cannot be met, all temporary ESC measures shall be removed within 30 calendar days after final site stabilization or after the temporary measures are no longer needed. In no case will final cleanup be delayed beyond the end of the next recommended seeding season.

Construction debris will be removed from the ROW and grade the ROW to leave the soil in the proper condition for planting.

2.18.2 Permanent Seeding (MVP-ES11)

The goals of permanent seeding are to establish a dense, self-propagating, low-maintenance ground cover that will minimize erosion and sedimentation while providing wildlife habitat benefits. To achieve these many goals requires attention to detail in selecting the seed mix and preparing the seedbed.

MOUNTAIN VALLEY may request a deviation from VESCH STD & SPEC 3.32 (Permanent Seeding) with each ESC and SWM plan submission to VADEQ for review and approval. State-specific seed mixes recommended for MOUNTAIN VALLEY are summarized in the site-specific ESC and SWM plans. These seed mixes will be applied along the project's ROW except where landowners request a specific seed mix and on state or federal land where agencies request specific seed mixes. In areas where a specific mitigation seed mix is not required, MOUNTAIN VALLEY will implement VESCH STD & SPEC 3.32 Table 3.32-C (Site Specific Seeding Mixtures for Appalachian/Mountain Area).

The low-maintenance seed mix appropriate for the region of the state where the project is located (see VESCH – STD & SPEC: Table 3.32-C) will be the default unless otherwise specified in the applicable permit conditions, mitigation specifications or landowner agreements. Certified seed will be used whenever possible and will be applied to the ROW within 12 months of the testing date. Legume seed will be treated with an inoculant specific to the species. Slopes steeper than 33% will be seeded immediately after final grading, weather permitting. All disturbed soils will be seeded within seven (7) calendar days of final grading, weather and soil conditions permitting.

Seedbed preparation includes adding lime and fertilizer and tilling or discing the top 4-6 inches of the soil, or soil roughening if tilling cannot be accomplished. When hydro seeding is to be used, the seedbed will be scarified to facilitate lodging and germination of the seed. Unless site-specific recommendations are received from the land owners or land management agencies, MOUNTAIN VALLEY will incorporate 4,000 lbs./acre of pulverized agricultural grade lime and 1,000 lbs./acre of 10-20-10 fertilizer into the soil. Soil pH modifier and fertilizer will be incorporated into the top two (2) inches of soil as soon as possible after application. Other fertilizer formulations, including slow-release sources of nitrogen (preferred from a water

quality standpoint), may be used provided they can supply the same amounts and proportions of plant nutrients). PCB-free hydro seed will be used.

Seeding rates will be based on pure live seed and used within 12 months of seed testing. Seed will be uniformly applied using a broadcast seeder, drill, culti-packer seeder, or hydroseeder. When dry seeding, the seeding depth should be ¼ to ½ inch. During hydroseeding, it is recommended to add 50% more seed to the tank if a machinery breakdown occurs. If the breakdown exceeds two (2) hours, a full rate of new seed may be necessary. Asphalt binders will not be used when hydroseeding near wetlands or water bodies. Twice the supplier's recommended rate of inoculant will be used on dry seeding, five times the recommended rate if hydroseeded.

The upland seed mix should not be applied within wetlands boundaries. Seeding and mulching in cultivated cropland will conform to the adjacent off ROW area unless otherwise requested by the landowner in writing.

Seeding of permanent vegetation will be performed within the recommended seeding dates per the VESCH. If seeding cannot be done within those dates, appropriate temporary erosion control measures will be used and seeding of permanent vegetation will be performed at the beginning of the next recommended seeding season. Permanent seed may be applied out of the recommended window in addition to temporary seeding; however, the contractor must be prepared to return during the next recommended seeding window to reseed any areas that did not develop adequate permanent cover. Lawns may be seeded on a schedule established with the landowner.

2.18.3 Mulching (MVP-ES45)

Following seed application, mulch will be applied to help the seed stay in place, to hide the seed from animals, and to retain soil moisture. Mulch can consist of straw, erosion control fabric, hydraulically applied blanket, or some functional equivalent. Mulch will be free of noxious weeds. Hay shall not be used as mulch.

RECOMMENDED LOOSE MULCH AND MATERIALS AND APPLICATION RATES

Mulch Application	Rate (lbs./acre)	Notes
Straw	4000	Free from weeds and coarse matter. Must be anchored. Spread with mulch blower or by hand.
Fiber Mulch	1500	Do not use as mulch for winter cover or during hot, dry periods. Apply as slurry.
Corn Stalks	8000-12,000	Cut or shredded in 4-6" lengths. Air-dried. Do not use in fine turf areas. Apply with mulch blower or by hand.
Wood Chips	8000-12,000	Free of coarse matter. Air-dried. Do not use in fine turf areas. Apply with mulch blower, chip handler, or by hand. Apply additional 12 lbs. slow-release nitrogen/ton of wood chips.

Mulch Application	Rate (lbs./acre)	Notes
Bark Chips or Shredded Bark	50-70 cu. Yds.	Free of coarse matter. Air-dried. Do not use in fine turf areas. Apply with mulch blower, chip handler, or by hand.

Installation of erosion control fabric, such as soil stabilization blankets/ matting or bonded fiber blankets, at a minimum, will occur on waterbody banks at the time of final bank re-contouring. Anchor the erosion control fabric with staples or other appropriate devices. Fiber matrix or polyacrylamide-based erosion control products (MVP-ES40 and MVP-ES40-1) will be substituted for erosion control blanket in agricultural areas.

Mulch will be spread uniformly over the area to cover at least 75 percent of the ground surface at a rate of 2 tons/acre of straw or its equivalent. If wood chips are used as mulch, do not use more than 6 tons/acre and add the equivalent of 12 lbs./acre of available nitrogen per ton.

Application of liquid mulch binders and tackifiers may be used in place of mechanical crimping/anchoring. Heaviest application will occur on the crest of ridges and steep slope areas (including spoil piles) to prevent mulch displacement. MOUNTAIN VALLEY will monitor mulch application and function throughout the project duration. If MOUNTAIN VALLEY determines mulch coverage to be sparse due to wind or other factors, reapplication will be conducted as needed.

Ensure that mulch is anchored to minimize loss by wind and water. When anchoring by mechanical means, use a mulch-anchoring tool to properly crimp the mulch to a depth of 2 to 3 inches. When anchoring with liquid mulch binders, use rates recommended by the manufacturer. Do not use liquid mulch binders within 100 feet of wetlands or water bodies.

2.18.4 Soil Stabilization Blankets and Matting

Slopes in excess of 30% will be stabilized with steep slope soil stabilization blankets and matting techniques identified in the VESCH - STD & SPEC 3.36 Soil Stabilization Blankets and Matting. The blanket shall be nontoxic to vegetation and to the germination of seed and shall not be injurious to the unprotected skin of humans. The netting will be entwined with the mulching material/fiber to maximize strength and provide for ease of handling. It is recommended that the mulching material/fibers should interlock or entwine to form a dense layer, which not only resists raindrop impact, but also allow vegetation to penetrate the blanket. Blanket mulches will be started at the top of the slope and unrolled downhill, and adjacent blankets will be overlapped by a minimum of 2 inches. Wire staples 11-gauge or better and a minimum of 6 inches in length will be used to secure the blanket mulch in place in accordance with VESCH STD & SPEC 3.36 Soil Stabilization Blankets and Matting.

In addition to VESCH STD & SPEC 3.36 Soil and Stabilization Blankets and Matting, MOUNTAIN VALLEY will utilize hydraulically applied soil stabilization blankets and matting (i.e. EarthGuard, Flexterra or equivalent) as an alternative to the rolled ESC blanket material identified under VESCH STD & SPEC 3.36. Information regarding the hydraulically applied blankets as shown on MVP-ES-40 and MVP-ES-40.1.

2.18.5 Mulch Before Seeding

Mulch before seeding if:

- Final cleanup, including final grading and installation of permanent erosion control measures, is not completed in an area within 7 calendar days (per MS-1) after the trench in that area is backfilled; or

- Construction or restoration activity is interrupted for extended periods, such as when seeding cannot be completed due to seeding period restrictions; if mulching before seeding, increase mulch application on all slopes within 100 feet of waterbodies and wetlands to a rate of3 tons/acre.

2.18.6 Bare Root Sapling and Shrub Planting

MOUNTAIN VALLEY may utilize bare root sapling and shrub planting to supplement seeding at its discretion or where required by a federal or state agency. The purpose of plantings is to establish target native tree species comparable to the region, site characteristics (e.g., topography; soil characteristics; adjacent vegetation), and adjacent forest composition in order to encourage the timely reestablishment of habitat removed during project construction. For small mammals and birds, adequate spacing of planted shrubs can form a large clump or thicket and provide excellent cover, refuge, or brood-rearing habitat often absent in open landscapes. Furthermore, planting a diverse array of native shrubs and saplings with varying blooming periods will provide reliable sources of pollen and nectar for pollinator species during spring, summer, and autumn.

All species planted will be native to the area, and the seed source or ecotype of the saplings and shrubs will be as local as possible with preference given to within-state, then mountainous regions of an adjacent state, followed by within the Appalachian Mountain range.

A variety of factors are considered when planting bare-root seedlings. Storage of seedlings is important to ensure viability and to limit loss of seedlings prior to planting. To the extent practicable, time between delivery of seedlings to the restoration site and planting is limited. To prevent desiccation and preserve moisture, seedlings are kept in original shipping container (e.g., sack; box) and stored in cool, moist, and shady locations that will not receive direct sunlight, and is sheltered from wind. Refrigerated storage is used when possible.

Immediately prior to planting, seedlings are inspected for damage that may result in seedling mortality. Seedlings are examined and discarded if the following are present: broken stems or main roots, mold or mildew, stems with missing bark, desiccated roots, or a root system less than five (5) inches long. Seedlings deemed suitable are planted using a spade, shovel, or planting bar between October 1 and April 30 following seeding application (i.e., woody plants, forbs, and graminoids).

Holes for seedlings will be dug deep enough to fit the entire bare root system without bending; typically, between 8 and 10 inches. If roots are longer than the depth of the typical planting hole, roots shall be pruned. All pruning will take place in a manner to avoid desiccation (e.g., in shade). Following pruning, roots are moistened. Roots shall be treated with root dip absorbent polymers and mycorrhizal root dip inoculates in accordance with manufacturer's recommendations. One seedling will be placed in each hole with the roots inserted to the bottom and then lifted upward slightly so that the root collar is at or slightly below the finished grade. Each seedling is fertilized with a 5-gram tablet of controlled release fertilizer. When filling the planting hole, the seedling is maintained upright. The spade, planting bar, or shovel is inserted behind the planting hole and tilted back to close the bottom of the planting hole. The tool is then tilted forward to close the top of the hole. Soil is gently packed to fill any remaining voids.

2.18.7 After Restoration

Permanent vegetation will not be considered established until a ground cover is achieved that is uniform and mature enough to survive and inhibit erosion. In general, a stand of vegetation cannot be determined to be fully established until it has been maintained for one full growing season after planting. Temporary ESC BMPs will be inspected and maintained until a ground cover that is uniform, mature enough to survive, and will inhibit erosion is achieved and established. Soils disturbed during ESC maintenance activities will be permanently seeded and mulched to prevent further erosion. All temporary ESC measures shall be

removed within 30 calendar days after the site has been permanently stabilized and the temporary ESC measures are no longer needed, unless written authorization is received from the program authority. Following removal of the ESC measures, all areas disturbed during removal of the ESC measures will be seeded and mulched. MOUNTAIN VALLEY anticipates that one full growing season after restoration planting is complete and vegetation has established, construction will be complete, and the ROW enters the maintenance cycle (see Section 5.0 - Maintenance of Permanent Right-of-Way).

2.18.8 Off-Road Vehicle Control

At the request of a land management agency, measures may be installed and maintained to control unauthorized vehicle access to the ROW. These measures may include:

- Signs;
- Fences with locking gates;
- Slash and timber barriers, pipe barriers, or a line of boulders across the ROW; and/or
- Conifers or other appropriate trees or shrubs across the ROW.

TEMPORARY EROSION CONTROLS

MOUNTAIN VALLEY will utilize ESC measures contained within the VESCH as well as those project specific ESC measures included in the site-specific ESC plans. The temporary ESC details and measures described in the VESCH should be reviewed with the concurrence of the LEI, EI and Construction Supervisor before being implemented to ensure they conform to the site-specific conditions. Any measures not included in the VESCH, these Standards and Specifications, or a VADEQ-approved ESC plan must receive written approval from the appropriate agencies prior to implementation. All temporary ESC devices will be functional before upslope land disturbance takes place. All ESC structures and systems will be maintained, inspected, and repaired as needed to ensure continued performance of their intended function until replaced by permanent ESC devices or restoration is complete. All temporary devices will be removed within 30 days after site restoration or after the temporary measures are no longer needed. The Virginia Erosion and Sediment Control Handbook (1992) can be found digitally HERE.

3.1 ESC MEASURE IN NEED OF ROUTINE MAINTENANCE

All ESC structures and systems will be maintained, inspected, and repaired as needed in accordance with good engineering practices and, where applicable, manufacturer specifications to ensure continued performance of their intended function until replaced by permanent ESC devices or restoration and stabilization is complete. If an ESC measure is identified by any LEI, EI, or Construction Supervisor as needing routine maintenance, or if any VADEQ or other federal or state inspector provides MOUNTAIN VALLEY with an inspection report identifying an ESC structure or system as needing routine maintenance, the issue will be logged on MVP's punchlist. Because inspection activities are completed by multiple entities daily, items on the punchlist as well as items identified during agency and MOUNTAIN VALLEY inspections will be reconciled with all agency Leads on a daily basis to eliminate duplicate listings. Items identified as routine maintenance (described below) would not be included on the VADEQ tracker unless an extension is needed, or the item has exceeded the available repair window. Items listed as ineffective (described below) will be included on the VADEQ tracker. Notifications received from VADEQ inspectors after normal business hours shall be logged on the following day. Timely maintenance shall be completed as soon as practicable, but within such time as to prevent the erosion and sediment control measure from

becoming ineffective and no later than three (3) calendar days from the date of notification (unless an extension has been granted by VADEQ). ESC measures identified by MVP's inspection staff or an agency inspection report as needing "routine maintenance" will be logged on MVP's punchlist separately from ESC measures identified as "ineffective."

"Routine maintenance" means minor upkeep, repair, cleaning, or amendment of an ESC measure that appears to be functioning adequately, but which may become ineffective if maintenance is not performed in a reasonable time period. This provision is intended to apply to ESC measures with minor flaws, damage, degradation, or capacity reductions that are not expected to prevent the measure from functioning effectively during a normal precipitation event should one occur following the inspection. Examples of ESC measures in need of routine maintenance (within 3 days) of identification include, but are not limited to:

- Compost Filter Sock (CFS)
    - Sediment deposition/buildup that is equal to or greater than 50% of the height of the CFS installation; and/or
    - Minor damage and holes, such as those that result from livestock or wildlife grazing, third-party vehicle crossings, landowner activities, or staking damage and do not result in the filter media contents (mulch) being lost from the CFS netting in a manner that renders the control ineffective.
- Silt Fence/Priority 1/Super Silt Fence
    - Sediment deposition/buildup that is equal to or greater than 50% of the aboveground height of the SF/Priority1/SSF installation;
    - Minor holes (generally less than 2 inches in diameter), such as those that result from livestock or wildlife grazing, fallen trees/limbs or wind damage, that pose no reasonable potential for off-ROW sediment discharge to occur;
    - Fabric that has become loose from stakes due to high winds, downed trees or limbs, or livestock grazing, or similar causes that has no reasonable potential for off-ROW sediment discharge to occur; and/or
    - Fence that has been knocked down due to livestock or wildlife grazing, landowner activities (i.e. ATV, vehicles or farm equipment crossings), or similar causes that has no reasonable potential for off-ROW sediment discharge to occur.
- Waterbars[1]
    - Temporary Conditions
        - Minor erosion along the throat (flow path) of the waterbar that results in channel erosion;
        - End treatments that have sediment accumulation equal to or greater than 50% of the aboveground height of the bmp; and/or
        - Sumps that have sediment accumulation equal to or greater than 50% of the overall depth of the sump.
    - Permanent Conditions

[1] Waterbars shall extend to the edge of the ROW and tie-in to the perimeter BMP to ensure runoff exits the ROW through the waterbar end treatment and does not accumulate behind the perimeter control. As result, the earthen waterbar will be constructed and maintained so that there is no gap (open space) between the top of the waterbar and the perimeter control (silt fence, Priority 1, super silt fence or compost filter sock) installation. Waterbars constructed in this manner shall not be flagged as needing routine maintenance.

        - Minor erosion along the throat (flow path) of the waterbar that results in channel erosion; and/or
        - End treatment/level spreaders that have a measurable amount of sediment deposition.
    - Disturbed Areas Temporarily Stabilized [2]
        - Measurable rill erosion develops in the treated area.

ESC measures that would require routine maintenance under normal circumstances will not be designated as such if, in the judgment of the inspector (MOUNTAIN VALLEY, VADEQ or FERC), other relevant circumstances necessitate prompt (24 hour) action to avoid or minimize the potential for environmental harm. Those circumstances may include, for example, the presence of a stream, wetland, or karst feature within 100 feet downgradient of the ESC measure, an approaching storm or extreme weather event (e.g., named tropical storm), or extended period of dormancy.

3.2 INEFFECTIVE ESC MEASURE

An "ineffective" temporary ESC measure is an ESC BMP that does not appear to be functioning adequately and therefore requires immediate maintenance to restore the measure to proper function. This provision is intended to apply to ESC measures with major damage, degradation, or capacity reductions that could prevent the measure from functioning during a normal precipitation event should one occur following the inspection. Examples of ESC measures in need of immediate maintenance (within 24 hours) include, but are not limited to:

- Rock Construction Entrance
    - Observation that the rock construction entrance is not preventing mud or sediment from being tracked onto a public roadway.
- Rill Erosion
    - Area showing rill erosion is impacting the functioning of down-gradient erosion and sediment control measures.
- Cleanwater Diversion
    - Stormwater run-on bypasses the cleanwater diversion berm, directly entering the right-of-way;
    - Cleanwater diversion berm becomes compromised (due to erosion or third-party damage); and/or
    - Runoff from the LOD is entering the plunge pool.
- Any routine maintenance of ESCs or best management practices (BMPs) that directly contribute stormwater runoff to sensitive areas*;
- Disturbed, unstabilized, or unprotected areas that directly contribute stormwater runoff to sensitive areas*;
- ESCs that are not functioning;
- ESCs not installed per the approved Standards & Specifications, ESC/SWM plans (as applicable), or manufacturer specifications;

[2] Application of hydraulic or pelletized forms of fiber mulch (EarthGuard) on disturbed areas remains effective from six to twelve months following application depending on precipitation amounts (up to 20 inches), even if it is not visible.

- ESCs at or within imminent risk of exceeding the designed capacity;
- ESCs at or within imminent risk of releasing sediment off LOD; and/or
- ESCs downslope of an area that has become unstable due to, for example, a slip.

**Sensitive areas will be defined as streams, wetlands, road crossings, and karst features*

SPECIAL PROCEDURES

MOUNTAIN VALLEY will implement specialized construction procedures in areas deemed an environmentally sensitive area such as waterbody and wetland crossings, areas of steep slopes and other areas of concern as identified below.

4.1 WATERBODY AND WETLAND CROSSINGS

Wetlands and waterbodies are natural resources given additional protection under the law because they provide important ecological benefits which may be altered or harmed by construction activities. Wetlands are areas where the plants have adapted to saturated soil conditions for extended periods of time. Wetlands often do not have standing water or even saturated soil at all times during the year and may host plants from flowers and grasses to common shrubs and trees. Waterbody is a term used for any permanent standing or flowing water, or defined channel, such as streams, rivers, ponds and reservoirs. Streams(the area from top of bank to top of bank) may be one of the following: perennial, meaning they typically have some flowing water year round (except in cases of drought), intermittent, meaning they only have flowing water during high flow periods such as spring but they have defined banks and stream bed, and ephemeral, meaning they only exists for a short period following precipitation or snowmelt.

A qualified professional (i.e. wetland and stream biologist) will identify all wetland and water body crossings during the planning and survey phase of the Project.

For every waterbody and wetland, a buffer will be added to both sides of each crossing to ensure that any transitional area is also treated as an environmentally sensitive area. Buffers will extend 50 feet where possible, or as far as topographic conditions permit, along the right-of-way from where the trench centerline enters the wetland and waterbody.

To minimize impacts to waterbody and wetland crossings, they will be treated as separate construction entities, except during clearing activities, and efforts will be made to cross these areas during low flow. Once grubbing and grading starts at a waterbody or wetland crossing it will be actively conducted for consecutive days until the crossing is completed and the work area restored. In general, the same measures as already discussed for upland construction also apply to waterbody and wetland crossings. Exceptions and Procedures of special emphasis are discussed below. Permits may include conditions that further modify these requirements. Crossings will be constructed as close to perpendicular to the axis of the waterbody channel as engineering and routing conditions permit. If the pipeline parallels a waterbody, at least 15 feet of undisturbed vegetation will be maintained between the waterbody and the right-of-way, if possible, except at the crossing location. Where waterbodies meander or have multiple channels, the pipeline will be routed to minimize the number of waterbody crossings.

The methods described in this section will be employed unless incompatible or more stringent requirements are imposed by the U.S. Army Corps of Engineers, Virginia Marine Resources Commission, or other appropriate federal or state authority.

Time Windows for Construction: If the below indicated species is present within the waterbody, no in-stream construction activities will be conducted during the following time windows unless written approval is received from the appropriate federal or state agency:

- Coldwater Fisheries - March 1 – June 30; and
- Warmwater Fisheries - April 15 – July 15
- Natural Trout Streams October 1 - March 31 for Brown Trout (*Salmo trutta*) and Brook Trout (*Salvelinus fontinalis*) waters, and March 15 - May 15 for Rainbow Trout (*Oncorhynchus mykiss*) waters;
- Stockable Trout Streams - there is no time of year restrictions for stockable trout; however, MOUNTAIN VALLEY will consult with the Virginia Department of Wildlife Resources' Aquatic Regional Area Manager before constructing in stockable trout streams.
- Roanoke Log Perch (*Percina rex*) waters - March 15 - June 30.
- Orangefin madtom (*Noturus gilberti*) waters - March 15 – May 31
- Atlantic pigtoe (*Fusconaia masoni*), James spinymussel (*Parvaspina collina*), pistolgrip (*Tritogonia verrucosa*), and yellow lance (*Elliptio lanceolata*) – May 15 – July 31
- Green floater (*Lasmigona subviridis*) and Yellow lampmussel (*Lampsilis cariosa*)– April 15 – June 15 and August 15 - September 30

Additional time-of-year restrictions may be observed as appropriate or required by regulatory agencies to protect aquatic species not included in this list.

Planning and Survey: MOUNTAIN VALLEY intends to employ one of the Utility Stream Crossing (VESCH STD & SPEC 3.25) methods to complete open water crossings. The method selected during planning and surveying may need to be altered based on field conditions at the time of construction. Alterations must be approved by the Construction Supervisor and the LEI/EI prior to implementation. MOUNTAIN VALLEY will contact the plan-approving Authority if necessary.

The principal methods of crossing waterbodies in the Commonwealth will be open-cut dry-ditch. These methods include Flume Pipe Crossing (VESCH STD & SPEC: Plate 3.25-3), Cofferdam Crossing (VESCH STD & SPEC: Plate 3.25-4) and Dam and Pump (MVP-15). In the event a conventional bore or directional drill method is proposed or required, the crossing would be conducted in accordance with these details following approval of necessary federal and state permitting requirements.

For crossings of all state-designated fisheries as well as waterbodies with sensitive species concerns, all construction equipment will cross the waterbody on an equipment bridge. Equipment bridges are not required at minor waterbodies that do not have a state-designated fishery classification (for example, agricultural or intermittent drainage ditches).

For crossings of waterbodies greater than 10 feet in width, use of equipment operating in the waterbody will be limited to that needed to construct the crossing. All other construction equipment must cross on an equipment bridge.

Except where a federal or state agency requires a trenchless crossing method, wetland crossings will be constructed using standard trench-and-backfill methods. Heavy equipment working in wetlands will utilize equipment mats or other suitable methods to minimize soil disturbance and compaction.

Staging areas for waterbody and wetland crossings will be located outside the buffer areas and will be the minimum necessary to stage the waterbody or wetland crossing. No refueling, hazardous materials storage, equipment maintenance, or equipment parking will take place within 100 feet of the waterbody or wetland

crossing. If pumps are being used within the waterbody or wetland crossing, small quantities of fuel in Gerry cans may be stored on site within a spill containment device, otherwise fuel may not be stored within waterbody and wetland crossings. Equipment and vehicles will not be washed in any waterways. The LEI/EI will specify additional stabilization measures as needed to prevent equipment from rutting within waterbody and wetland crossings.

Waterbody and wetland crossings will be clearly marked in the field prior to the start of tree clearing activities.

Additional Temporary Workspace (ATWS) and Access Roads: Clearing of vegetation between extra work areas and the edge of the wetland will be limited to the permitted construction ROW. The size of extra work areas will be limited to the minimum needed to construct the waterbody crossing. The only access roads, other than the construction right-of-way, that will be used in wetlands are those existing roads that can be used with minimal or no modification to the wetland.

Temporary Erosion and Sediment Control: Per MS-4, sediment basins and traps, perimeter dikes, sediment barriers and other measures intended to trap sediment shall be constructed as a first step in any land-disturbing activity and shall be made functional before upslope land disturbance takes place. Sediment barriers will be properly maintained throughout construction and reinstalled as necessary (such as after backfilling of the trench) until replaced by permanent erosion controls or restoration of adjacent upland areas is complete. Sediment barriers will be installed across the entire construction right-of-way at all waterbody crossings. Where waterbodies are adjacent to the construction right-of-way, sediment barriers will be installed along the edge of the construction right-of-way as necessary to contain spoil and sediment within the ROW. Trench plugs will be used at all waterbody crossings to prevent diversion of water into upland portions of the pipeline trench and to keep any accumulated trench water out of the waterbody. Trench plugs will be of sufficient size to withstand upslope water pressure.

Clearing: Clearing operations will be permitted within the buffer at all waterbody and wetland crossings but no grubbing or grading will be conducted until the contractor is prepared to install the pipe and backfill. Temporary equipment crossings will be installed to facilitate equipment crossings of waterbody and wetland areas during clearing activities. Care will be taken during clearing operations not to deposit mud in open water, and to minimize rutting of the right-of-way. All woody debris will be removed from within the waterbody or wetland crossing for disposal. Vegetation will be cut off at ground level, leaving existing root systems in place, and removed from the wetland for disposal. Timber riprap may be employed to stabilize the equipment work area provided all timber is obtained from within the approved construction work area. All timber riprap must be installed to facilitate removal upon completion of construction. Any disturbed soil will be mulched before the clearing crew leaves the waterbody or wetland crossing at the end of each day. MOUNTAIN VALLEY will reduce the construction LOD at waterbody and wetland crossings to 75 feet to minimize impacts. Clearing activities within wetland areas will be restricted to the 75-foot temporary construction LOD.

Grubbing and Grading: Before grading begins and as grubbing progresses, sediment barriers (staked bales or silt fence, compost filter socks, etc.) will be installed across the construction area at the edge of the water or the edge of the wetland, and along the sides of the construction work area as needed to prevent the flow of spoil into the waterbody or wetland. Clearing of vegetation in wetlands would be limited to trees and shrubs, which would be cut flush with the surface of the ground and removed from the wetland. Stump removal, topsoil segregation, and excavation would be limited to the area immediately over the trench line within the 50-foot permanent ROW easement per, as applicable, permit requirements from the U.S. Army Corps of Engineers or VADEQ, FERC PROCEDURES, and/or a project's FERC Certificate conditions (MVP-53). Trees located within 15 feet of the pipeline with roots that could compromise the integrity of the pipeline coating may be selectively cut and removed from the permanent ROW. A limited amount of stump removal and grading may be conducted within the permanent ROW easement in wetlands to ensure a safe working environment. In wetlands, very little grading is expected, as topography is generally flat and low-

lying.

Per MS-13, when a live waterbody must be crossed by construction vehicles more than twice in a 6-month period, a temporary stream crossing of non-erodible material must be provided.

Temporary ROW diversions (interceptor diversions) will be installed at the ends of the waterbody or wetland crossing.

Equipment Bridges: Only clearing equipment may cross waterbodies before installation of equipment bridges. The number of such crossings of each waterbody will be limited to one per piece of equipment. Soil will not be used to construct or stabilize equipment bridges. Equipment bridges will be constructed using one of the following methods:

- Equipment pads and culvert(s)
- Clean rock fill and culvert(s) that conforms to the requirements in STD & SPEC 3.24 (VESCH – STD & SPEC: Plate 3.24-2)
- Flexi-float or portable bridge(s) (VESCH – STD & SPEC: Plate 3.24-1)
- Timber mat bridges

Each equipment bridge will be designed and maintained to withstand and pass the highest flow that would reasonably be expected to occur while the bridge is in place and prevent soil from entering the waterbody. Equipment bridges will be removed following completion of restoration of the ROW with permanent seeding, unless it is authorized to remain as a permanent bridge. If there will be more than 30 days between final cleanup and the beginning of permanent seeding and reasonable alternative access to the right-of-way is available, equipment bridges will be removed as soon as possible after final cleanup.

Trenching: Trenching activities will begin promptly after grading is completed. If trenching of adjacent upland areas has been completed but will not be backfilled before the waterbody or wetland crossing is trenched, a trench plug will be left in place at the end of the waterbody or wetland crossing to prevent stormwater runoff from entering the waterbody or wetland by way of the trench. During excavation, the top one foot of wetland soil or streambed substrate will be segregated and stockpiled separate from the trench spoil. This segregated material will be utilized during restoration of the waterbody or wetland to enhance restoration with the native seedbank and substrate materials.

Any water that must be removed from the work area will be conducted through a dewatering structure. Dewatering structures will be located in an upland area, outside of riparian buffer areas, whenever possible. The dewatering activity will be carefully monitored to prevent erosion and sedimentation in the waterbody or wetland, and in such a manner that no heavily silt-laden water flows into any waterbody.

A minimum of the top one (1) foot of topsoil will be conserved from over the trench in wetlands without standing water or saturated soil.

If standing water or saturated soils are present, low-ground-weight construction equipment, will be used or normal equipment will be operated on timber riprap, prefabricated equipment mats, or geotextile fabric overlain with gravel. Geotextile fabric used for this purpose must be strong enough to allow removal of all gravel and fabric from the wetland.

Spoil Pile Placement and Control: All spoil from waterbody crossings will be placed in the construction right-of-way at least 10 feet from the water's edge or in additional extra work area as described above. Sediment barriers will be used to prevent the flow of spoil into any waterbody.

Pipe Installation: For smaller crossings, the pipe string will be assembled outside the waterbody or wetland crossing and carried into position. For larger crossings, pipe assembly will be conducted outside of the waterbody or wetland crossing except for those crossings that utilize the porta-dam crossing method. For

all large porta-dam crossing methods, assembly will be conducted in the dry area behind the porta-dam. All welding and coating debris will be fully removed from the waterbody or wetland crossing prior to retuning flow to the waterbody. As determined necessary by MOUNTAIN VALLEY, saddle bags filled with clean pea gravel or sand for pipe weights within waterbody or wetland crossings will be used to ensure negative buoyancy.

Backfilling: Backfilling will begin promptly after pipe installation is completed. Permanent trench breakers will be installed in the banks of stream channels and at the ends of wetlands. The top 12 inches of backfill will be made with clean native stream substrate.

Final Grading: Final grading will begin promptly after backfilling is completed. If final grade is reached on any portion of the wetland site, vegetation will be established to prevent erosion. Temporary seeding will be applied within 7 days if any portion of the site will remain dormant for more than 14 days to prevent erosion. Disturbed areas will be restored to pre-construction contours, and in wetlands, topsoil will be replaced preserving the native seed bank which will enable restoration with native plant species. Sediment barriers at the edge of the wetland or edge of the water will be repaired or replaced as necessary. Permanent ROW diversions (interceptor diversions) will be installed at the edge of the buffer area or base of the slope nearest the waterbody and wetland. All materials used to stabilize the equipment work area will be removed (e.g. timber riprap or timber mats). Permanent or temporary soil stabilization shall be applied to denuded areas within seven days after final grade is reached on any portion of the site.

If soil and weather conditions prevent final grade to be established in a wetland (e.g. if the permit specified a winter construction window), a temporary approximate grade will be established. ESC measures will be restored or replaced as needed, and temporary stabilization will be applied.

Restoration: Restoration will begin immediately after final grade is established. Stream banks will be restored by vegetative stabilization (VESCH STD & SPEC 3.22) where site conditions warrant or by riprap (VESCH STD & SPEC 3.19) where banks slope are 3h:1v or steeper. Vegetative stabilization generally includes planting a perennial conservation seed mix from Table 3.32-B located in the VESCH. If grubbing has not been extensive, then native shrub and tree species are expected to sprout and regenerate naturally. Stream banks will be seeded prior to mulch application. A sediment barrier will be maintained at the edge of the water until revegetation of the streambank is successful.

Wetlands will be temporarily seeded in accordance with Typical Construction Detail MVP-ES11.4 and mulched with clean straw (where required), then allowed to revegetate with native seedbank present in the segregated topsoil. A sediment barrier will be maintained around the restored area until revegetation is successful.

In wetlands where saturated conditions or standing water is present, topsoil segregation will be conducted to the extent practicable. Following installation of the pipeline, the trench will be backfilled using native wetland soils and restored to preexisting conditions. No soil or rock will be imported for use during backfilling of the trench. Annual ryegrass will be applied to wetland areas and mulched with straw (where required) to temporarily stabilize the area while the native wetland seedbank reestablishes the area with native vegetation. No seeding should be conducted in areas of standing water. The riparian buffers will be restored using the procedures discussed above for upland areas.

For all affected forested wetlands, restoration activities will be conducted in accordance with approved permit conditions and mitigation requirements. If saplings are required to be planted within the temporary ROW areas, this will be conducted in accordance with Section 2.18.6 – Bare Root Sapling and Shrub Planting (VESCH STD & SPEC: Plates 3.37-4, 3.38-8, and 3.38-9) unless otherwise specified by applicable permit conditions.

4.1.1 Specialized Crossing Procedures

MOUNTAIN VALLEY has considered specialized procedures for use during project planning, permitting and implementation at waterbody and wetland crossings. A discussion of these construction procedures that may be implemented during construction is included in the following sections.

4.1.2 Horizontal Directional Drill Method

The horizontal directional drill (HDD) is a method that allows for trenchless construction across an area by pre-drilling a smaller diameter pilot hole below the depth of a conventional pipeline lay and then pulling the pipeline through the pre-drilled borehole. Two bore pits are established prior to initiating the HDD; one at the entry and one at the exit location. A series of wires are deployed at the ground surface to map the bore path during installation. The method utilizes a slurry referred to as drilling mud, which is composed of 95 percent water and bentonite, a naturally occurring clay mineral. Bentonite-based drilling mud is a non-toxic, non-hazardous material that is also used to construct potable water wells. The drilling mud is pumped under pressure through the inside of the drill pipe and flows back (returns) to the drill entry point along the outside of the drill pipe. The purpose of the drilling mud is to lubricate the drill bit and convey the drill cuttings back to the drill entry point where the mud is reconditioned and re-used in a closed, circulating process. It also forms a cake on the rock surface of the borehole, which helps to keep the drill hole open and maintain circulation of the drilling mud system. A pilot hole is drilled to establish a smaller diameter bore from entry to exit point. The bore diameter is then increased to the necessary diameter using a series of reamers to establish the bore to the necessary diameter. Once completed, the pipe segment will be assembled and pulled through the bore.

If proposed, an HDD contingency plan will be developed, and geotechnical investigations would be conducted. During construction, MOUNTAIN VALLEY will minimize or avoid impacts by implementation of the construction practices outlined in the *HDD Contingency Plan*. MOUNTAIN VALLEY will consult with VADEQ and other regulatory agencies for approval on this crossing method prior to implementation.

4.1.3 Conventional Bore Method

Some waterbodies are directly associated with or adjacent to roads or railroads. Where these roads or railroads are to be crossed using a horizontal boring machine, the waterbody will typically be included within the length of the bore. Some elevated or channelized waterbodies, such as irrigation ditches, may also be successfully bored, depending upon the groundwater level in the area. To complete a conventional bore or guided conventional bore, two pits will be excavated, one on each side of the feature to be bored. A boring machine will be lowered into one pit, and a horizontal hole will be bored to a diameter equal to the diameter of the pipe (or casing, if required) at the depth of the pipeline installation. The pipeline section and/or casing will then be pushed through the bore to the opposite pit. If additional pipeline sections are required to span the length of the bore, they will be welded to the first section of the pipeline in the bore pit before being pushed through the bore (MVP-51—Typical Waterbody Conventional Bore).

4.1.4 Guided Conventional Bore

This methodology is very similar to the conventional bore method, except a small diameter “guided pilot” is installed first. The drill string is then attached to the front of the conventional auger during the final hole opening phase. After the pilot hole is successfully across the span, the drill string remains in place and the conventional auger bore machine completes the bore to the required diameter attaching to the drill stem to

keep the conventional auger bore in line. The stems are removed on the exit side as the auger advances from the launch side. No fluids are utilized during the conventional auger bore phase.

4.1.5 Microtunnel Method

Microtunneling is an enhanced drilling technique that allows for trenchless excavation beneath features including roads, highways, railroads, rivers, waterbodies, environmentally sensitive areas, landfills, and shore approaches. As in a conventional bore, Microtunneling typically requires two pits to be excavated, one on each side of the feature to be bored. These pits are typically closer to the feature being crossed than they would be for an HDD. Unlike a conventional auger bore, microtunneling utilizes a microtunneling boring machine (MTBM), which uses remote-operated hydraulic cylinders to steer the machine along the proposed bore path. Microtunneling only requires one drilling pass as the product pipe is in inserted behind the MTBM as it completes the bore—significantly reducing the risk of collapse. Additionally, microtunneling's use of a much smaller volume of drilling fluid at a drastically reduced pressure greatly minimizes the risk of an inadvertent return.

4.1.6 Direct Pipe

Direct Pipe drilling is a proprietary trenchless installation method that combines the advantages of traditional HDD and microtunneling technology, while reducing the potential for inadvertent returns associated with HDD. Direct Pipe drilling uses an MTBM drilling head and benefits from the same advantages as microtunneling including low IR potential, steerability, installation of pipe with a single drilling pass, and mitigated risk of bore hole collapse. Direct pipe can be used for trenchless construction below features including roads, railways, rivers, waterbodies, environmentally sensitive areas, landfalls, and shore approaches.

4.1.7 Bore Pits

Use of bore pits (required for the horizontal directional drill method, conventional bore method, guided conventional bore method, microtunnel method, and direct pipe) requires excavation of launching and receiving pits located in workspace on each side of the feature being crossed. The excavation of bore pits is not materially different from other upland construction activities. Bore pits will be excavated within the approved limits-of-disturbance. The bore pit excavations are sloped or shored to comply with all local, state, and federal safety regulations. Like trench excavation, bore pits produce spoil piles from the excavated material to create the pit, which are monitored and managed until the bore is complete, and the bore pits are backfilled. Those spoil piles shall be stabilized and/or provided with sediment trapping measures in accordance with the requirements applicable to soil stockpiles (e.g., Sections 2.13, 4.2.2, and 6.0). Dewatering may be required and, if so, will be conducted in accordance with the requirements for trench dewatering (Section 2.15.2).

4.1.8 Flume Pipe Method

If the stream crossing is less than ten feet wide the flume pipe method may be used. The flume pipe method is typically used in combination with an equipment crossing and starts with the installation of the dam, pump, and flume, continuing with the trench excavation, the pipeline installation, backfilling of the trench and ending with the stabilization of the stream bank. This process will be completed as fast as practicable from

flume installation to stabilization of the stream bank. The flume pipe crossing must be made operational prior to the start of construction in the stream. No material will be removed from the stream until the flume is in place. The flume is sandbagged at each end to direct the stream flow through the flume, and the outlet is protected with riprap to minimize scour. The pipeline trench can then be excavated (while dry), the pipe installed, and backfilling completed with the flume pipe in place. Spoil piles will be kept a minimum of 10 feet from the water's edge and will be contained by sediment barriers. Trenching and backfilling must be completed, and the disturbed stream banks must be stabilized with riprap or vegetation before the flumes for the pipeline and equipment crossings are removed (VESCH STD & SPEC 3.23 and STD & SPEC 3.25: Plate 3.25-3, respectively).

4.1.9 Cofferdam (Porta-dam) Method

This method may be used for crossing channels 10 feet or wider and will be designed so as not to prevent the flow of the stream. A cofferdam will be constructed within the construction ROW (using cofferdam products, etc.), enclosing approximately 60% the streambed in a semi-circle (VESCH STD & SPEC: Plate 3.25-4). The cofferdam should seal tightly to the streambed to minimize water from entering the construction area. Pumps will be needed to keep water out of excavations. All earth disturbance will occur in the dry area behind the cofferdam. The pipe will be installed, and the disturbed area backfilled and stabilized. Sediment barriers at the waterline should be in good working order before the cofferdam is removed. Stabilization will occur with either riprap or vegetation. The cofferdam is then set up from the opposite bank and extends far enough to include the tie-in point in mid-stream. The remainder of the pipe is installed and the tie-in weld is made. Clean up follows the same procedures described above.

4.1.10 Pump-Around (Dam and Pump) Method

The pump-around method is a "dry ditch" construction technique utilizing pumps and hoses to convey waterbody flow around the excavation area (MVP-ES8). The following restrictions apply when using the pump-around method.

- Sandbag bulkheads or porta-dams shall be constructed above and below the area of excavation.
- Stand-by pump(s) and hose(s) must be on-site during the crossing.
- Pumps shall have secondary containment in accordance with the SPCC Plan.
- Downstream flow must be maintained throughout trenching, pipe laying and backfilling operations.
- Screening (intake hose) must meet the minimum specification per agency requirements.
- Dewater structure with energy dissipater shall be utilized to prevent scour and increased sedimentation.
- Filter bags can be used to maintain clean water.

4.2 AREAS OF SPECIAL CONCERN

MOUNTAIN VALLEY has identified areas of special concern that exist within a project area. A discussion of these areas follows.

4.2.1 Steep Slope Areas

Slope gradients will be identified on the ESC plans in steep slope areas. Potential for erosion may be

present in areas of steep slopes and increases as slope length and gradient increases. Additional erosion and sediment control measures may be necessary in these areas based upon field conditions at the time of construction. Refer to Table 10 for the slope ranges and erosion hazard.

Table 10. Erosion Hazard Ratings

Slope Gradient	Length of Slope	Erosion Hazard Rating
0-7%	< 300 feet	Low
7-15%	< 150 feet	Moderate
0-7%	> 300 feet	High
7-15%	> 150 feet	
≥15%	> 75 feet	

Additionally, steep slopes are defined differently for each of the six counties within the Commonwealth in which MOUNTAIN VALLEY presently operates, detailed in Table 11 below.

Table 11. County-Specific Steep Slopes Definitions

County	Steep Slope Definition	Source	Notes
Craig	Not defined	N/A	**No local definitions found**
Giles	> 20%	Giles Co. 2012 Comp Plan	Revision adopted 2012; Natural Resources-Slope
Montgomery	> 25%	Montgomery Co. 2025 Comp Plan	Adopted 2004, revised 2011; Planning and Land Use Policies, PLU 1.2; also mentioned in Co. Code Sec 10-39(h)4
Roanoke	> 33%	Roanoke Co. Code	Sec. 8.1.3 – Definitions; Chapter 12 Stormwater Design Manual
Franklin	> 25%	Franklin Co. 2025 Comp Plan	Adopted 2007; also mentioned in Co. Code Sec 25-189(f)(4) in regards to required open space for residential cluster development
Pittsylvania	> 25%	Pittsylvania Co. 2010 Comp Plan	Chapter 2 -Natural and Cultural Environment

Construction activities within areas considered as steep slope conditions will be conducted in accordance with the BMPs presented in a project's Landslide Mitigation Plan (if applicable to a project) and MOUNTAIN VALLEY's steep slope typical details (see Appendices F and B, respectively).

4.2.2 Soils Properties

Soils mapping information for soils crossed by the Project will be provided on the Existing Conditions plan drawing set included as part of the ESC/SWM plans. The soil erodibility factor (K) denotes the sensitivity of different soils to the forces of erosion. Areas that have a high erodibility rating will be noted as a critical area on the Project's Existing Conditions plans. Additional erosion and sediment control measures may be necessary in these areas based upon field conditions at the time of construction. Refer to Table 12 for the erodibility factors:

Table 12. Erodibility Factor

Erodibility Factor (K)	Erodibility Rating
≤ 0.23	Low
0.23 - 0.36	Moderate
≥ 0.36	High

The soil reactivity (pH) is a major factor in the establishment of vegetation and permanent stabilization of the disturbed areas. The surface soil pH and associated lime application rate are specified in Section 2.18.2 (Permanent Seeding) and will be noted on the ESC plans. Additional information regarding acid forming materials (soils/rock) are detailed below in Section 4.2.4 Acidic Soil Areas.

Sensitive soils such as agricultural soils (prime farmlands or farmland soils of statewide importance), wetland soils and topsoil in all areas will be segregated during implementation. During preparation of the LOD and trench excavation, topsoil will be segregated and stockpiled separately from excavated subsoil. Topsoil will be temporarily stabilized with mulch and seeded (as needed) in accordance with typical construction detail MVP-ES45. Following installation of the pipeline and backfilling of the trench with subsoil, MOUNTAIN VALLEY will disc the subsoil in accordance with Section 2.17.3 (Soil Compaction Mitigation) to enhance revegetation of the ROW. During backfill and final grading, topsoil and subsoil will be returned to their original profile. Permanent slope breakers, if required, will be installed in accordance with typical construction detail MVP-17 and MVP-18. Once the topsoil has been returned to its original profile, additional soil compaction mitigation will be conducted over the full LOD followed by permanent seed and mulch installation.

4.2.3 Landslide Prone Areas

Landslides occur primarily in weathered bedrock or colluvial soil and within old landslide debris located on steep slopes. Where appropriate based on-site conditions, MOUNTAIN VALLEY will develop a Landslide Mitigation Plan (LMP) to address areas of concern identified prior to construction and present mitigation strategies that may be implemented at other areas during construction. The LMP areas are identified by reviewing available historic aerial photographs, soils data, and topographic maps. Construction operations will be staffed with geotechnical personnel who will identify additional areas in which the LMP mitigation measures will be implemented (and additional mitigation measures, as necessary).

4.2.4 Acidic Soils Areas

Areas of acidic soils are known to occur within portions of Virginia. In order to identify and mitigate potential impacts should these soils be encountered, an Acid Forming Materials Identification and Testing Work (AFM) Plan will be referenced for implementation during activities.

4.2.5 Karst Areas

Karst areas are known to occur in portions of Virginia. If karst areas will be crossed by a pipeline construction project, MOUNTAIN VALLEY will prepare a Karst Hazards Assessment that describes construction methods to mitigate or eliminate potential impacts (see Appendix D) for karst features that cannot be avoided through minor variations within the construction easement. If conditions require, Karst Specialist inspection teams will be deployed during construction to monitor karst features and provide recommendations for avoidance or mitigation. Locations of all karst features identified during project investigations will be included on the ESC and SWM plan drawings submitted to VADEQ for each construction spread.

4.2.6 Waterbody and Wetland Areas

During planning, routing, and design phases of a pipeline construction project, MOUNTAIN VALLEY will conduct desktop analyses and field delineations to identify waterbody and wetland areas within the study corridor. Identified waterbody resources include streams (unnamed as well as named tributaries), springs/seeps, water supply wells, ponds, and other surface impoundments as well as wetlands. Desktop review as well as field verification will be utilized to identify private ponds located within 1,500 feet downslope of a project LOD. All waterbody and wetland resources identified within the Project LOD and areas immediately adjacent to the LOD (including temporary workspaces, ATWS, contractor yards, access roads, etc.) will be depicted on a project's ESC and SWM plan drawings. All waterbody and wetland areas disturbed by construction activities will be permitted under the US Army Corps of Engineers / VADEQ Joint Permit Application process.

Project ESC plans are designed with appropriate BMPs to protect all crossed and adjacent resources including waterbody and wetland areas from potential sedimentation as result of construction activities.

4.2.7 Other Environmentally Sensitive Areas

During routing, field investigations, and design, other environmentally sensitive areas can be identified. Other environmentally sensitive areas include but are not limited to the following: threatened and endangered species areas, culturally significant areas (cemeteries, historical or archaeological resources), or areas identified by landowners as being of concern. Since environmentally sensitive areas are treated as confidential for the protection of those resources, these resources will not be specifically identified on ESC or SWM plans. MOUNTAIN VALLEY will comply with all mitigation requirements imposed by the relevant federal or state agencies with authority for these resources – such as any requirements developed through the Endangered Species Act and National Historic Preservation Act consultation processes – and will utilize appropriate BMPs deployed during construction as an additional level of protection for these areas.

4.2.8 Water Supply Sources

MOUNTAIN VALLEY will develop a Water Resources Identification and Testing Plan which outlines

procedures for identification and testing of both private and public water supply for any pipeline construction projects. MOUNTAIN VALLEY will identify public water supply sources within three miles downstream of the proposed project disturbances as well as private water supply resources (springs/wells) within 150 feet of the LOD in non-karst areas and within 500 feet of the LOD in karst areas (as applicable). MOUNTAIN VALLEY will conduct desktop reviews supplemented by field verification (where access has been granted) as well as in discussions with property owners to identify locations of private water supplies. Landowners and public water suppliers with water supply resources located within the parameters listed above will be contacted regarding access to request permission for MOUNTAIN VALLEY will complete baseline testing prior to construction activities.

4.2.9 Subsurface Drainage Areas

Project activities in Virginia are likely to encounter subsurface drainage features during construction activities. These include drain tiles and irrigation lines. Locations of these resources are identified during routing, landowner discussions during ROW acquisition, and when exposed during construction implementation. Locations will be identified during pre-construction stakeout (when known). All drain tiles including septic (sewer) drain field lines, drain tiles and irrigation lines damaged or disturbed during construction will be repaired and returned to their original condition and function. Any disruption to service and alternative mitigation measures will be coordinated with the affected landowner.

During construction, MOUNTAIN VALLEY will install permanent trench breaker drains to facilitate removal of accumulated groundwater from the pipeline trench. Permanent trench breaker drains will be installed and maintained in accordance with typical construction details MVP-20 Typical Trench Breaker Requirements and MVP-35 Trench Breaker Daylight Drain. In addition, MOUNTAIN VALLEY will install cutoff drains to convey subsurface flow/groundwater through the permanent ROW in areas of side-hill construction per typical construction details MVP-36 through MVP-38 and MVP-43 and MVP-44, respectively. Appropriate outlet protection will be installed as needed. All trench breaker drains and cut- off drain installations will be noted on the ESC/SWM drawings following installation.

4.2.10 Drainage Features

Non-jurisdictional drainage features such as roadside ditches, swales, diversion ditches and diversion terraces may be crossed during construction activities. During construction, MOUNTAIN VALLEY will maintain service through these drainage features to the extent practicable. This will include installation of temporary culverts or pump around contingency if water is present at time of crossing installation. Following installation of the Project, all non-jurisdictional drainage features will be returned to pre-construction contours and conditions.

4.2.11 Utility Line Crossings

Portions of a pipeline route may cross existing public and private utility corridors. Many of the locations will be identified during field routing activities and during property owner negotiations. Locations of these utilities are not depicted on the Project ECS plans to minimize potential for misidentification of the utility location. In order to accurately depict utility locations prior to commencement of Project earth disturbing activities, MOUNTAIN VALLEY's contractors will notify Miss Utility of Virginia at www/va811.com or 1-800-552-7001 to have existing utility line locations delineated. For distribution and service lines that are not covered by the VA811 notice, MOUNTAIN VALLEY will coordinate with the property owner to identify approximate line locations. In addition, MOUNTAIN VALLEY contractors will utilize appropriate line locating equipment to

identify locations of buried service lines (gas/water/electric) that are not covered by the VA811 system. Appropriate signage will be installed to identify locations of existing utilities prior to commencing construction.

Aboveground utility lines including electric (distribution and transmission), telephone, tv cable, or other will be appropriately delineated. Aboveground utility locations are typically identified using a combination of signage, dedicated spotter and physical barriers placed in proximity to the utility line. Examples include use of ground signage and hazard or car lot ribbon tied to non-conductive goal posts placed on either side of the LOD. Locations of overhead utility crossings that require identification are determined during pre-construction stakeout of the LOD and appropriate marking installed at that time.

5.0 MAINTENANCE OF PERMANENT RIGHT-OF-WAY

5.1 POST-CONSTRUCTION MONITORING AND MAINTENANCE

Follow-up inspections of all disturbed areas after the first and second growing seasons will be conducted to determine the success of revegetation. In general, revegetation cannot be determined to be fully established until it has been maintained for one full year after planting. Permanent vegetation shall not be considered established until a ground cover is achieved that is uniform, mature enough to survive and will inhibit erosion. If vegetative cover and density is not acceptable or there are excessive noxious weeds after two full growing seasons, a professional agronomist will determine the need for additional restoration measures (such as fertilizing or reseeding). When necessary, the measures recommended by the agronomist will be implemented. In agricultural areas, revegetation shall be considered successful when upon visual survey, crop growth and vigor are similar to adjacent undisturbed portions of the same field, unless the easement agreement specifies otherwise.

Drainage and irrigation systems will be monitored and problems resulting from pipeline construction in active agricultural areas will be corrected. Trench breaker drains and cut-off drains installed within the pipeline trench will be monitored and maintained functional during operation of the Project. Outlet locations will be field identified via appropriate measures (i.e. signage, flagging, etc.).

Normally, the entire permanent ROW will be maintained. Maintaining this width is necessary for the following reasons:

- Access for routine pipeline patrols and corrosion surveys.
- Access in the event that emergency repairs of the pipeline are needed.
- Visibility during aerial patrols. The full width of the ROW will be kept clear where overhanging foliage decreases visibility.

Vegetation maintenance adjacent to waterbodies will be limited to allow a riparian strip at least 25-feet wide, as measured from the waterbody's ordinary high-water mark, to permanently revegetate with native plant species across the entire ROW. However, to facilitate periodic pipeline corrosion/leak surveys, a corridor centered on the pipeline and up to 10 feet wide will be mowed annually and may be maintained in an herbaceous state. In addition, trees that are located within 15 feet of the pipeline and are greater than 15 feet in height may be cut and removed from the ROW.

The success of wetland revegetation will be monitored in accordance with the FERC PLAN and PROCEDURES and any other requirements from the U.S. Army Corps of Engineers.

Shrubs or other vegetation used to screen long sections of the ROW from public view will be properly maintained. Efforts to control unauthorized off-road vehicle use, in cooperation with the landowner, will continue throughout the life of the Project. Signs, gates, and vehicle trails will be maintained as necessary.

5.1.1 Long Term Responsibility and Maintenance

Upon completion of any project, MOUNTAIN VALLEY will provide the VADEQ with a document with the following information:

- The responsible parties that will provide for the long-term maintenance of the project;
- Maintenance Agreements, with VADEQ's review and approval, for any applicable structural BMPs; and
- MOUNTAIN VALLEY will comply with Table 1 – Forest & Open Space from the Virginia Runoff Reduction Method Compliance Spreadsheet User's Guide & Documentation (April 2016) regarding mowing and general maintenance.

5.2 MAINTENANCE TECHNIQUES

5.2.1 Mowing

ROW will be maintained in compliance with Table 1 – Forest & Open Space from the Virginia Runoff Reduction Method Compliance Spreadsheet User's Guide & Documentation (April 2016) regarding mowing and general maintenance. However, to facilitate periodic corrosion and leak surveys, a corridor not exceeding 10 feet in width centered on the pipeline may be maintained annually in an herbaceous state (brush hogged no more than annually). Full ROW clearing is to occur no more frequently than once every 3 years. In no case shall routine vegetation maintenance clearing occur between April 15 and August 1 of any year.

In wetland areas, no routine vegetation mowing or clearing will be conducted over the full width of the permanent ROW in wetlands. In order to facilitate periodic inspections, a corridor centered over the pipeline and up to 10 feet wide may be cleared at a frequency necessary to maintain the 10-foot corridor in an herbaceous state. In addition, trees within 15 feet of the pipeline with roots that could compromise the integrity of the pipeline coating may be selectively cut and removed from the permanent ROW. Native herbaceous and woody shrub species will be allowed to reestablish in wetland ROW as noted above.

Herbicides or pesticides will not be used in or within 100 feet of a wetland, except as authorized by the appropriate federal or state agency.

5.2.2 Wetland Right-of-Ways

Maintenance of permanent ROW in wetlands will be performed in compliance with all applicable wetland permit conditions as well as Section 2.18.7. of these Standards and Specifications, and FERC's PLAN and PROCEDURES. There will be no herbicides or pesticides applied in or within 100 feet of a wetland boundary, except as allowed by the appropriate federal or state agency.

5.2.3 Erosion Control

Erosion issues identified on the pipeline ROW during facility operations will be reported to the local MOUNTAIN VALLEY Operations Supervisor and addressed accordingly. These reports may originate from landowners, agencies, or MOUNTAIN VALLEY personnel performing routine patrols. Corrective measures will be performed as needed.

5.2.4 Routine Pipeline Patrol

Routine pipeline ROW inspections will be performed to ensure that MOUNTAIN VALLEY can maintain continuous, reliable service to its customers. During these inspections, all permanent ESC devices installed during construction will be inspected to ensure that they are functioning properly. In addition, attention should be given to:

- Fallen timber or other perils to the pipeline;
- Signs of ground settlement/movement that might endanger the pipeline or adjacent lands;
- Signs of encroachment on the pipeline or pipeline ROW;
- Missing or damaged line markers or fence enclosures;
- Emergency contact information is posted on all enclosures and line markers verification;
- Areas of erosion and washouts across the ROW;
- Permanent ROW diversions (Slope Breakers);
- Waterbody crossings; and
- Any other conditions that could imperil the pipeline or conflict with MOUNTAIN VALLEY's rights under existing ROW agreements.

The local MOUNTAIN VALLEY Operations Supervisor will be notified of any conditions that need attention. Corrective measures taken will be documented and performed on a priority or as needed basis.

5.3 REPORTING

The Program Administrator shall maintain records that identify by milepost:

1. Method of application, application rate, and type of fertilizer, pH modifying agent, seed, and mulch used;
2. Acreage treated:
3. Dates of backfilling and seeding; and
4. Names of landowners requesting special seeding treatment and a description of the follow-up actions.
5. Weekly e-reporting to the applicable VADEQ regional office.

6.0 VIRGINIA EROSION AND SEDIMENT CONTROL REGULATIONS (9VAC25-840-40) MINIMUM STANDARDS

An erosion and sediment control program adopted by an operator must be consistent with the following criteria, techniques and methods, unless a variance request is granted by VADEQ:

Minimum Standard 1 – Permanent or temporary soil stabilization shall be applied to denuded areas within seven days after final grade is reached on any portion of the site. Temporary soil stabilization shall be applied within seven days to denuded areas that may not be at final grade but will remain dormant for longer than 14 days. Permanent stabilization shall be applied to areas that are to be left dormant for more than one year.

Minimum Standard 2 – During construction of the project, soil stockpiles and borrow areas shall be stabilized or protected with sediment trapping measures. The applicant is responsible for the temporary protection and permanent stabilization of all soil stockpiles on site as well as borrow areas and soil

intentionally transported from the project site.

Minimum Standard 3 – A permanent vegetative cover shall be established on denuded areas not otherwise permanently stabilized. Permanent vegetation shall not be considered established until a ground cover is achieved that is uniform, mature enough to survive and will inhibit erosion.

Minimum Standard 4 – Sediment basins and traps, perimeter dikes, sediment barriers and other measures intended to trap sediment shall be constructed as a first step in any land-disturbing activity and shall be made functional before upslope land disturbance takes place.

Minimum Standard 5 – Stabilization measures shall be applied to earthen structures such as dams, dikes and diversions immediately after installation.

Minimum Standard 6 – Sediment traps and sediment basins shall be designed and constructed based upon the total drainage area to be served by the trap or basin.

A. The minimum storage capacity of a sediment trap shall be 134 cubic yards per acre of drainage area and the trap shall only control drainage areas less than three acres.
B. Surface runoff from disturbed areas that is comprised of flow from drainage areas greater than or equal to three acres shall be controlled by a sediment basin. The minimum storage capacity of a sediment basin shall be 134 cubic yards per acre of drainage area. The outfall system shall, at a minimum, maintain the structural integrity of the basin during a 25-year storm of 24-hour duration. Runoff coefficients used in runoff calculations shall correspond to a bare earth condition or those conditions expected to exist while the sediment basin is utilized.

Minimum Standard 7 – Cut and fill slopes shall be designed and constructed in a manner that will minimize erosion. Slopes that are found to be eroding excessively within one year of permanent stabilization shall be provided with additional slope stabilizing measures until the problem is corrected.

Minimum Standard 8 – Concentrated runoff shall not flow down cut or fill slopes unless contained within an adequate temporary or permanent channel, flume or slope drain structure.

Minimum Standard 9 – Whenever water seeps from a slope face, adequate drainage or other protection shall be provided.

Minimum Standard 10 – All storm sewer inlets that are made operable during construction shall be protected so that sediment-laden water cannot enter the conveyance system without first being filtered or otherwise treated to remove sediment.

Minimum Standard 11 – Before newly constructed stormwater conveyance channels or pipes are made operational, adequate outlet protection and any required temporary or permanent channel lining shall be installed in both the conveyance channel and receiving channel.

Minimum Standard 12 – When work in a live watercourse is preformed, cautions shall be taken to minimize encroachment, control sediment transport and stabilize the work area to the greatest extent possible during construction. Non-erodible material shall be used in the construction of causeways and cofferdams. Earthen fill may be used for these structures if armored by non-erodible cover materials.

Minimum Standard 13 – When a live water course must be crossed by construction vehicles more than twice in any six-month period, a temporary vehicular stream crossing constructed of non-erodible material shall be provided.

Minimum Standard 14 – All applicable federal, state and local regulations pertaining to working in or crossing live watercourses shall be met.

Minimum Standard 15 – The bed and banks of a watercourse shall be stabilized immediately after work

in the watercourse is completed.

Minimum Standard 16 – Underground utility lines shall be installed in accordance with the following standards in addition to other applicable criteria.

A. No more than 500 linear feet of trench may be opened at one time.

B. Excavated material shall be placed on the uphill side of trenches.

C. Effluent from dewatering devices shall be filtered or passed through an approved sediment trapping device, or both and discharged in a manner that does not adversely affect flowing streams or offsite property.

D. Material used for backfilling trenches shall be properly compacted in order to minimize erosion and promote stabilization.

E. Restabilization shall be accomplished in accordance with these regulations.

F. Applicable safety regulations shall be complied with.

Minimum Standard 17 – Where construction vehicle access routes intersect paved or public roads, provisions shall be made to minimize the transport of sediment by vehicular tracking onto the paved surface. Where sediment is transported onto a paved or public road surface, the road surface shall be cleaned thoroughly at the end of each day. Sediment shall be moved from the roads by shoveling or sweeping and transported to a sediment control disposal area. Street washing shall be allowed only after sediment has been removed in this manner. This provision shall apply to individual development lots as well as to larger land-disturbing activities.

Minimum Standard 18 – All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization or after the temporary measures are no longer needed, unless otherwise authorized by the VESCP authority. Trapped sediment and the disturbed soil areas resulting from the disposition of temporary measures shall be permanently stabilized to prevent further erosion and sedimentation.

Minimum Standard 19 – Properties and waterways downstream from development sites shall be protected from sediment deposition, erosion and damage due to increases in volume, velocity and peak flow rate of stormwater runoff for the stated frequency storm of 24-hour duration in accordance with the following standards and criteria. Stream restoration and relocation project that incorporate natural channel design concepts are not man-made channels and shall be exempt from any flow rate capacity and velocity requirements for natural or man-made channels:

A. Concentrated stormwater runoff leaving a development site shall be discharged directly into an adequate natural or man-made receiving channel, pipe or storm sewer system. For those sites where runoff is discharged into a pipe or pipe system, downstream stability analyses at the outfall of the pipe or pipe system shall be performed.

B. Adequacy of all channels and pipes shall be verified in the following manner:

1. The applicant shall demonstrate that the total drainage area to the point of analyses within the channel is one hundred times greater than the contributing drainage area of the project in question; or

2. (a) Natural channels shall be analyzed by the use of a 2-year storm to verify that stormwater will not overtop channel banks nor cause erosion of channel bed or banks

   (b) All previously constructed man-made channels shall be analyzed by the use of a 10-year storm to verify that stormwater will not overtop its banks and by the use of a 2-year storm to demonstrate that stormwater will not cause erosion of channel bed or banks; and

(c) Pipes and storm sewer systems shall be analyzed by the use of a 10-year storm to verify that stormwater will be contained within the pipe or system.

C. If existing natural receiving channels or previously constructed man-made channels or pipes are not adequate, the applicant shall:

(1) Improve the channels to a condition where a 10-year storm will not overtop the banks and a 2-year storm will not cause erosion to the channel, the bed, or the banks; or

(2) Improve the pipe or pipe system to a condition where the 10-year storm is contained within the appurtenances;

(3) Develop a site design that will not cause the pre-development peak runoff rate from a 2-year storm to increase when runoff outfalls into a natural channel or will not cause the pre-development peak runoff rate from a 10-year storm to increase when runoff outfalls into a man-made channel; or

(4) Provide a combination of channel improvement, stormwater detention or other measures which is satisfactory to the VESCP authority to prevent downstream erosion.

D. The applicant shall provide evidence of permission to make the improvements.

E. All hydrologic analyses shall be based on the existing watershed characteristics and the ultimate development of the subject project.

F. If the applicant chooses an option that includes stormwater detention, the applicant shall obtain approval from the VESCP of a plan for maintenance of the detention facilities. The plan shall set forth the maintenance requirements of the facility and the person responsible for performing the maintenance.

G. Outfall from a detention facility shall be discharged to a receiving channel, and energy dissipaters shall be placed at the outfall of all detention facilities as necessary to provide a stabilized transition from the facility to the receiving channel.

H. All on-site channels must be verified to be adequate.

I. Increased volumes of sheet flows that may cause erosion or sedimentation on adjacent property shall be diverted to a stable outlet, adequate channel, pipe or pipe system or to a detention facility.

J. In applying these SWM criteria, individual lots or parcels in a residential, commercial or industrial development shall not be considered to be separate development projects. Instead, the development, as a whole, shall be considered to be a single development project. Hydrologic parameters that reflect the ultimate development condition shall be used in all engineering calculations.

K. All measures used to protect properties and waterways shall be employed in a manner which minimizes impacts on the physical, chemical and biological integrity of rivers, streams and other waters of the state.

L. Any plan approved prior to July 1, 2014, that provides for stormwater management that addresses any flow rate capacity and velocity requirements for natural or man-made channels shall satisfy the flow rate capacity and velocity requirements for natural or man-made channels if the practices are designed to (i) detain the water quality volume and to release it over 48 hours; (ii) detain and release over a 24-hour period the expected rainfall resulting from the one year, 24-hour storm; and (iii) reduce the allowable peak flow rate resulting from the 1.5, 2, and 10-year, 24-hour storms to a level that is less than or equal to the peak flow rate from the site assuming it was in a good forested condition, achieved through multiplication of the forested peak flow rate by a reduction factor that

is equal to the runoff volume from the site when it was in a good forested condition divided by the runoff volume from the site in its proposed condition, and shall be exempt from any flow rate capacity and velocity requirements for natural or man-made channels as defined in any regulations promulgated pursuant to § 62.1-44.15:54 or 62.1-44.15:65 of the Act.

M. For plans approved on and after July 1, 2014, the flow rate capacity and velocity requirements of § 62.1-44.15:52 A of the Act and this subsection shall be satisfied by compliance with water quantity requirements in the Stormwater Management Act (§ 62.1-44.15:24 et seq. of the Code of Virginia) and attendant regulations, unless such land-disturbing activities (i) are in accordance with provisions for time limits on applicability of approved design criteria in 9VAC25-870-47 or grandfathering in 9VAC25-870-48 of the Virginia Stormwater Management Program (VSMP)

Regulation, in which case the flow rate capacity and velocity requirements of § 62.1-44.15:52 A of the Act shall apply, or (ii) are exempt pursuant to § 62.1-44.15:34 C 7 of the Act.

N. Compliance with the water quantity minimum standards set out in 9VAC25-870-66 of the Virginia Stormwater Management Program (VSMP) Regulation shall be deemed to satisfy the requirements of this subdivision 19. Compliance with SWM regulatory requirements is required for projects that meet the threshold for SWM land disturbing activity.

In addition to the minimum erosion and sedimentation control standards and specifications, MOUNTAIN VALLEY will complete and, if required or requested by VADEQ, submit SWM calculations regarding water quantity per Section 9VAC25-870-66 and water quality per Section 9VAC25-870-65 and -96 of the Virginia Stormwater Management Program Regulation. The calculations will be provided under separate cover along with the design elements required to meet stormwater quantity and quality requirements which will be depicted on the project ESC plans.

APPENDIX A – U.S. FOREST SERVICE PUBLICATIONS

The following provides project-specific information for the Mountain Valley H-605 Pipeline.

This information will be addressed in the relevant plan sets for any other projects.

SUGGESTED SEED MIXES FOR PIPELINE RIGHTS-OF-WAYS AND ASSOCIATED DISTURBANCES ON THE MONONGAHELA AND GEORGE WASHINGTON-JEFFERSON NATIONAL FORESTS

November 2016

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Introduction

This document is meant to provide direction for assembling seed mixes to be used in reclamation and restoration of disturbed soils associated with pipeline installations and repairs/maintenance on the MNF and GW-Jefferson National Forests. Initially, the primary goal of seeding is to establish a vegetative cover to minimize surface erosion and sedimentation resulting from precipitation and surface flow. The secondary goal of these seeding guidelines is to assist with establishing an assortment of native species beneficial for wildlife and pollinators. All recommended species are commercially available.

Because this area possesses such diverse landscapes and microclimates, it is critical to deploy appropriate seed mixes in appropriate habitats. However, native plants that provide diverse wildlife benefits and structural diversity on the landscape often do not germinate or grow fast enough to provide initial erosion control. Therefore, fast-germinating, non-invasive, annual cover crops are recommended for the first round of seeding to stabilize exposed soil. Once those have established and erosion is no longer an immediate threat, native seed mixes tailored to site-specific conditions should be installed among the erosion control species where possible.

When using native seed, use as local an ecotype as is available, in the following order of preference:

- from within state
- from the mountain regions of an adjoining state
- from within 100 miles, as long as it is within the Appalachian mountain ecosystem

This document contains:

- Species recommendations for both temporary and permanent erosion control mixes
- Species recommendations for native mixes beneficial for wildlife and pollinators
- Site specific species recommendations for special site conditions (upland/high elevation, riparian, wetland, and dry low pH soils). Wetland indicator status codes are used to indicate species' soil moisture preferences. (USDA NRCS)

SPECIES FOR EROSION CONTROL

Temporary erosion control species:
To be applied

- wherever erosion control is needed outside of normal seeding seasons
- concurrent with permanent erosion control, and
- prior to permanent seeding with wildlife mixes, where such follow-up is appropriate.

Select at least two of the following species for temporary mixes, or suggest an existing erosion control seed mix containing at least some of these species but not containing anything that would act invasive at the site. Please describe how seed mixes will be adjusted to accommodate different slope classes (for example, 0-8%, 8-15%, 15-30%, 30-50%, etc.)

Table 1: Temporary erosion control species

Name	**pH preference**	**Wetland Indicator Status**
Annual Ryegrass (Lolium multiflorum (L. perenne var. italicum))	5.0-7.9	NI/moderate
German/Foxtail Millet (Setaria italica)	5.3-6.9	FACU
Cereal Rye (Secale cereale)	52-8.0	NI/damp
Browntop Millet (Panicum ramosum) (introduced in VA & south; possibly ok for WV?)	5.5-6.9	FACU

Permanent erosion control species:
To be applied

- only during normal seeding season in spring and fall
- on slopes too steep or inaccessible for planting equipment, or
- on areas planned to be left not in final grade for more than 1 year.

Select at least 5 of the following species for permanent mixes, or suggest an existing restoration seed mix containing at least some of these species but not containing anything that would act invasive at the site. Please also include at least one species from Table 1 or one non-native from Table 2 to provide quick cover and mulching/organic matter. Please describe how seed mixes will be adjusted to accommodate different slope classes (for example, 0-8%, 8-15%, 15-30%, 30-50%, etc.).

Table 2: Permanent erosion control species

Name	**pH preference**	**Wetland Indicator Status**
Non-native		
Hard Fescue (Festuca ovina var. duriuscula (F. longifolia))	4.5-8.5	NI/dry
Creeping Red Fescue (Festuca rubra)	5.8-8.0	FACU

Chewings Fescue (Festuca rubra ssp. commutata)	acid tol.	FACU
Redtop (Agrostis alba)	4.5-8.0	FACW
Native		
Highly Preferred		
Indiangrass, (Sorghastrum nutans)	5.0-7.8	UPL
Purpletop (Tridens flavus)	4.5-6.5	FACU
Preferred		
Autumn Bentgrass, (Agrostis perennans)	5.5-7.5	FACU
Canada Wildrye (Elymus canadensis)	5.0-7.9	FACU+
Creeping Red Fescue (Festuca rubra)	5.8-8.0	FACU
Deertongue (Dichanthelium clandestinum)	4.0-7.5	FAC+
Marsh (Dense) Blazing Star (Spiked Gayfeather), (Liatris spicata)	5.6-7.5	FAC+
New England Aster, (Aster novae-angliae (Symphyotrichum)	?	FACW
Oxeye Sunflower, (Heliopsis helianthoides)	?	FACU
Panicledleaf Ticktrefoil, (Desmodium paniculatum)	6.0-7.0	FACU
Showy Ticktrefoil, (Desmodium canadense)	wide tol	FAC
Slender Bushclover, (Lespedeza virginica)	acid tol	NI/dry
Slender Mountainmint (Pycnanthemum tenuifolium)	?	FAC-FACW
Virginia Wildrye, (Elymus virginicus)	5.0-7.4	FACW-
Wild Bergamot, (Monarda fistulosa)	6.0-8.0	UPL
Wild Senna (Senna hebecarpa (Cassia h.))	circumn.	FAC
Moderately preferred		
Partridge pea (Chamaecrista fasciculate)	5.5-7.5	FACU
Blackeyed Susan, (Rudbeckia hirta)	6.0-7.0	FACU-
Grain Rye (Secale cereale)	5.2-8.0	NI
Switchgrass (Panicum virgatum)	4.5-8.0	FAC
Ticklegrass (Rough Bentgrass), (Agrostis scabra)	6.0-8.0	FAC

NATIVE SPECIES FOR WILDLIFE AND POLLINATORS

To be installed as permanent vegetation in areas accessible to necessary drill or other planting equipment. (Because native seed mixes need to be drilled or otherwise covered to enhance germination success, only areas accessible to the necessary equipment should be designated for follow-up native seeding.)

For each habitat type, pick at least five species, or suggest an existing restoration seed mix containing at least some of these species but not containing anything not native to the state, or anything that would act invasive at the site. A temporary cover crop will also likely be necessary to stabilize the site and protect overwintering seeds.

As with erosion control mixes, please describe how native seed mixes will be adjusted to accommodate different slope classes (for example, 0-8%, 8-15%, 15-30%, 30-50%, etc.).

Table 3: Native species for wildlife and pollinators (pH and Wetland indicator status left blank for duplicate species)

Name	**pH preference**	**Wetland Indicator Status**
Dry Soils/Upland		
Blackeyed Susan, (Rudbeckia hirta)	6.0-7.0	FACU-
Common Milkweed, (Asclepias syriaca)	calcareous	FACU
Indiangrass, (Sorghastrum nutans)	5.0-7.8	UPL
Oxeye Sunflower, (Heliopsis helianthoides)	?	FACU
Panicledleaf Ticktrefoil, (Desmodium paniculatum)	6.0-7.0	FACU
Partridge Pea, (Chamaecrista fasciculata (Cassia f.))	5.5-7.5	FACU
Showy Ticktrefoil, (Desmodium canadense)	wide tol	FAC
Switchgrass, (Panicum virgatum)	4.5-8.0	FAC
Virginia Wildrye, (Elymus virginicus)	5.0-7.4	FACW-
High Elevation		
Mountain Mint, Pycnanthemum spp.	?	FAC-FACW
Wild Bergamot, (Monarda fistulosa)	6.0-8.0	UPL
Virginia Wildrye, (Elymus virginicus)	5.0-7.4	FACW-
Riparian		
Autumn Bentgrass, (Agrostis perennans)	5.5-7.5	FACU
Big Bluestem, 'Niagara' (Andropogon gerardii, 'Niagara')	6.0-7.5	FAC
Boneset, (Eupatorium perfoliatum)	?	FACW+
Common Sneezeweed, (Helenium autumnale)	4.0-7.5	FACW+
Indiangrass, (Sorghastrum nutans)	5.0-7.8	UPL
Joe Pye Weed, (Eupatorium fistulosum)	4.5-7.0	FAC+
Maryland Senna (Senna marilandica (Cassia m.))	4.0-7.0	FAC+
New York Ironweed, (Vernonia noveboracensis)	4.5-8.0	FACW+
Partridge Pea, (Chamaecrista fasciculata (Cassia f.))	5.5-7.5	FACU
Spotted Joe Pye Weed, (Eupatorium maculatum (Eupatoriadelphus maculatus))	5.5-7.0	FACW
Swamp Milkweed (Asclepias incarnata)	5.0-8.0	OBL
Virginia Wildrye, (Elymus virginicus)	5.0-7.4	FACW-
Wild Senna (Senna hebecarpa (Cassia h.))	circumn.	FAC
Wetland/Wet Soils (pH indicators left blank in this section because the majority of "problem" acid soil sites are dry uplands. Wetland indicators left blank because all plants are appropriate for wetlands)		
Blue False Indigo, (Baptisia australis)		
Bottlebrush Grass, (Elymus hystrix (Hystrix patula))		
Canadian Anemone, (Anemone canadensis)		
Canadian Burnet, (Sanguisorba canadensis)		

Deertongue, 'Tioga' (Panicum clandestinum (Dichanthelium c.), 'Tioga')		
Fringed (Nodding) Sedge, (Carex crinita)		
Great Blue Lobelia, (Lobelia siphilitica)		
New York Ironweed, (Vernonia noveboracensis)		
Path Rush, (Juncus tenuis,)		
Purple Node Joe Pye Weed, (Eupatorium purpureum)		
Redtop Panicgrass, (Panicum rigidulum (P. stipitatum))		
Soft Rush (Juncus effusus)		
Spotted Joe Pye Weed, (Eupatorium maculatum (Eupatoriadelphus maculatus))		
Squarrose Sedge, (Carex squarrosa)		
Swamp Milkweed (Asclepias incarnata)		
Switchgrass, 'Cave-In-Rock' (Panicum virgatum, 'Cave-In-Rock')		
Tussock Sedge, (Carex stricta)		
Wild Senna (Senna hebecarpa (Cassia h.))		
Woolgrass, (Scirpus cyperinus)		

Low pH (acidic) soils

Few of the species listed above would naturally grow well in acidic soils as defined in this project (pH less than 4.8) However, many of the species listed above would persist for several years following a lime addition with the initial seeding of soils. Blackberries and goldenrods do well in sunny, acid, dry soils, and ferns, lycopodiums, and mosses persist as vegetative cover in more shaded areas. The following are some suggestions of upland/dry site perennial species native to WV and VA, and the minimum pHs they can tolerate (all available from Ernst Seeds):

Table 4: Species for low pH soils

Name	**pH preference**	**Wetland Indicator Status**
Purpletop (Tridens flavus)	4.5-6.5	FACU
Purple lovegrass (Eragrostis spectabilis (Pursh) Steud.)	4.0-7.5	UPL
Virginia spiderwort (Tradescantia virginiana)	4.0-8.0	FACU
Common blackberry (Rubus allegheniensis)	4.6-7.5	FACU-
Canada goldenrod, (Solidago Canadensis)	4.8-7.5	FACU
Indian hemp (Apocynum cannabinum)	4.5-7.0	FACU
White avens, (Geum canadense)	4.5-7.5	FACU
Splitbeard bluestem (Andropogon ternarius var. Michx.) (native to VA & KY, & south; a warm season bunchgrass.)	4.0-7.5	FACU
Slender woodoats ((Chasmanthium laxum (Uniola laxa))	4.5-7.0	FAC

REFERENCES

Ernst Conservation Seeds. 2016. Accessed August 8, 2016. http://www.ernstseed.com/speciesmix-search/

Steinfeld, D.E., S.A. Riley, K.M. Wilkinson, T.D. Landis, L.E. Riley. 2007. Roadside Revegetation: An Integrated Approach to Establishing Native Plants. Federal Highway Administration, Western Federal Lands Highway Division. Vancouver, WA. http://www.nativerevegetation.org/learn/manual/ch_10_3.aspx

Federal Energy Regulatory Commission. 2013. Upland Erosion Control, Revegetation, and Maintenance Plan, May 2013 Version. Office of Energy Projects, Washington, D.C.

USDA-NRCS Wetland Indicator Status: More information and sources. https://plants.usda.gov/wetinfo.html Accessed 11/14/16.

Virginia Department of Conservation and Recreation. 1992. Virginia Erosion and Sediment Control Handbook. Division of Soil and Water Conservation, Richmond, VA.

VA State Water Control Board. Virginia Administrative Code, Title 9 Environment. Chapter 840: Erosion and Sediment Control Regulations.

Virginia Department of Forestry. 2002. Virginia's Forestry Best Management Practices for Water Quality, Fourth Edition.

Virginia Department of Forestry. 2011. Virginia's Forestry Best Management Practices for Water Quality, Technical Manual, Fifth Edition.

SUGGESTED SEEDING TECHNIQUES FOR PIPELINE RIGHTS-OF-WAYS AND ASSOCIATED DISTURBANCES ON THE MONONGAHELA AND GEORGE WASHINGTON-JEFFERSON NATIONAL FORESTS

November 2016

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Introduction

This document provides guidelines for erosion control seeding techniques in the reclamation and restoration of disturbed soils associated with pipeline installations and repairs/maintenance on National Forest lands. Erosion is an expected consequence of any soil disturbing activity that crosses variable and severe terrain. Therefore, a variety of short term and long term erosion control measures must be implemented. These include but are not limited to physical measures such as contouring; revegetation measures such as re-seeding and mulching; and follow up monitoring. This document specifically addresses seeding and mulching techniques.

The goal of this document is to assist contractors with designing projects so that projects are consistent with Forest Plan goals and objectives. Because every site is unique, guidelines are meant to be descriptive, not prescriptive. Specific proposals still need Forest Service approval. However, ensuring from the start that project designs are consistent with Forest Plan direction will facilitate both the review and implementation process.

Restoration objectives

The initial goal of seeding is to establish a vegetative cover to minimize surface erosion and sedimentation. The secondary goal of seeding is to assist with establishing an assortment of native species beneficial for wildlife and pollinators. Because native species often do not establish as easily nor spread as readily as species typically used for erosion control, it is important to use them in conjunction with erosion control species, and also to use techniques that maximize germination rates and likelihood of survival. This includes proper initial site stabilization, choosing appropriate site specific seed mixes, and using appropriate seeding techniques once the site has been stabilized. Follow-up monitoring and maintenance are also required so that site problems are dealt with immediately and treatments adjusted as needed.

This document includes guidelines for the following:

1) General erosion control and seeding
2) Seeding seasons
3) Nutrient additions
4) Mulch and binders

GENERAL DIRECTION FOR EROSION CONTROL AND SEEDING

Project plans must specify how each of these guidelines will be met.

- Placement of sequestered topsoil prior to seeding.
- Seed shall be Virginia or West Virginia certified seed (bag tags attached; seed certification shall meet each state's standards for their certified seed classification) or alternative seed sourced from approved distributers.
- USFS approval of treatments outside normal seeding seasons.
- All leguminous seed shall be either be pre-inoculated from a supplier, or mixed with inoculant specified for use on that particular seed according to manufacturer's directions. Inoculants shall be manually applied at double the manufacturer's rate. Inoculant shall be mixed with legume seed prior to mixing with other seeds. For hydro-seeding, use a minimum of five times the dry seeding rate of inoculant. (Flynn, 2015; Monsanto 2015)
- A minimum of 100 lbs/ac of seed will be applied when seeding for permanent erosion control (VA BMP) unless otherwise specified by the seed mix provider.
- A success standard/threshold, such as 70-85% ground cover, must be delineated, and provisions to monitor and report on site conditions. Please describe plans for implementing mitigation measures (in case of planting failures) to ensure planting success.
- Describe how subsoil will be tested for compaction, and loosened prior to topsoil replacement if necessary.
- Dry fertilizer and lime may need to be incorporated into the top 2-5 inches of soil after application, at rates indicated by the results of site-specific soil tests. Please describe plans for doing so. (FERC 2013, Virginia DEQ)
- All seeding must occur promptly after construction halts, either temporarily or permanently. Erosion control seed mixtures must be sufficient to stabilize sites for varying lengths of time, and seed mixes may need to vary depending on that timeframe. Please describe how quickly seeding will occur, and the decision thresholds for applying temporary versus permanent erosion control seed mixtures.
- Areas to be planted with species beneficial for wildlife after pipeline installation will be treated with temporary erosion control mix during a normal seeding season.
- Areas not to be treated with wildlife seed species will be treated with permanent erosion control seeding during a normal seeding season.
- Seeding rates should be doubled when hydroseeding (Steinfeld et. al., 2007)

NORMAL SEEDING SEASONS

Appropriate seasons for seeding can vary dramatically depending on elevation. Spring seeding can be conducted from March 15th – June 1st, and fall seeding can be done from August 15th – October 15th, but neither timeframe is appropriate in its entirety at all elevations.
Please describe the timeframe in which seeding is proposed according to site specific elevations. Seeding windows should allow time for application, germination, and survival.

NUTRIENT ADDITIONS

In the absence of soil chemistry tests, the following guidelines can be used to develop fertilizer and liming rates**. Whenever possible, nutrient additions should be based on soil chemistry data in the interpretations provided with the order 1 soil survey.**

Fertilizer: 600-800 lbs/ac, 10-20-10 (Nitrogen, Phosphorous, Potassium), 400 lbs/ac 15-30-15, 800-1000 lbs/ac 10-10-10.

Lime: 1500-4000 lbs/ac (pelletized or dust), 4000 lbs/ac, Hydro Lime (2.5 gal container is equivalent to 1000 lbs limestone)—5-10 containers /ac.

MULCH AND BINDERS

Use of mulch materials and binders will be needed. Use of hay is prohibited on National Forest land due to invasive species concerns. Below are some guidelines that apply when selecting these materials for various sections of the ROW. Please describe how each of these issues will be addressed. All techniques must be appropriate for the % slope on which they will be applied. Please describe how mulching, seeding, and binding techniques will be adjusted to accommodate different slope classes (for example, 0-8%, 8-15%, 15-30%, 30-50%, etc.)

- Materials must be certified weed free or be accompanied by vendor's test results for noxious weed content.
- Seeded areas can be mulched with weed free straw at a rate of 2-4K lbs/ac, hand spread or blown, fiber mulch hydro-seeded at 1500-2000 lbs/ac., or other appropriate material.
- Natural biodegradable products are preferred. Materials must be demonstrated to be free of invasive species, including but not limited to plants, pests, and pathogens.
- Hydraulic erosion control products (HEPC) must be suitable for wildlife.
- If the use of stabilization netting is required/permitted, wildlife friendly geotextiles must be used. These products must either not contain netting, or netting must be made of 100% biodegradable non-plastic materials such as jute, sisal, or coir fiber. Plastic netting (such as polypropylene, nylon, polyethylene, and polyester), even if advertised as biodegradable, is not an acceptable alternative. Any netting used must also have a loose-weave design with movable joints between horizontal and vertical twines to reduce the chance for wildlife entanglement, injury, or death. (CA Coastal Commission, 2012)
- Avoid the use of silt fences reinforced with metal or plastic mesh.
- When no longer required, (after soils are stable and the vegetative cover is established), temporary erosion control and sediment control products should be promptly removed.
- Any products that require mixing with water need to have a Forest Service-approved water source. The source of water must not be contaminated with non-native invasive organisms that could spread into streams.

Hydroseeding

- Wood-fiber hydraulic mulches are generally short-lived and require a 24-hour period to dry before rainfall occurs.

- Wood fiber naturally has tackifying properties, but fiber alone may not be sufficient on steep slopes. In those cases the addition of a tackifier will help keep the seeds in contact with the soil. Describe plans to assess when this will be necessary, and describe the tackifier and application methods to be used.
- As wood chips, shredded woody materials, and other high-carbon materials decompose, they remove plant nutrients such as nitrogen from the soil. This can reduce soil fertility and make it difficult for grasses to grow. This should be taken into account when planning restoration seeding.

Binders

- The use of hydroseeding with binders will most likely be required in many areas on FS lands due to the steep terrain. Please describe site conditions where this will be used.
- The success of soil binders are somewhat dependent on the soil type present. If soil is compacted or high in clay and silt, soil binders may not penetrate soil surfaces.
- Whether short-life or long-life, soil binders should be non-toxic and organic based, such as guar, psyllium, or pitch and rosin emulsions. Please describe type of binder to be used under what circumstances, and specific application rates and methods.
- Materials or additives used as binders or emulsifiers cannot be toxic to soil organisms or otherwise prevent or inhibit seed germination.

REFERENCES

California Coast Commission. 2012. Water Quality Fact Sheet Series: Wildlife-Friendly Plastic-Free Netting. https://www.coastal.ca.gov/nps/Wildlife-Friendly_Products.pdf

Babcock, D. and R.A. McLaughlin. 2008. Soil Facts: Mulch Options for Erosion Control on Construction Sites. Accessed on August 8, 2016. https://content.ces.ncsu.edu/mulch-options-for-erosion-control-on-construction-sites

Catchments and Creeks Pty Ltd. 2010. Soil Binders: Erosion Control Technique. Accessed August 8, 2016. http://www.catchmentsandcreeks.com.au/docs/SBS-1.pdf

Ernst Conservation Seeds. 2016. Accessed August 8, 2016. http://www.ernstseed.com/speciesmix-search/

Flynn, R. 2015. Inoculation of Legumes. Extension Agronomist, Department of Extension Plant Sciences, New Mexico State University. Web address: http://aces.nmsu.edu/pubs/_a/A130/welcome.html

Michigan Department of Environmental Quality. Hydroseeding. https://www.michigan.gov/documents/deq/nps-hydroseeding_332128_7.pdf

Monsanto BioAg. 2015. Why inoculate or double inoculate? Web address: http://www.monsantobioag.com/global/us/Documents/Why-Inoculate-or-Double-Inoculate.pdf

Soil Binders. 2014. Best Management Practices Manual: Chapter 1 Temporary Erosion Control Management. Accessed August 5, 2016. http://itd.idaho.gov/enviro/stormwater/BMP/PDF%20Files%20for%20BMP/Chapter%201/Chapter%201%20Erosion%20Control%20Best%20Management%20Practices.pdf

Steinfeld, D.E., S.A. Riley, K.M. Wilkinson, T.D. Landis, L.E. Riley. 2007. Roadside Revegetation: An Integrated Approach to Establishing Native Plants. Federal Highway Administration, Western Federal Lands Highway Division. Vancouver, WA. http://www.nativerevegetation.org/learn/manual/ch_10_3.aspx

Federal Energy Regulatory Commission. 2013. Upland Erosion Control, Revegetation, and Maintenance Plan, May 2013 Version. Office of Energy Projects, Washington, D.C.

USDA-NRCS-Montana. Hydro Seeding and Mulching. 2000. Construction Specification. Accessed August 5, 2016. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_053966.pdf

Virginia Department of Conservation and Recreation. 1992. Virginia Erosion and Sediment Control Handbook. Division of Soil and Water Conservation, Richmond, VA.

VA State Water Control Board. Virginia Administrative Code, Title 9 Environment. Chapter 840: Erosion and Sediment Control Regulations.

Virginia Department of Forestry. 2002. Virginia's Forestry Best Management Practices for Water Quality, Fourth Edition.

Virginia Department of Forestry. 2011. Virginia's Forestry Best Management Practices for Water Quality, Technical Manual, Fifth Edition.

APPENDIX B– STORMWATER METHODOLOGY

1.0 STORMWATER ANALYSIS AND BMP DESIGN METHODOLOGY

This Stormwater Methodology presents the general technical approach MOUNTAIN VALLEY intends to apply for projects covered by the Standards and Specifications. Project- or site-specific conditions may warrant departures from this general methodology, however. Any such departures will be documented and explained in SWM Plans submitted to DEQ for review and approval. Stormwater analysis and Best Management Practices (BMP) designs will be performed for all Project site areas to ensure that the following Virginia state regulations have been satisfied:

- Water Quality (9VAC25-870-63)
- Water Quantity (9VAC25-870-66)
- Offsite Compliance Options (9VAC25-870-69)

For the majority of this Project, stormwater BMPs will be designed to reduce total phosphorous loading in order to meet stormwater quality requirements (see ***Section 1.1***) and/or reduce runoff peak flow rate and volume to meet water quantity requirements (see ***Section 1.2***). MOUNTAIN VALLEY will utilize specifications from the Draft 2013 or Published 2011 Virginia Stormwater BMP Clearinghouse for BMP design.

1.1 STORMWATER QUALITY CALCULATIONS

Stormwater quality will be evaluated using the Virginia Runoff Reduction Method (VRRM). The stormwater quality evaluation will demonstrate that the total phosphorous load does not exceed the threshold of 0.41 lbs./acre-year for new development. New impervious cover within the Project LOD will include access roads and pad sites. In instances where existing impervious areas, such as access roads, are to be used or improved for the Project, VRRM for re-development calculations will demonstrate either 10% or 20% reduction from predevelopment phosphorus loads based on land disturbance less than or greater than one acre, respectively.

To utilize the site specific annual rainfall values, noted in ***Section 1.1.1***, Version 2.8 of the VRRM spreadsheet will be used for design. At the Transco Interconnect site in Pittsylvania County, Version 3.0 of the VRRM spreadsheet will be used for design (per DEQ, Project Standards and Specifications Meeting, 09 March 2017, Virginia Department of Environmental Quality, Richmond, VA), because at this time the Version 3.0 Redevelopment VRRM spreadsheet accounts for lower total phosphorus loading rates for projects containing pre- and post-construction forested areas.

Only the site area, or the area within the LOD, will be considered when evaluating stormwater quality in each drainage area. Appropriate post-developed land covers will be used to calculate phosphorous loading per the VRRM spreadsheet. For pre-developed forested areas, under normal operating conditions, the post construction ROW will be considered Forest/Open Space land cover for water quality calculations. For pre-developed non-forested areas, under normal operating conditions, these areas will revert to pre-developed land use (e.g. agricultural uses including tilling, pasture, hayfield, etc.). Therefore, the post construction ROW in non-forested areas will be based on Table 1: Land Cover Guidance for VRRM Compliance Spreadsheets, Virginia Runoff Reduction Method Compliance Spreadsheet User's Guide & Documentation dated April 2016.

1.1.1 Annual Precipitation Data

Annual precipitation values range from 35 to 60 inches along the length of the Project. Therefore, local annual precipitation values will be used when performing water quality calculations (per DEQ, Stormwater Management Technical Meeting, 29 November 2016, Virginia Department of Environmental Quality, Richmond, VA). Refer to ***Figures 1 and 2*** below for local annual precipitation values obtained from PRISM weather stations.

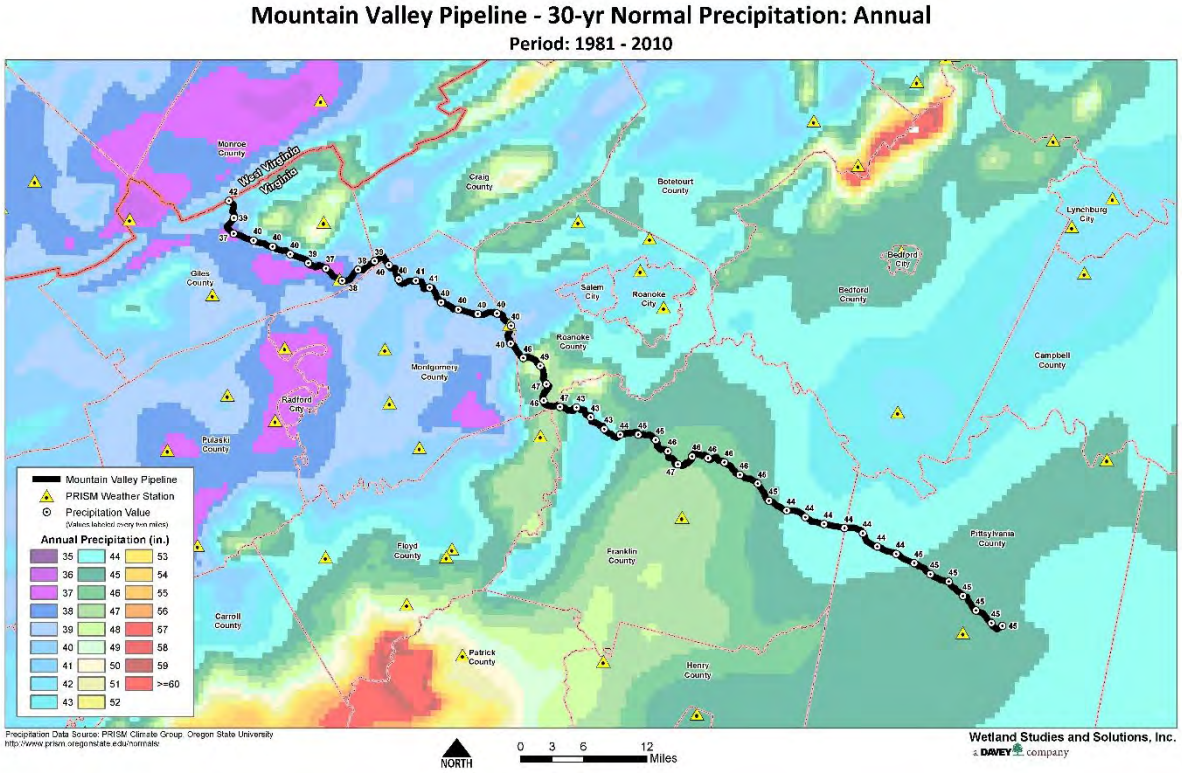


Figure 1. 30-Yr Annual Normal Precipitation – Raw Data

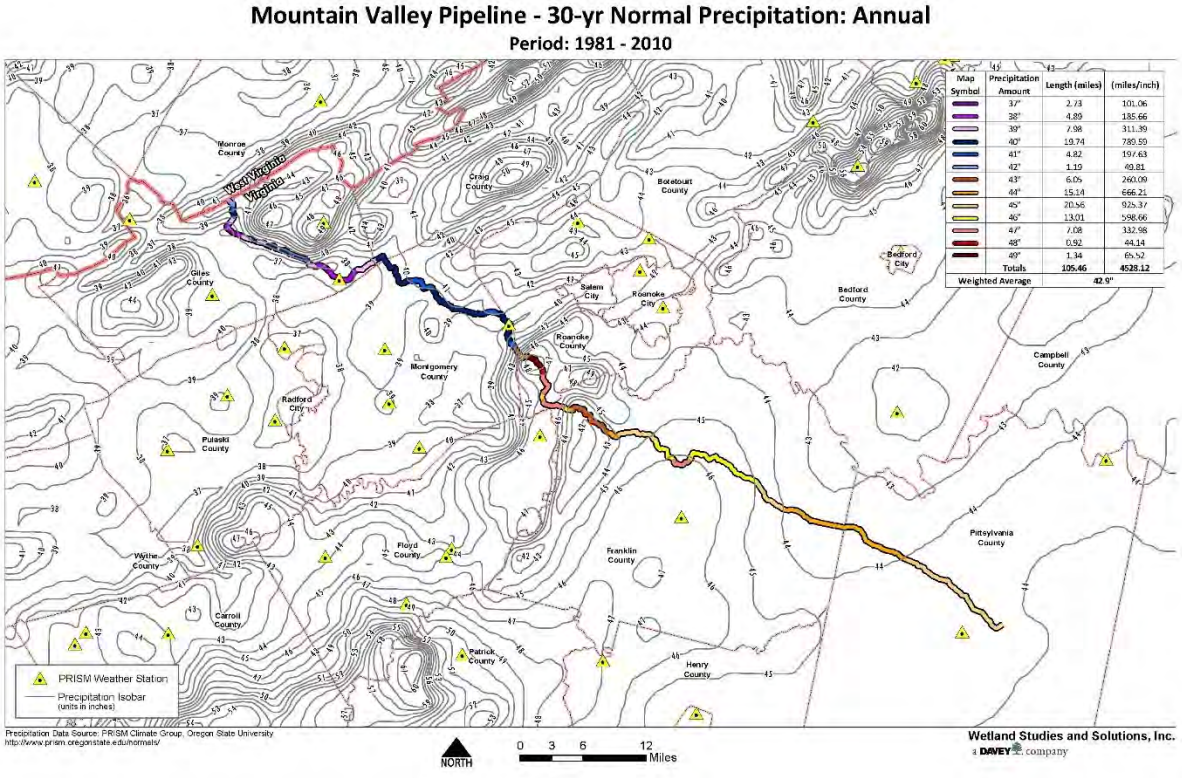


Figure 2. 30-Yr Annual Normal Precipitation – Pipeline Weighted Average Precipitation with Isobar

1.2 STORMWATER QUANTITY CALCULATIONS

The energy balance method will be applied to the 1-year storm event in order to meet the 9VAC-870-66 stormwater quantity requirements. The Hydraflow Hydrographs extension for AutoCAD Civil 3D will be used to calculate the peak flow rates and runoff volumes for the energy balance equations; Hydraflow Hydrographs will perform hydrologic calculations in accordance with the Natural Resource Conservation Service (NRCS; formerly Soil Conservation Service [SCS]) Technical Release 55 (TR-55) methods.

1.2.1 Energy Balance Method (9VAC-25-870-66 Part B)

The energy balance method equations, as detailed in 9VAC25-870-66.B.3.a, are as follows:

Equation 1

$$Q_{Developed} \leq I.F.* \left(Q_{Pre-developed} * RV_{Pre-developed}\right)/RV_{Developed}$$

Equation 2

$$Q_{Developed} \leq Q_{pre-developed}$$

where:

$Q_{Developed}$	=	The allowable peak flow rate of runoff from the developed site
I.F.	=	Improvement Factor (0.8 for sites > 1 acre; 0.9 for sites ≤ 1 acre)
$RV_{Developed}$	=	The volume of runoff from the site in the developed condition
$Q_{Pre-Developed}$	=	The peak flow rate of runoff from the site in the pre-developed condition
$RV_{Pre-Developed}$	=	The volume of runoff from the site in pre-developed condition

- The improvement factor used will be 0.8 in most cases.
- The majority of pre-developed conditions are forested.
- $Q_{Developed}$ need never be less than the following:

Equation 3

$$\left(Q_{Forest} * RV_{Forest}\right)/RV_{Developed}$$

where:

Q_{Forest}	=	The peak flow rate of runoff from the site in a forested condition
RV_{Forest}	=	The volume of runoff from the site in a forested condition
$RV_{Developed}$	=	The volume of runoff from the site in the developed condition

- With the improvement factor, Equation 1 will result in a $Q_{Developed}$ lower than the value determined using Equation 3. Therefore, Equation 3 will be used for the majority of the Project to determine compliance with the Energy Balance Method and stormwater quantity requirements.

- Runoff volume (RV) and peak flow rate (Q) will be calculated in Hydraflow Hydrographs using TR-55 methodology as discussed in ***Section 1.2.3***, and the computed values corresponding to the 1-year 24-hour storm event for the pre-developed, developed, and forest conditions will be used to determine if the energy balance requirements (i.e., Equations 1 through 3 above) have been satisfied (see ***Section 1.2.4***).

1.2.2 Sheet Flow (9VAC-25-870-66 Part D)

If pre-development runoff conditions include sheet flow, and sheet flow can be maintained in the post-development condition, stormwater quantity regulations will be satisfied demonstrating no adverse effects on downstream properties per 9VAC-25-870-66 Part D. In this case, the Project site area would be exempt from the stormwater quantity requirements presented in ***Section 1.2.1***.

No adverse effects will be demonstrated by calculating the sheet flow velocity for the post-development 2-year 24-hour storm and comparing it to permissible velocities. Travel time will be calculated using Manning's kinematic solution:

Equation 4

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}}$$

where:	T_t	=	Travel time (hours)
	n	=	Manning's roughness coefficient
	L	=	Flow length (feet)
	P_2	=	2-year 24-hour rainfall (inches)
	s	=	Slope of hydraulic grade line (foot/foot)

The sheet flow travel time will then be converted to velocity via the following equation:

Equation 5

$$V = \frac{L}{3600 T_t}$$

where:	V	=	Average velocity (foot/second)
	3600	=	Conversion from hours to seconds

Calculated post-development sheet flow velocities will be less than the permissible velocities.

- VESCH Table 5-14 Permissible Velocities for Grass Lined Channels
- VESCH Table 5-22 Permissible Velocities for Unlined Earthen Channels

If a level spreader is necessary to dissipate concentrated flow into sheet flow, the following specification will be used:

- Virginia Stormwater BMP Clearinghouse Specification No. 2 Sheet flow to a vegetated filter strip or conserved open space

Per 9VAC-25-870-66 Part D, no further water quantity controls are required "if all runoff from the site is sheet flow." Therefore, diversions will be used as necessary within the Project site area to route surface runoff through the level spreader. See ***Section 1.3.2*** for information pertaining to level spreader design.

1.2.3 Hydraflow Hydrographs – Q and RV Calculations

The Hydraflow Hydrographs extension for AutoCAD Civil 3D will perform peak flow rate and runoff volume calculations in accordance with the Natural Resource Conservation Service (NRCS; formerly Soil

Conservation Service [SCS]) Technical Release 55 (TR-55) methods for the 1-, 2-, and 10-year 24-hour storm events, and the results for the 1-year event will be used as inputs when completing the energy balance method calculations (see ***Section 1.2.1***). It should be noted that modelling up to the 10-year event is necessary because some stormwater BMPs, such as a grass channels and level spreaders, need to be shown to have enough capacity to convey up to the 10-year event.

Hydraflow Hydrographs requires the following input data in order to calculate peak flow rates and runoff volumes: drainage area, design storm precipitation data, curve number(s), time of concentration flow paths, and BMP storage and outlet data (if applicable; see ***Section 1.3.1***).

1.2.3.1 Drainage Area Delineation

Drainage areas along the proposed pipeline route will be delineated based on rivers and tributaries that have been delineated by, and are therefore recognized by, the VADEQ (shapefile obtained from Virginia Environmental Geographic Information Systems [VEGIS] website: http://www.deq.virginia.gov/ConnectWithDEQ/VEGIS/VEGISDatasets.aspx, Dataset Name: 2014 Integrated WQ Report Rivers.zip). Only the portion of the corresponding VADEQ river/tributary drainage area that runs on to the project LOD will be considered; for pipeline sections that run across/through valleys (i.e., in the vicinity of stream crossings), the drainage area considered will be limited to the LOD. An example is provided in ***Figure 3***.

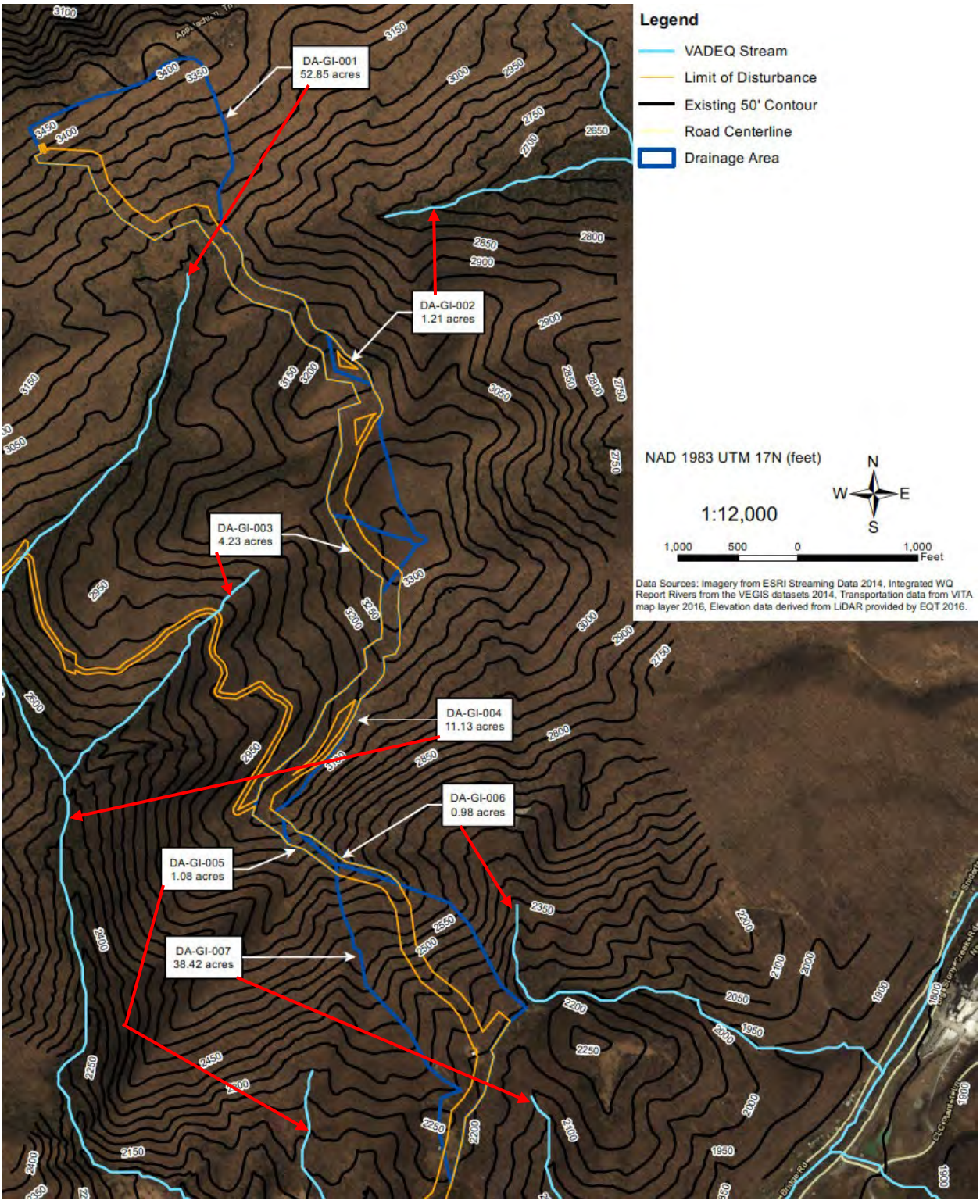


Figure 3. Giles County Drainage Area Delineation Example

1.2.3.2 Design Storm Precipitation Data

Design storm values for the 1-, 2-, and 10-year 24-hour storms were compiled from multiple sources including local code, the Virginia Stormwater Handbook 1999 Edition, the Virginia Stormwater Handbook DRAFT 2013 Edition, and the NOAA Atlas 14 data for the stations closest to the current pipeline alignment. To meet stormwater management requirements, projects are typically subject to the most stringent regulation. Therefore, the maximum rainfall intensity of the four sources will be used in stormwater calculations as presented on ***Figure 4***.

An NRCS Type II storm distribution will be used in Hydraflow Hydrographs, which is applicable to the Project location as shown on ***Figure 5***.

1.2.3.3 Curve Number (CN)

The NRCS Runoff Curve Number (CN) method is used to estimate runoff in Hydraflow Hydrographs. The NRCS runoff equation is:

Equation 6

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

where: Q = Runoff (in)
P = Rainfall (in)
S = Potential maximum retention after runoff begins (in)

S is related to the soil and cover conditions of the drainage area through the CN. CN has a range of 0 to 100, and S is related to CN by:

Equation 7

$$S = \left(\frac{1000}{CN}\right) - 10$$

The major factors that determine CN are the hydrologic soil group (HSG) and land cover type. For pre-developed forested areas, under normal operating conditions, the pipeline right-of-way land cover type for the developed condition will be considered 50 feet of meadow and 75 feet of brush. For pre-developed non-forested areas, under normal operating conditions, the pipeline right-of-way land cover type for the developed condition will revert to the pre-developed land cover type. All land cover types are assumed to be in good condition. CN values will be obtained from Technical Release 55 (TR-55); an excerpt from the CN tables included in TR-55 is provided in ***Table 1***. The land cover and soil map data sources that will be used for this Project is as follows:

- *Land Use Data Source*: 2015 ESRI World Imagery Aerials and the Digitized Land Use.
- *Soil Map Data Source*: 2014 Gridded Soil Survey Geographic (SSURGO) soils dataset for the Commonwealth of Virginia, obtained from the USDA.

1.2.3.4 Time of Concentration Flow Paths

Stormwater moves through a given drainage area as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The time of concentration (TOC) is computed by summing all the travel times for consecutive components of the drainage conveyance system; TOC influences the shape and peak of the runoff hydrograph.

For the pre-developed condition, the time of concentration will be calculated in Hydraflow Hydrographs in accordance with TR-55 using the longest flow path from the most remote location within the drainage area to the outlet. For the developed condition, the time of concentration will be calculated in Hydraflow Hydrographs in accordance with TR-55 using a flow path that is representative of the hydrologic changes following construction (i.e., changes in surface water runoff due to permanent waterbars, stormwater BMPs, etc.).

Factors that affect TOC include surface roughness, slope, and flow path length. TOC flow paths and associated slopes will be determined using existing contour data. Each flow type (i.e., sheet flow, shallow concentrated flow and open channel flow) is described below in more detail.

Sheet Flow

Sheet flow is flow over plane surfaces. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact, drag over the plane surface, obstacles such as litter, crop ridges, and rocks, and erosion and transportation of sediment. ***Table 2*** provides Manning's n values for sheet flow for various surface conditions.

Generally, beyond 100 feet the flow becomes concentrated flow. Therefore, a maximum sheet flow length of 100 feet will be used for this Project.

Shallow Concentrated Flow

The following counties place restrictions on the length of shallow concentrated flow:

- Franklin County
    - o Maximum shallow concentrated flow lengths are 1,000-feet
- Roanoke County
    - o Maximum Shallow concentrated flow lengths are 1,000-feet

These restrictions on shallow concentrated flow will only be used when completing stormwater calculations in these counties. In other counties, surface flow along the flow path following 100 feet of sheet flow will be considered shallow concentrated flow until the flow becomes channelized.

Open Channel Flow

Open channel flow is assumed when flow becomes channelized, and a determination can be made as to when flow becomes channelized along the flow path based on existing contour data or aerial imagery. Bank full flow for a representative cross section along the channel is assumed in Hydraflow Hydrographs for the purpose of calculating time of concentration. ***Table 3*** provides Manning's n values for open channel flow.

1.2.4 Hydraflow Hydrographs Output and Energy Balance Calculations

Hydraflow Hydrographs performs calculations in accordance with TR-55 and provides a runoff hydrograph output for each modeled condition (i.e., pre-developed, developed, and forest). The calculated peak flow rate (Q) and hydrograph volume, or runoff volume (RV), for the 1-year 24-hour storm event will be obtained from the corresponding "Hydrograph Summary Report" page of the Hydraflow Hydrographs output report as shown on ***Figure 6***. Those results will be used as inputs when completing the energy balance method calculations (see ***Section 1.2.1***).

If the energy balance requirements are not satisfied, stormwater BMP design is required (see ***Section 1.3***).

1.3 STORMWATER BMP DESIGN

For this project, stormwater Best Management Practices (BMPs) will be designed as needed to meet stormwater quality (see ***Section 1.1***) and quantity (see ***Section 1.2***) requirements. MOUNTAIN VALLEY will utilize specifications from the Virginia Stormwater BMP Clearinghouse for BMP design. Although all BMPs will be considered for use to satisfy quality requirements, the specifications listed below are those most likely to be implemented with this Project:

- Specification No. 2 Sheet flow to a vegetated filter strip or conserved open space
- Specification No. 3 Grass channels
- Specification No. 4 Soil compost amendment

Stormwater BMP details are included in the project-specific plans submitted to DEQ for review. It should be noted, Specification No. 2 may be exempt from stormwater quantity requirements presented in ***Section 1.2.1***, per 9VAC25-870-66 Part D, if it can be demonstrated that sheet flow results in no adverse effects on downstream properties. Refer to ***Section 1.2.2*** for further discussion on sheet flow.

In instances where there is no feasible stormwater BMP design option that can be implemented to satisfy stormwater quality requirements , MOUNTAIN VALLEY will purchase off-site nutrient credits from registered mitigation banks in accordance with 9VAC25-870-69; the registered mitigation bank must be located within the same or an adjacent HUC watershed and demonstrate the required number of credits are available for purchase.

1.3.1 BMP Sizing Calculations

Stormwater BMPs will be designed to reduce total phosphorous loading in order to meet stormwater quality requirements (see ***Section 1.1***) and/or reduce runoff peak flow rate and volume to meet water quantity requirements (see ***Section 1.2***). The effect of routing runoff through stormwater BMPs is achieved in Hydraflow Hydrographs by routing the drainage area hydrograph for the developed condition to a “Pond” element; “Pond” elements are defined in Hydraflow Hydrographs by entering stage-storage and outlet data. It should be noted that level spreaders (Specification No. 2) are not defined using “Pond” elements in Hydraflow Hydrographs because they are designed to provide outlet protection and, as detailed in Specification No. 2, serve a water quality function; level spreaders are not sized to reduce runoff peak flow rate and volume. See ***Section 1.3.2*** for information pertaining to level spreader design.

For grass channel BMPs (Specification No. 3), the subsurface storage within the soil amendment area and surface storage up to a 1-ft ponding depth above the soil amendment area (assuming 1-ft check dam height within channels) will be considered when calculating BMP stage-storage data. A rectangular weir with a crest elevation corresponding to 1-ft above ground surface (i.e., assumed check dam height within channel) will be assumed when defining the BMP outlet. The Excel spreadsheet that will be used to calculate stage-storage data for grass channels is shown on ***Figure 7***.

For waterbars with soil amendment BMPs (Specification No. 4), the subsurface storage within the soil amendment area and surface storage up to a 0.5-ft ponding depth area above the soil amendment area (assuming 0.5-ft height of compost filter sock at the ends of permanent waterbars) will be considered when calculating BMP stage-storage data. If there are multiple waterbars with soil amendment BMPs within a drainage area, the storage associated with each individual BMP will be summed across the drainage area and used as input for Hydraflow Hydrographs. A rectangular weir with a crest elevation corresponding to 0.5-ft above ground surface (i.e., assumed height of compost filter sock at the ends of permanent waterbars)

will be assumed when defining the BMP outlet. The Excel spreadsheet that will be used to calculate stage-storage data for waterbars with soil amendments is shown on ***Figure 8***.

In instances where stormwater BMPs are needed in order to meet water quantity requirements, the stormwater BMP design will be an iterative process during which BMPs will be re-sized across the drainage area as necessary until the energy balance requirements are satisfied (see ***Section 1.2.1***). ***Figure 9*** shows where the calculated peak flow rate (Q) and hydrograph volume, or runoff volume (RV), for the developed condition with BMPs appear on the Hydraflow Hydrographs output report; these will be the values that will be used as inputs when completing the energy balance method calculations.

1.3.2 Additional BMP Design Calculations

Additional calculations will be completed for the following stormwater BMPs in order to show that the design meets the corresponding specifications: Sheet Flow to a Vegetated Filter Strip or Conserved Open Space (Specification No. 2) and Grass Channels (Specification No. 3).

Level Spreaders (Specification No. 2)

Level spreaders will be designed in accordance with the following specification:

- Virginia Stormwater BMP Clearinghouse Specification No. 2 Sheet flow to a vegetated filter strip or conserved open space

Per the specification listed above, level spreaders should be designed to accommodate the peak flow rate corresponding to the 10-year 24-hour design storm. The goal when designing a level spreader is to ensure an appropriate length of the discharge feature – a length that does not allow for erosive velocities down slope.

Specification No. 2 requires a level spreader length of 13 feet per 1 cubic feet per second (cfs) of flow when discharging to native grasses or thick ground cover, and a length of 40 feet per 1 cfs of flow when discharging to a forested or reforested buffer.

Grass Channels (Specification No. 3)

Grass channel design must meet the criteria set forth in Virginia BMP Clearinghouse Specification No. 3. Criteria include 10-year 24-hour design storm capacity as well as shear and velocity values within prescribed limits for the grass lining specified in VESCH Table 5-14 Permissible Velocities for Grass Lined Channels. Grass channel calculations within Specification No. 3 are based on open channel equations. The Excel spreadsheet that will be used for grass channel design calculations is shown on ***Figure 10***.

TABLES

Table 1 – Excerpt CN Table from TR-55

Table 2-2a Runoff curve numbers for urban areas 1/

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area 2/	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) 3/:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89

Table 2 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Urban:	
Concrete, Asphalt, or Gravel	0.005 – 0.015
Average Grass Cover	0.40
Rural Residential (1 - 10 acre lots, maintenance or grazing assumed)	0.40
Urban Residential (maintained lawns assumed, with effects of landscaping, driveways, roofs included in combined value):	
1 - 3 building units/acre	0.30
3 - 10 building units/acre	0.20
> 10 building units/acre	0.15
Commercial/Industrial (effects of landscaping, driveways, roofs included in combined value)	0.11
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40
Cultivated Areas:	
Bare Packed Soil (free of stone)	0.10
Fallow (no residue)	0.05
Conventional Tillage:	
No Residue	0.06 – 0.12

Table 2 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
With Residue	0.16 – 0.22
Chisel Plow:	
No Residue	0.06 – 0.12
With Residue	0.10 – 0.16
Fall Disking (with residue)	0.30 – 0.50
No Till:	
No Residue Cover	0.04 – 0.10
20 – 40% Residue Cover	0.07 – 0.17
60 – 100% Residue Cover	0.17 – 0.47
Rural Residential (1 – 10 acre lots, maintenance or grazing assumed)	0.40
Sources: *-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA* *-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC*	

Table 3 – Manning's n Values for Open Channel Flow

Channel Type	**Manning n**		
	Min.	Normal	Max.
1. Lined or Constructed Channels			
a. Cement:			
Neat, surface	0.010	0.011	0.013
Mortar	0.011	0.013	0.015
b. Concrete:			
Trowel finish	0.011	0.013	0.015
Float finish	0.013	0.015	0.016
Finished, with gravel on bottom	0.015	0.017	0.020
Unfinished	0.014	0.017	0.020
Gunite, good section	0.016	0.019	0.023
Gunite, wavy section	0.018	0.022	0.025
On good excavated rock	0.017	0.02	-
On irregular excavated rock	0.022	0.027	-
c. Concrete Bottom Float Finish with sides of:			
Dressed stone in mortar	0.015	0.017	0.020
Random stone in mortar	0.017	0.020	0.024
Cement rubble masonry, plastered	0.016	0.020	0.024
Cement rubble masonry	0.020	0.025	0.030
Dry rubble or riprap	0.020	0.030	0.035

Table 3 – Manning's n Values for Open Channel Flow

Channel Type	Manning n		
	Min.	Normal	Max.
d. Gravel Bottom with sides of:			
Formed concrete	0.017	0.020	0.025
Random stone mortar	0.020	0.023	0.026
Dry rubble or riprap	0.023	0.033	0.036
e. Brick:			
Glazed	0.011	0.013	0.015
In cement mortar	0.012	0.015	0.018
f. Masonry:			
Cemented rubble	0.017	0.025	0.030
Dry rubble	0.023	0.032	0.035
g. Dressed Ashlar / Stone Paving	0.013	0.015	0.017
h. Asphalt:			
Smooth	0.013	0.013	0.017
Rough	0.016	0.016	0.017
i. VegetalLining	0.030	-	0.500
j. Wood:			
Planed, untreated	0.010	0.012	0.014
Planed, creosoted	0.011	0.012	0.015
Unplaned	0.011	0.013	0.015
Plank with battens	0.012	0.015	0.018
Lined with roofing paper	0.010	0.014	0.017
2. Excavated or Dredged Channels			
a. Earth, Straight, and Uniform:			
Clean, recently completed	0.016	0.018	0.020
Clean, after weathering	0.018	0.022	0.025
Gravel, uniform section, clean	0.022	0.025	0.030
With short grass, few weeds	0.022	0.027	0.033
b. Earth Winding and Sluggish:			
No vegetation	0.023	0.025	0.030
Grass, some weeds	0.025	0.030	0.033
Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
Earth bottom and rubble sides	0.028	0.030	0.035
Stony bottom and weedy banks	0.025	0.035	0.040
Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-Excavated or Dredged:			
No vegetation	0.025	0.028	0.033

Table 3 – Manning's n Values for Open Channel Flow

Channel Type	Manning n		
	Min.	Normal	Max.
Light brush on banks	0.035	0.050	0.060
d. Rock Cuts:			
Smooth and uniform	0.025	0.035	0.040
Jagged and irregular	0.035	0.040	0.050
e. Channels not Maintained, Weeds and Brush Uncut:			
Dense weeds, high as flow depth	0.050	0.080	0.120
Clean bottom, brush on sides	0.040	0.050	0.080
Same as above, highest stage of flow	0.045	0.070	0.110
Dense brush, high stage	0.080	0.100	0.140
3. Main Channels			
a. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective	0.040	0.048	0.055
f. Same as (d) with more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
4. Mountain Streams, No Vegetation in Channel, Banks usually Steep, Trees and Brush along Banks Submerged at High Stages			
a. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. Bottom: cobbles with large boulders	0.040	0.050	0.070

Sources:

-ASCE, (1982), Gravity Sanitary Sewer Design and Construction, ASCE Manual of Practice No. 60, New York, NY

-Chow, V.T., (1959), Open Channel Hydraulics, McGraw-Hill, New York, NY

FIGURES

Figure 5 – Approximate Geographic Boundaries for NRCS Rainfall Distributions

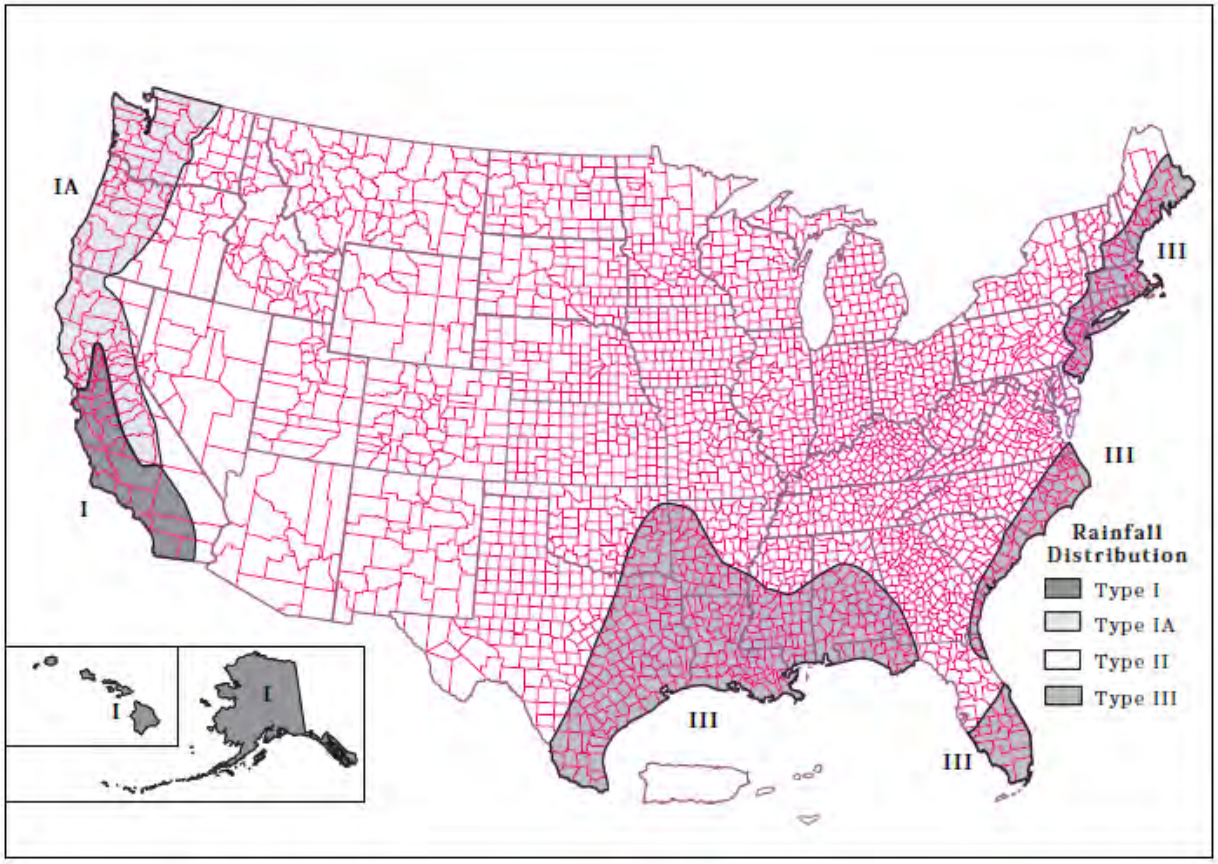


Figure 6 – Q and RV Output from Hydraflow Hydrographs

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	0.083	1	1440	1,835	----	----	----	DA-GI-001 PRE
2	SCS Runoff	0.059	1	1440	956	----	----	----	DA-GI-001 POST
3	SCS Runoff	0.059	1	1440	956	----	----	----	DA-GI-001 Pre-Forest

Figure 7 – Grass Channel BMP Storage Volume Calculations Spreadsheet

Equations Used:

[1] $V_{gravel\ storage\ behind\ each\ check\ dam} = L*W_{bottom\ of\ channel}*D_{gravel}*(40/100)$

[2] $V_{soil\ storage\ behind\ each\ check\ dam} = L*W_{bottom\ of\ channel}*D_{soil}*(20/100)$

[3] $V_{surface\ storage\ behind\ each\ check\ dam} = 0.5*L*D*(W_{top\ of\ check\ dam} + W_{bottom\ of\ channel})/2$

[1]Equation #2b under "Volume Reduction Calculations" in Section 6.4.5 of PA BMP Manual, assuming that gravel is made up of 40% voids.

[2]Equation #2b under "Volume Reduction Calculations" in Section 6.4.5 of PA BMP Manual, assuming that soil compost amendment is made up of 20% voids.

[3]Equation under "Volume Reduction Calculations" in Section 6.4.8 of PA BMP Manual.

Inputs:

Depth of Gravel Layer, D_{gravel} (ft) =	0	
Depth of Soil Amendment Area, D_{soil} (ft) =	1	Refer to Table 4.3 in VA DEQ Stormwater Design Specification No. 4; Note that compost amendment may not be necessary for HSG A/B soils
Total Length of Channel in Drainage Area, L_{total} (ft) =	645.01	
Average Length of Channel Behind Each Check Dam, L (ft) =	49.61615385	
Bottom Width of Channel, $W_{bottom\ of\ channel}$ (ft) =	2	Channel bottom width should be 4-8' per VA DEQ Stormwater Design Specification No. 3. Separate channel design calculations show that for the proposed channel dimensions, the 10-year design flow is contained within the channel (minimum of 6 inches of freeboard) and the flow velocity within the channel is non-erosive up to the 10-year design storm event per VA DEQ Stormwater Design Specification No. 3.
Channel Side Slopes (H:V) =	3	Channel side slopes should be 3H:1V or flatter per VA DEQ Stormwater Design Specification No. 3. Separate channel design calculations show that for the proposed channel dimensions, the 10-year design flow is contained within the channel (minimum of 6 inches of freeboard) and the flow velocity within the channel is non-erosive up to the 10-year design storm event per VA DEQ Stormwater Design Specification No. 3.
Number of Check Dams in Drainage Area, n =	13	
Design Infiltration Rate, IR (in/hr) =	0.2	Min. rate of 0.30 in/hr for HSG A soils and 0.15-0.30 in/hr for HSG B soils (see Chap. 4, p. 4-30 in VA Stormwater Management Handbook Volume II (First Edition, 1999)
Top Width of Check Dam, $W_{top\ of\ check\ dam}$ (ft) =	8	
Surface Ponding Depth, D (ft) =	1	Assume 1' check dam height within channels
Check Dam Side Slopes (H:V) =	2	Rock check dam side slopes should be 2H:1V per VADEQ 1992 Manual detail

Calculations:

Total Storage Depth per BMP (ft) =	2
Surface Storage Volume Behind Each Check Dam (cf) =	124.0403846
Subsurface Storage Behind Each Check Dam (cf) =	19.84646154
Total Storage Volume Behind Each Check Dam (cf) =	143.8868462
Total BMP Storage Volume in Drainage Area (cf) =	1870.529
Calculated Infiltration Period per BMP (hr) =	87

Depth-Storage Data

Depth (ft)	Width (ft)	Length (ft)	Storage Volume in Channel Behind Check Dam (cf)	Storage Volume in Drainage Area (cf)
0	2	49.61615385	0	0
0.5	2	49.61615385	9.923230769	129.002
1	2	49.61615385	19.84646154	258.004
1.5	5	51.61615385	81.86665385	1064.2665
2	8	53.61615385	143.8868462	1870.529
2.5	11	55.61615385	205.9070385	2676.7915

Figure 8 – Waterbar with Soil Amendment BMP Storage Volume Calculations Spreadsheet

Equations Used:

[1]Vgravel storage = $L*W*D_{gravel}*(40/100)$

[2]Vsoil storage = $L*W*D_{soil}*(20/100)$

[3]Vsurface storage = [W*S*D^2]+[L*S*D^2]+[W*L*D]+[((2*S*D)^2*D)/3]

[1]Equation #2b under "Volume Reduction Calculations" in Section 6.4.5 of PA BMP Manual, assuming that gravel is made up of 40% voids.

[2]Equation #2b under "Volume Reduction Calculations" in Section 6.4.5 of PA BMP Manual, assuming that soil compost amendment is made up of 20% voids.

[3]Equation #1 under "Volume Reduction Calculations" in Section 6.4.5 of PA BMP Manual, but calculation also takes into account surface side slopes.

Inputs:

Depth of Gravel Layer, D_{gravel} (ft) =	0	
Depth of Soil Amendment Area, D_{soil} (ft) =	1	Refer to Table 4.3 in VA DEQ Stormwater Design Specification No. 4; Note that compost amendment may not be necessary for HSG A/B soils
Length of Waterbar Soil Amendment Area, L (ft) =	5	Assume max. length of 50' for waterbar soil amendment areas (i.e., limited to permanent ROW)
Width of Waterbar Soil Amendment Area, W (ft) =	2	
Inside Embankment Side Slopes, S (H:V) =	2	Assume 2H:1V surface side slopes for waterbars
Number of Perm. Waterbars in Drainage Area, n =	10	
Design Infiltration Rate, IR (in/hr) =	0.2	Min. rate of 0.30 in/hr for HSG A soils and 0.15-0.30 in/hr for HSG B soils (see Chap. 4, p. 4-30 in VA Stormwater Management Handbook Volume II (First Edition, 1999)
Surface Ponding Depth, D (ft) =	0.5	Assume 0.5' CFS height at the end of waterbars

Calculations:

Total Storage Depth per BMP (ft) =	1.5
Surface Storage Volume per BMP (cf) =	9.166666667
Subsurface Storage Volume per BMP (cf) =	2
Total Storage Volume per BMP (cf) =	11.16666667
Total BMP Storage Volume in Drainage Area (cf) =	111.6666667
Calculated Infiltration Period per BMP (hr) =	67

Depth-Storage Data

Depth (ft)	Width (ft)	Length (ft)	Storage Volume per BMP (cf)	Storage Volume in Drainage Area (cf)
0	2	5	0	0
0.5	2	5	1	10
1	2	5	2	20
1.5	4	7	11.16666667	111.6666667
2	6	9	31.33333333	313.3333333

Figure 9 - Q and RV Output from Hydraflow Hydrographs for Developed Condition with BMPs

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	0.007	1	804	232	------	------	------	DA-GI-006 PRE
2	SCS Runoff	0.008	1	800	232	------	------	------	DA-GI-006 POST
3	SCS Runoff	0.007	1	804	232	------	------	------	DA-GI-006 Pre-Forested
4	Reservoir	0.006	1	1023	120	2	2856.50	112	WB Soil Amend Storage

Figure 10 – Grass Channel Design Calculations Spreadsheet

CHANNEL DESIGN DATA

PROJECT NAME:	**MVP Project - Transco Interconnect Site**		
LOCATION:	**Pittsylvania County, VA**		
PREPARED BY:	**DJW**	**DATE:**	May 31, 2017
CHECKED BY:	**0**	**DATE:**	January 0, 1900

CHANNEL OR CHANNEL SECTION	CH-A (MIN)	CH-A (MAX)	CH-B (MIN)	CH-B (MAX)	CH-C	CH-D	CH-E	CH-F	
TEMPORARY OR PERMANENT? (T OR P)	P	P	P	P	P	P	P	P	
SPECIAL PROTECTION WATERSHED? (YES OR NO)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
DESIGN STORM (2, 5, OR 10 YR)	10	10	10	10	10	10	10	10	
ACRES (AC)	8.12	8.12	1.61	1.61	0.48	0.80	2.09	0.80	
MULTIPLIER (1.6, 2.25, OR 2.75)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Qr (REQUIRED CAPACITY) (CFS)[1]	11.68	11.68	2.59	2.59	0.77	1.44	3.36	1.44	
Q (CALCULATED AT FLOW DEPTH d) (CFS)	11.68	11.68	2.59	2.59	0.77	1.44	3.36	1.44	
VEGETATIVE LINING RETARDANCE	--	--	--	--	--	--	--	--	
PROTECTIVE LINING[2]	Bermudagrass	Bermudagrass	Bermudagrass	Bermudagrass	Bermudagrass	Bermudagrass	Bermudagrass	Bermudagrass	
n (MANNING'S COEFFICIENT)[2]	0.064	0.042	0.067	0.057	0.076	0.068	0.114	0.101	
Va (ALLOWABLE VELOCITY) (FPS)	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	
V (CALCULATED AT FLOW DEPTH d) (FPS)	1.86	4.42	1.50	2.09	1.05	1.42	0.49	0.63	
τ_a (MAX ALLOWABLE SHEAR STRESS) (LB/FT^2)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d) (LB/FT^2)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
CHANNEL BOTTOM WIDTH (FT)	2.00	2.00	2.00	2.00	2.00	2.00	10.00	0.00	
CHANNEL SIDE SLOPES LEFT, Z_1 (H:V)	3.00	3.00	3.00	3.00	3.00	2.00	2.00	2.00	
CHANNEL SIDE SLOPES RIGHT, Z_2 (H:V)	3.00	3.00	3.00	3.00	3.00	2.00	2.00	2.00	
D (TOTAL DEPTH) (FT)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	
CHANNEL TOP WIDTH @ D (FT)	14.00	14.00	14.00	14.00	14.00	10.00	18.00	8.00	
d (CALCULATED FLOW DEPTH) (FT)	1.15	0.66	0.49	0.39	0.26	0.37	0.61	1.07	
CHANNEL TOP WIDTH @ FLOW DEPTH d (FT)	8.91	5.97	4.97	4.35	3.58	3.48	12.43	4.26	
BOTTOM WIDTH:DEPTH RATIO (12:1 MAX)	1.74	3.02	4.05	5.11	7.60	5.40	16.48	N/A	
d_{50} STONE SIZE (IN)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
A (CROSS-SECTIONAL AREA) (SQ. FT.)	6.28	2.64	1.72	1.24	0.73	1.02	6.81	2.27	
R (HYDRAULIC RADIUS)	0.677	0.427	0.336	0.277	0.200	0.278	0.535	0.476	
S (BED SLOPE)[3] (%)	1.08	4.87	1.97	3.54	2.45	2.32	0.33	0.50	
S_c (CRITICAL SLOPE) (%)	7.08	3.53	9.71	7.46	14.71	10.84	23.84	21.26	
$.7S_c$ (%)	4.95	2.47	6.79	5.23	10.30	7.59	16.69	14.88	
$1.3S_c$ (%)	9.20	4.59	12.62	9.70	19.13	14.09	30.99	27.64	
STABLE FLOW? (Y/N)	Y	Y	Y	Y	Y	Y	Y	Y	
FREEBOARD BASED ON UNSTABLE FLOW (FT)	0.16	0.22	0.06	0.06	0.02	0.04	0.02	0.05	
FREEBOARD BASED ON STABLE FLOW (FT)	0.29	0.17	0.12	0.10	0.07	0.09	0.15	0.27	
MINIMUM REQUIRED FREEBOARD[4] (FT)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)	V	V	V	V	V	V	V	V	

1. Use 10-Year 24-Hour peak flow for channel drainage area as calculated in Hydraflow Hydrographs using TR-55 methodology.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in separate columns.
3. Slopes may not be averaged.
4. For grass/vegetated channels, the minimum freeboard is 0.5 ft per VA DEQ Stormwater Design Specification No. 3.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.

ATTACHMENT 1– STORMWATER MANAGEMENT NARRATIVE

TEST AREA STORMWATER MANAGEMENT NARRATIVE
01/22/2018

Preface

In an effort to address DEQ comments regarding Spread 8 stormwater management plans, a test watershed was used for development of the proposed stormwater management methodology. The following narrative provides some background on the Project as a whole, and details how the methodology applied in the test area will meet both water quality and quantity requirements (including channel, flood, and sheet flow requirements) in accordance with Chapter 870 of the Virginia Administrative Code (9VAC25-870). Channel protection for concentrated flows shall be met via the Energy Balance Method. Flood protection for concentrated flows shall be met via reduction in the 10-year 24-hour runoff. Sheet flow requirements will be met via no increases in sheet flow volumes and physical spreading via water bar end treatments. Additional information is also provided for site conditions that may be experienced in other Project areas that are not located within this test watershed. When approved, this methodology will be implemented across the remainder of the Project.

Contents

I. Project Description

The Project will extend from the existing Equitrans, L.P transmission system and other natural gas facilities in Wetzel County, West Virginia to Transcontinental Gas Pipe Line Company, LLC's Zone 5 Compressor Station 165 in Pittsylvania County, Virginia. In addition, the Project will include approximately 171,600 horsepower of compression at three compressor stations currently planned along the route, as well as measurement, regulation, and other ancillary facilities required for the safe and reliable operation of the pipeline. The pipeline is designed to transport up to 2.0 million dekatherms per day of natural gas.

II. Typical Pipeline Corridor Post-Development Condition

The typical 125-foot wide pipeline construction corridor within the site area will be restored following construction in the manner described below. Refer to the *Section 4.1 Post-Development Condition* of the PSS&S for additional information. **Figure 1** below shows the typical pipeline corridor.

A. 75-foot temporary construction ROW will be restored to pre-development conditions.

   i. If forested, post-development condition will be brush (seeded with herbaceous and woody species per *Section 2.9.2 Permanent Seeding* and *MVP-ES11* of the PSS&S) and allowed to naturally return to forest condition subject to landowner actions.
   ii. If agricultural land, post-development condition will return the temporary ROW to agricultural use and will be modeled as such in the stormwater calculations.
   iii. If pre-development conditions included any impervious cover, such as asphalt or gravel access roads, these impervious surfaces will remain and/or be restored in the post-development condition.
   iv. Other pre-development conditions such as meadow, wetland, lawn, etc. will be restored to pre-development conditions and will be modeled as such in the stormwater calculations.
   v. NOTE: where applicable for water quantity purposes, the entire Limits of Disturbance (LOD), including both the temporary and permanent ROW, will be analyzed.

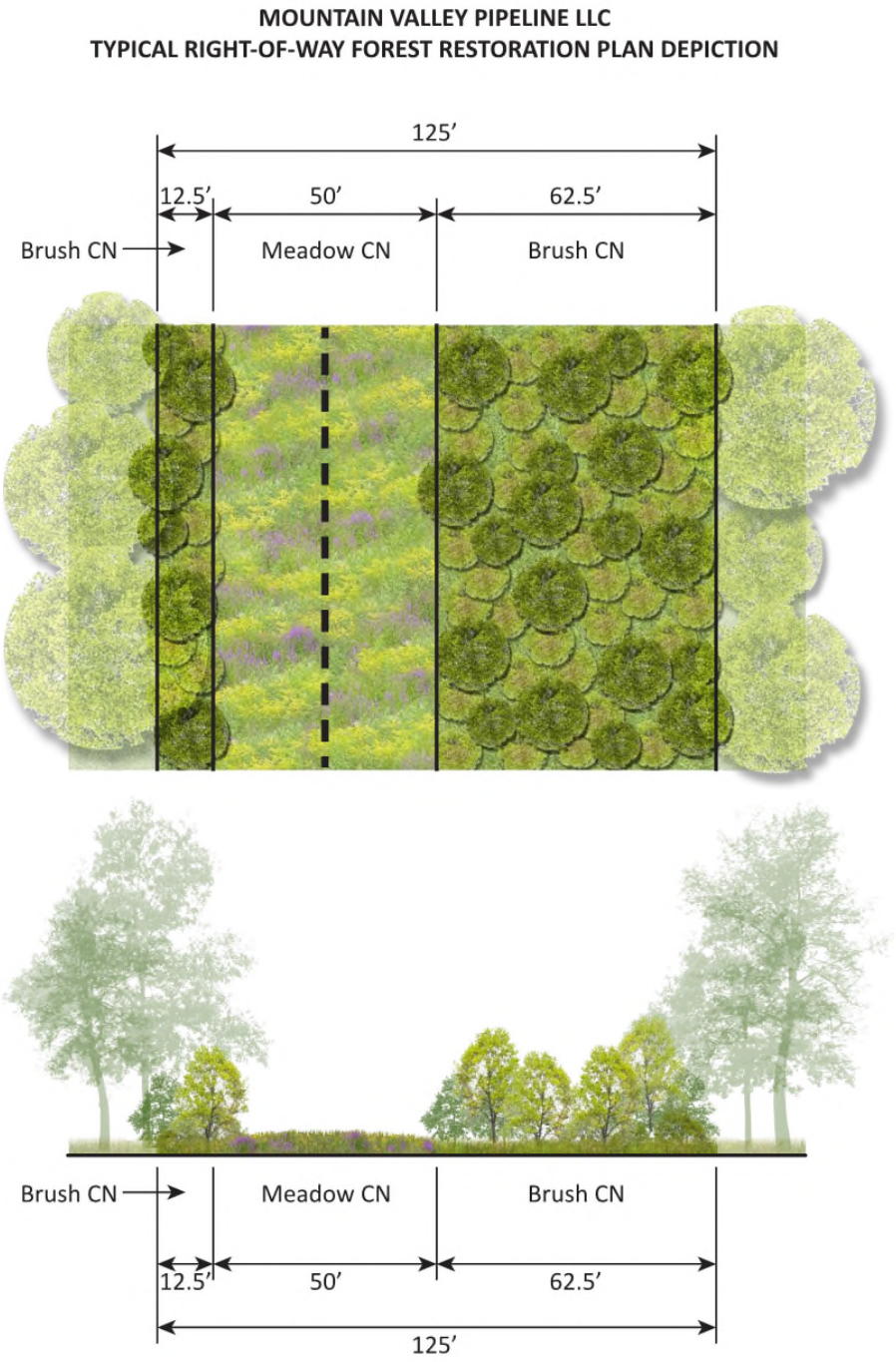
B. 50-foot permanent ROW will be seeded and restored to meadow conditions if the pre-development land use is not agricultural. The following practices will apply:

   i. Mowing and general maintenance will be consistent with the "Forest & Open Space" practices listed in the Virginia Runoff Reduction Method (VRRM) Compliance Spreadsheet User's Guide & Documentation (April 2016), Table 1. *Land Cover Guidance for VRRM Compliance Spreadsheets*.
   ii. The full width permanent ROW will not be mowed any more frequently than once every three (3) years.

iii. A corridor not exceeding 10 feet in width located directly over the pipeline will be mowed annually for inspection purposes in accordance with Federal Energy Regulatory Commission (FERC) PLAN and PROCEDURES.

iv. NOTE: where applicable for water quality purposes, only the permanent ROW will be analyzed.

Figure 1. Typical Right-of-Way Forest Restoration Plan Depiction



III. Project Stormwater Methodology

The Mountain Valley Pipeline Project (Project) traverses agricultural and forested lands along its 106-mile route from Giles to Pittsylvania County. The Project will meet all Virginia Department of Environmental Quality (DEQ) requirements as detailed in this and additional reference documents. Runoff conditions are not degraded and water quality requirements are met or exceeded. Where water bars spaced per *M.V.P. 17.2 Slope Breaker/Right-of-Way Diversion/Waterbar* are instituted to slow water flows, end treatments have been designed to further assure that sheet flow conditions and non-erosive velocities are maintained. Land use changes from pre- to post-construction are categorized below, along with discussion on how stormwater management requirements will be satisfied per land use category.

The 2015 Environmental Systems Research Institute (ESRI) World Imagery aerial photography digitized land use is used for land cover data. This may be superseded if field survey is present (e.g. existing gravel roads). See PSS&S *Appendix D Section 1.2.3.3 Curve Number* for additional information.

A. Prior Developed Lands

Portions of pipeline easements which traverse prior developed lands (e.g. access roads, agricultural areas, pasture, etc.), will be restored to existing predevelopment conditions with no improvements. Per Guidance Memo No. 15-2003 *Postdevelopment Stormwater Management Implementation Guidance for Linear Utility Projects*, preparation and implementation of stormwater management calculations is unnecessary for these areas. DEQ has clarified that it is not their expectation that permanent best management practices (BMPs) be installed on restored ROW.

Areas where predevelopment land cover conditions will be altered and MVP will comply with post-construction stormwater quality and quantity requirements, including the preparation of stormwater management calculations and a stormwater management plan per 9VAC25-870 and 9VAC25-880. In such instances, the outfall within the project must comply with Part IIB of the stormwater regulations, thereby addressing water quantity criteria for channel and flood protection.

B. Pre-construction Agricultural Lands

Pre-construction agricultural areas/fields will be returned to crop production, pasture, meadow, hay fields, etc., in identical condition (i.e. with topsoil stocked, respreads, disked and seeded), upon completion of pipeline construction. Agricultural areas are therefore exempt from meeting the Virginia Water Quality (9VAC25-870-63) and Water Quantity (9VAC25-870-66) requirements per § 62.1-44.15:34 and 9VAC25-870-300.

C. Pre-construction Non-Agricultural Lands with no Impervious Cover

i. Water Quality

Pre-construction non-agricultural and forested areas will satisfy Virginia Water Quality new development requirements per the most recent version of Virginia's 6th order National Watershed Boundary Dataset via the Virginia Runoff Reduction Method (9VAC25-870-63.A.1 and 9VAC25-870-65.A, respectively).

Under normal operating conditions, the post construction permanent right-of-way (ROW) will be considered "Forest/Open Space" land cover for VRRM water quality calculations per *Section 4.3 Stormwater Quality Calculations* of the *Project Specific Standards and Specifications for Virginia* (PSS&S). As such, the ROW phosphorus loading will always be less than the 0.41 pounds per acre per year maximum for new development, as shown in the following table:

TP Load per acre based on VRRM Land Cover and HSG (lb TP/ac/yr) *

Cover Type	**A Soils**	**B Soils**	**C Soils**	**D Soils**
Forest/Open Space	0.05	0.07	0.09	0.11

*Based on the following default VRRM values:
Annual rainfall for the state of Virginia = 43 inches
Target Rainfall Event = 1 inch
Total Phosphorus Event Mean Concentration = 0.26 mg/L

Therefore, no phosphorus reduction is required.

ii. Water Quantity: Concentrated Flow

Pre-construction non-agricultural and forested areas resulting in concentrated flow will satisfy Virginia Water Quantity channel and flood protection requirements (9VAC25-870-66.B.3.a and 9VAC25-870-66.C.2.b, respectively). Both channel and flood protection requirements compare runoff volumes and peak flows from pre- to post-construction condition. These values are based on curve numbers associated with land use. The Project will always result in lower post-development curve numbers in pre-construction non-agricultural areas with no impervious cover.

The restored ROW will be a brush/meadow combination and, therefore, result in a *lower* CN than that for "Woods, Good" condition for all Hydrologic Soil Groups (HSG's), with the exception of "A" soils where it will be equivalent, as explained in *Section 4.2.2 Curve Numbers* of the PSS&S and depicted in the following table:

TR-55 Runoff Curve Numbers

Cover Type	A Soils	B Soils	C Soils	D Soils
Woods, Good	30	55	70	77
Pipeline, 125-ft Right-of-Way*	30	52	67	75

*These are weighted curve numbers based on 50-feet of meadow and 75-feet of brush conditions of the same HSG soils within the restored ROW per *Section II. Typical Pipeline Corridor Post-Development Condition*.

Channel protection requirements can be satisfied using the Energy Balance Method per 9VAC25-870-66.B.3.a. The Energy Balance Method is intended for post-development runoff to mimic forested conditions, and states the following:

> Under no condition shall … $Q_{Developed}$ be required to be less than that calculated in the equation $(Q_{Forest} * RV_{Forest})/RV_{Developed}$; where
> $Q_{Developed}$ = The allowable peak flow rate of runoff from the developed site.
> $RV_{Developed}$ = The volume of runoff from the site in the developed condition.
> Q_{Forest} = The peak flow rate of runoff from the site in a forested condition.
> RV_{Forest} = The volume of runoff from the site in a forested condition;

Flood protection requirements can be satisfied using 9VAC25-870-66.C.2.b. The MVP project is assuming a worst-case scenario in which localized flooding currently occurs during the 10-year 24-hour storm event. Therefore, the post-development peak flow rate for the 10-year 24-hour storm event must be "less than the pre-development peak flow rate".

Because the post-construction ROW always results in a CN less than or equal to that of woods, and time of concentration will never decrease due to possible retention behind the water bar end treatments, peak flows will never exceed those of forested conditions. Therefore, the Energy Balance Method requirements are automatically satisfied, and channel protection requirements are met. Additionally, based on CN reduction from pre- to post-construction conditions, 10-year 24-hour storm volumes will also always be reduced, thereby satisfying flood protection requirements.

D. Post-Construction New Impervious Cover

New impervious cover may include access roads and main line valve pad sites. Stormwater analysis and BMP designs will be performed for all Project site areas with new impervious cover to ensure that the following Virginia state regulations have been satisfied:

- Water Quality (9VAC25-870-63)
- Water Quantity (9VAC25-870-66)
- Offsite Compliance Options (9VAC25-870-69)

i. Water Quality

Areas with new impervious cover in the post-construction permanent condition will satisfy Virginia Water Quality requirements via one of two ways. First, pre-construction non-agricultural areas will result in low phosphorus loading (see *III.C.i* above). These low loading areas will offset higher loading from new impervious cover, resulting in a balance or load reduction over each 6th order, or Hydrologic Unit Code (HUC) 12, boundary. Alternatively, if phosphorus load reductions are required for individual locations, water quality requirements could be met via offsite compliance options (9VAC25-870-69) or onsite BMPs.

ii. Water Quantity

Areas with new impervious cover in the post-construction condition will satisfy Virginia Water Quantity requirements via appropriate stormwater management controls. These controls may include BMPs designed in accordance with the Virginia Stormwater BMP Clearinghouse (9VAC25-870-65.B), BMPs referenced in the PSS&S, physical spreading of runoff into sheet flow via water bar end treatments (see *I.D* below), level spreaders, other specific water quantity control measures, or a combination thereof.

E. Sheet Flow

Water quantity regulations for any ROW land use can be satisfied via sheet flow conditions (9VAC25-870-66.D). There are two instances where runoff will be in the form of sheet flow. The first is in areas where runoff leaves the site ROW as sheet flow in existing conditions, does not re-concentrate within 100 feet downstream, and the proposed condition will maintain existing sheet flow. The second is where runoff diverted by water bars installed per *M.V.P. 17 Slope Breaker/Right-of-Way Diversion/Waterbar* will be redistributed as sheet flow via water bar end treatments.

i. Project Limits

In a similar manner to the concentrated flow scenarios described above, the CN's in the post-construction condition will be less than or equal to the pre-construction condition. In areas of sheet flow where no water bars are present in the post-construction condition, existing grades will be re-established to ensure sheet flow in the post-construction condition. Therefore, <u>sheet flow volumes will never increase, there will be no downstream impacts, and "no further quantity controls are required" per *9VAC25-870-66.D.*</u>

Additional information on sheet flow, including calculations for non-erosive velocities, is available in *Section 4.4.5 Sheetflow* and *Appendix D Section 1.2.2 Sheet Flow* of the PSS&S.

ii. Water Bars

M.V.P. 17.3 Water Bar End Treatment Sizing details the methodology for ensuring sheet flow from water bars throughout the Project is achieved. To summarize, Rational Method calculations, including the use of Pittsylvania County precipitation data as a worst-case scenario (i.e. all other Project areas have lower rainfall levels), demonstrate non-erosive velocities and 0.1-foot depth across the end treatment weirs. For ease of construction, the level weir sections of the end treatments are conservatively sized to three standard lengths based on drainage area inspection:

Water Bar End Treatment Level Weir Section Lengths	
D.A. (ac)	**Length (ft)**
≤ 0.5	10
0.5 ≤ 1.0	15
1.0 ≤ 1.5	20
> 1.5*	Site Specific

*or Curve Numbers > 71

Water bar spacing is based on slope as shown in *M.V.P. 17.2 Slope Breaker/Right-of-Way Diversion/Waterbar*, reproduced here:

RECOMMENDED MAXIMUM SPACING FOR PERMANENT SLOPE BREAKERS	
PIPELINE GRADE	**DISTANCE (FEET)**
<2%	N/A
2-5%	400
6-15%	200
16-30%	100
>31%	50

Maximum water bar spacing of 400 ft with a 50 ft permanent ROW results in a drainage area of 20,000 sf (0.46 acre) per water bar. Therefore, water bars located in series, perpendicular to slope will always have drainage areas less than 0.5 acres and will be assigned the 10-ft water bar end treatment.

Rather than performing a detailed measurement of each water bar drainage area, the proposed methodology is to select the 10-foot water bar end treatment for all water bars located in series, perpendicular to slope.

Drainage areas for water bars at the top and bottom of any series, as well as any water bars not in series or on cross-slopes, will be delineated to determine drainage area size, CN, and appropriate water bar end treatment length.

This process should yield repeatable, conservative results in terms of selecting end treatment lengths. For larger watersheds or on cross-slopes, site specific analyses will be performed to determine if a maximum 20-ft end treatment length will suffice, an additional water bar is needed to reduce the drainage area, or if a site-specific design is required.

In a similar manner to the concentrated flow scenarios described above, the CN's in the post-construction condition will be less than or equal to the pre-construction condition. However, because the drainage area to the water bar end treatment is slightly larger in post-construction than in pre-construction condition, sheet flow volumes at the end of the water bar do increase. However, cumulatively the watershed sheet flow volumes do not increase because the post-construction CNs are less than or equal to the pre-construction CNs of the watershed. Additionally, water bar end treatments are designed to ensure sheet flow and non-erosive velocities, resulting in no impacts to down-gradient properties. Therefore, the conditions of 9VAC25-870-66.D are satisfied and "no further quantity controls are required."

F. Pre-Construction Rock Outcroppings

During planning of the project, MVP route survey and development specifically avoided construction constraints like rock outcrops because of the significant difficulties associated with constructing in these types of areas. If any rock outcrops are present they will consist of minor areas that represent a small amount of the area of disturbance and will, therefore, not affect stormwater management calculations.

Pre-construction curve numbers are based on overall land use. Existing rock outcroppings would be categorized as disconnected impervious cover and have a negligible effect on curve numbers of the surrounding area. During construction, rock outcroppings within the permanent ROW will be blasted in trenching activities. Blasting will convert large single pieces of impervious rock to small-sized (less than 6-inch diameter) rock pieces mixed with native soil, resulting in a post-construction increase in infiltration rate and a resulting curve number reduction. Post-construction curve numbers are conservative because they do not include this improved infiltration.

G. Karst Features

MVP's Karst Hazards Assessment (KHA) and Karst Mitigation Plan (KMP) are consistent with applicable sections of the Virginia Department of Conservation and Recreation (DCR) Technical Bulletin No. 2, Hydrologic Modeling and Design in Karst Guidance. The Technical Bulletin is intended to guide large-scale, long-duration development projects in karst terrain, while the MVP Project constitutes a shallow, linear short-term construction project with strict environmental controls and land reclamation to pre-construction conditions.

The KHA was initially prepared as part of the FERC Environmental Report (Resource Report #6 Geological Resources), with the most recent update submitted to the FERC in February 2017. The KHA involved detailed desktop review of public and proprietary data to identify karst features, with field verification to confirm and enhance the desktop review. This is consistent with the karst investigation criteria presented in the DCR Technical Bulletin No. 2. MVP considered the results of the KHA and implemented hundreds of alignment adjustments to avoid sensitive karst features. MVP completed field verification on all parcels along the current MVP Route (certain property owners had previously denied access to all MVP surveyors), and MVP will update the KHA for submittal to the FERC prior to initiating land disturbance.

The KMP was most recently updated in October 2017 to incorporate FERC Environmental Conditions (Implementation Plan #21). The KHA was also incorporated in the PSS&S, which is reviewed by the DEQ on an annual basis. MVP received approval on the PSS&S on June 20, 2017. The KMP requires that MVP Karst Specialist inspectors be on-site during all phases of land disturbing activities in karst terrain. In addition, the KMP requires the Karst Specialists to conduct a field review of the karst areas following tree felling activities to verify that no karst features were overlooked. The KMP includes inspection protocols for newly identified karst features (if any are found during tree felling activities or land disturbance), outreach instructions for the DCR Karst Protection Coordinator, erosion and sediment control and stormwater management Best Management Practices, as well as avoidance and mitigation strategies for karst features. In summary, the KMP is consistent with applicable guidance in the DCR Technical Bulletin No. 2 for karst evaluations during construction, erosion and sediment control, and stormwater management.

During planning of the project, MVP route survey and development specifically avoided construction constraints involving sensitive karst features, based on the results of the KHA, because of the potential difficulties associated with construction in the vicinity of sensitive karst features. As noted, MVP implemented several major and hundreds of minor route adjustments to avoid sensitive karst features to the extent practical, with the current alignment having only a minimal number of minor karst features (e.g., sinkholes) and sensitive water resources that were identified in the KHA. Based on the recommendations of the MVP and DCR's onsite Karst Specialist inspectors, additional minor alignment adjustments within the confines of the LOD may be coordinated with

MVP and implemented to avoid remaining features to the extent practical. The KMP includes stabilization and mitigation measures recommended for karst features that cannot be avoided.

MVP provided the KHA and KMP to the DCR - Karst Protection Coordinator for review, and incorporated recommendations from the agency. MVP also collaborated with the DCR - Karst Protection Coordinator to complete supplemental karst hydrogeologic evaluations (including dye trace studies) in the vicinity of the proposed alignment, in specifically-identified karst areas, as a contingency planning effort.

The KMP directs, based on observations of the Karst Specialist inspectors, additional avoidance or mitigation that may be necessary if any new karst features are encountered during land disturbance. As noted, the Karst Specialist inspectors will be on-site during all phases of land disturbance in karst terrain, and upon initial land clearing will inspect the LOD for karst features that may have been obscured by vegetation.

Per Section 4.0-5 of the KMP, the intent of ESC and related BMPs is to confine project-related disturbance to the LOD, protect sensitive karst features, and minimize erosion and enhance revegetation in those areas. In addition to ESC BMPs for standard pipeline construction, which includes specifications by regulatory agencies, additional BMPs will be implemented as specified by the Karst Specialist.

IV. Test Area Analysis

A test area was used to demonstrate the Project Stormwater Methodology. The test area is located at the start of Spread 8, within the Jefferson National Forest. Spread 8 consists of approximately 9.6 miles of 42" natural gas pipeline, constructed entirely within Giles County, with portions of the Spread passing through the Jefferson National Forest. The Spread starts at the Virginia / West Virginia State line and ends at the intersection of the pipeline and Kow Camp Road (State Route 615).

The test area existing conditions include forest with steep slopes and one existing access road. The existing road will not be improved and is, therefore, considered prior developed land. No agricultural land use is contained within the test area and no new impervious cover is proposed. Additional information is provided in *Appendix D Section 1.3 Stormwater BMP Design* of the PSS&S.

The remainder of this memo provides detailed information on how the proposed stormwater management methodology is in full compliance with VSMP requirements through a detailed analysis of the test area.

A. Pre-Construction Forested Lands

The test area is predominantly pre-construction forested lands, with the only exception being the existing access road. Runoff CN's for the main line pipeline running through forested lands will always be less than or equal to a "Woods, Good" condition, assuming there are no new impervious surfaces or changes to prior developed lands proposed in the drainage area (as is the case for this drainage area). As depicted in the table below, the restored ROW will result in a *lower* CN than that for "Woods, Good" condition for all Hydrologic Soil Groups (HSG's), with the exception of "A" soils where it will be equivalent. The implication of this CN Analysis will be discussed in more detail below.

TR-55 Runoff Curve Numbers

Cover Type	**A Soils**	**B Soils**	**C Soils**	**D Soils**
Woods, Good	30	55	70	77
Pipeline, 125-ft Right-of-Way*	30	52	67	75

*These are weighted curve numbers based on 50-feet of meadow and 75-feet of brush conditions of the same HSG soils within the restored ROW per *Section II. Typical Pipeline Corridor Post-Development Condition*.

B. Water Quality

Per *9VAC-25-870-63.A.1*, the test area is considered new development and must not exceed a total phosphorus load of 0.41 pounds per acre per year. No new impervious cover is proposed within the test area and the entire site post-development condition is "Forest/Open Space" land cover. This land use category has a loading rate dependent on HSG as shown below.

TP Load per acre based on VRRM Land Cover and HSG (lb TP/ac/yr)

Cover Type	**A Soils**	**B Soils**	**C Soils**	**D Soils**
Forest/Open Space	0.05	0.07	0.09	0.11

The test area consists of HSG A and B soils. As a result, phosphorus loading for the entire test area is less than the 0.41 pounds per acre per year maximum and, therefore, no phosphorus reduction is required. The difference between 0.41 and the actual loading per soil type can be used to offset loading reductions required for new impervious cover within the same 6th order, or HUC 12, boundary. In such cases, the calculations shall be provided to evaluate pollutant loading and pollutant removal requirements for the specific spread.

C. Water Quantity

Because the test area consists entirely of either prior developed areas (the existing gravel road) or pre-construction non-agricultural lands, no analysis was needed. To reiterate from Section III.C.2 above:

Because the post-construction ROW always results in a CN less than or equal to that of woods, and time of concentration will never decrease due to possible retention behind the water bar end treatments, peak flows will never exceed those of forested conditions. Therefore, the Energy Balance Method requirements are automatically satisfied, and channel protection requirements are met. Additionally, based on CN reduction from pre- to post-construction conditions, 10-year 24-hour storm volumes will also always be reduced, thereby satisfying flood protection requirements.

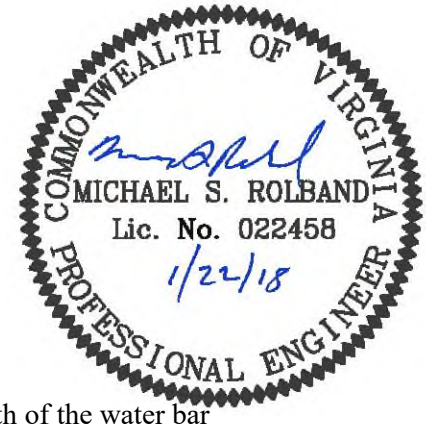
D. Sheet Flow Protection

This analysis includes a drainage area delineation for each water bar within the test area, excluding those in series and perpendicular to slope (numbered 8 through 17 in this analysis). Water bar end treatment lengths were assigned based on drainage area size and curve number per *M.V.P. 17.3 Water Bar End Treatment Sizing.*

Note that the test area contains four water bars with drainage areas greater than 1.5 acres. Site-specific calculations for these water bars were completed with the following results:

Water Bar	Drainage Area (ac)	Tc (min)	Post CN	Calculated End Treatment Length (ft)	Proposed End Treatment Length (ft)
6	1.57	28	30	5	20
18	2.04	41	49	10	20
45	1.57	27	55	10	20
46	1.82	20	54	13	20

For consistency with the conservative design standard table (refer to detail), all four water bars will use a 20-foot end treatment length. See *Post Construction Drainage Area Maps, revised 1-9-2018* for more information.



MVP 17.3

WATER BAR END TREATMENT SIZING AND DETAILS

1/22/18

The purpose of this detail is to document the methodology developed to size the length of the water bar end treatments to ensure flow leaving the permanent right-of-way is in the form of non-erosive sheet flow. Rather than perform a detailed, specific design for each and every water bar, this proposed methodology would provide conservatively sized end treatment lengths based primarily on the contributing drainage area. The intent is to provide several, incremental lengths that can be easily selected for each water bar that ensures the proposed length is not only adequate to produce sheet flow, but also facilitates constructability. This approach was performed for a test area within Spread 8, to demonstrate the methodology to be used as a template over the entire length of the pipeline project. The remainder of this detail outlines the approach and suggested end treatment lengths to be used for the project.

Flow Rate Computation

To calculate the required length of the end treatments, the flow rate to each water bar resulting from the 10-yr storm was necessary. Given the small size of the sub-sheds, use of the Rational Method to compute the flow rates was deemed to be an appropriate methodology. Each parameter and how they were computed is described below:

$$Q = C\,i\,A$$

Where:

Q = *10-yr flow rate, cfs*

C = *Runoff Coefficient:*

This parameter was determined using Table 4-5b in the *Virginia Stormwater Management Handbook* that provides C factors in relation to hydrologic soil groups, land uses, and land slopes. This provides a direct link to the NRCS methodologies employed for other aspects of this project and also accounts for the increase in runoff that results solely as a result of the steep slopes. For this exercise, Meadow, > 6% slope was used:

TABLE 4 - 5b
Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)
Rural Land Uses

STORM FREQUENCIES OF LESS THAN 25 YEARS													
Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

As noted in Table 4-5b, the maximum slope represented is ">6%", although project slopes exceed this level in certain areas. However, the applicability of using the Rational Method for this analysis and, as a result, the need to provide a link between CN and C factor warrants the use of this table.

i = *Intensity, in/hr:*

The Intensity-Duration-Frequency (I-D-F) curve for Pittsylvania County was used for this analysis as it was determined to be the most conservative County data for the pipeline project. It was derived using the VDOT Drainage Manual, *Appendix 6C-1, B, D and E Factors – Application* as it has been determined by VDOT/DCR that use of the BDE factors is appropriate for Rational Method calculations in smaller watersheds. The time of concentrations were computed using Seelye method (VDOT's preferred method, described in *Appendix 6D-1* of the VDOT Drainage Manual):

$$T_C = 0.225L^{0.42}S^{-0.19}C^{-1.0}$$

Where,

T_c = *Overland flow time, minutes*

L = *Length of strip, feet*

S = *Slope, feet/feet*

C = *Rational "C" value for ground character*

A = *Contributing Drainage Area, ac:*

Drainage areas to each water bar were delineated using available 2-ft C.I. topography.

Weir Flow Computation

With the flow to the water bars determined in the manner described above, the next step was to model the flow over the end treatments in order to compute the required length, as well as the sheet flow velocity below the level section to ensure it will not be erosive. To determine these parameters, flow over the level sections was modeled as a broad crested (rectangular) weir:

$$Q = C_w L H^{3/2}$$

Where:

Q = *10-yr flow rate, cfs*

C_w = *Rectangular Weir Coefficient, 3.33*

L = *Weir Length, ft*

H = *Head Over Weir, ft:*

This term is set to be 0.1 ft to ensure flow downslope of the end treatment is in the form of sheet flow.

Velocity Computation

To assess the velocity of the sheet flow downslope of the end treatment, Manning's equation was used:

$$V = (1.49/n)\, R^{2/3}\, S^{1/2}$$

Where:

V = *Overland Velocity, ft/s*

n = *Manning's Coefficient:*

This parameter was assumed to be 0.24 for sheet flow in "dense grasses" (TR-55, Table 3-1. Areas below the end treatments will be seeded with a native grasses and woody species, so the "dense grasses" n value was deemed to be the most appropriate vs the "short prairie grass" (n = 0.15) or "Bermuda grass" (n = 0.41) alternatives).

R = *Hydraulic Radius, ft:*

This term is defined as the cross-sectional flow area divided by the wetted perimeter. However, for shallow, wide flow this can be assumed to be equal to the flow depth. In this case this is set to the specified flow depth of 0.10 ft, per the following example (for an assumed 10 ft end treatment):

R = A / WP
= (0.1 ft * 10 ft) / (0.1 ft + 10 ft + 0.1 ft)
= 1.0 ft^2 / 10.2 ft
= 0.098 ft

Use depth = 0.10 ft

S = *Overland Slope, ft/ft:*

This parameter was measured for each water bar. A sheet flow path was delineated from the water bar end treatment perpendicular to contours until reaching either another downstream water bar or 100 feet, whichever occurred first. Slope was calculated by dividing the difference between the start and ending elevation and the total sheet flow path length.

Methodology

To compute the required length of the water bar end treatment, the weir equation was solved for length (L) using the flow rate determined by the Rational Equation, along with the other parameters defined above. To facilitate this process, a spreadsheet based calculator was developed:

Example

End Treatment Length Calculator

Enter Site Specific Data	T_c =	15	time of concentration to water bar, min
	A =	1.79	water bar drainge area, ac
	S =	0.35	weir discharge overland slope, ft/ft
Computed	i =	4.5	computed from IDF, in/hr
Enter Flow Parameters	C =	0.19	assumes >6% slope, meadow
	C_w =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **14 ft**

Velocity Check ------> **0.79 fps**

Site data is entered, including the time of concentration (T_c), drainage area (A), and overland slope below the end treatment (S). Using the entered T_c, the intensity (i) is calculated from the Pittsylvania I-D-F curve. The flow rate is computed using the Rational Equation and entered into the weir equation to solve for the end treatment length (via lookup tables). A check of the velocity is also performed using Manning's equation with the overland slope term entered into the calculator. This process was repeated for each of the 47 separate water bars analyzed in this example watershed.

Results for Spread 8 Test Area

To test out the proposed end treatment sizing methodology to be used as a project standard, it was applied to size the end treatments for the test area within Spread 8. The following plot (Figure 1) summarizes the computed end treatment lengths vs the size of the contributing watershed for each of the 47 water bars (detailed data is presented in Table 1). Note that four water bars (6, 18, 45, and 46) required site specific analyses.

Figure 1

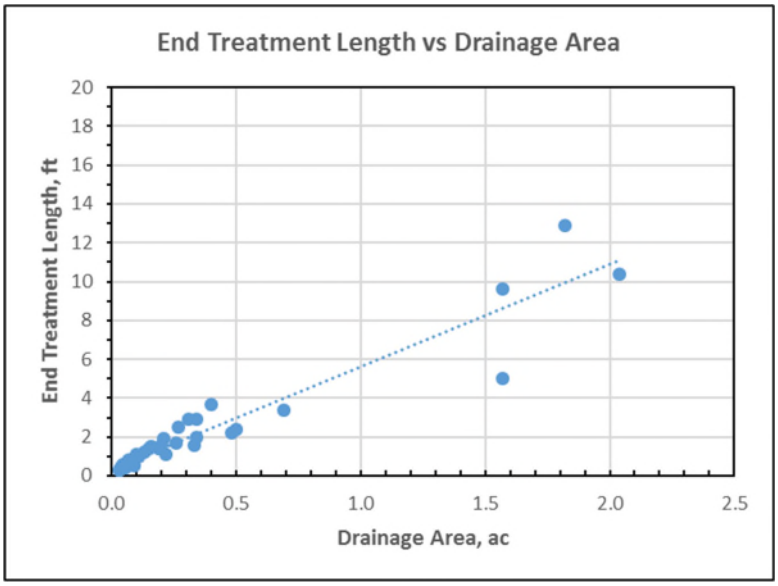


Table 1 – Test Watershed

				Velocity (fps)			
Waterbar	Drainage Area (ac)	T_c (min)	Slope (ft/ft)	10-yr	100-yr	C	End Treatment Length (ft)
1	0.69	10	0.47	0.92	1.05	0.10	3.4
2	0.22	10	0.49	0.94	1.05	0.10	1.1
3	0.33	11	0.41	0.86	0.96	0.10	1.6
4	0.48	12	0.47	0.92	1.05	0.10	2.2
5	0.50	11	0.51	0.96	1.08	0.10	2.4
6	1.57	28	0.44	0.89	1.02	0.10	5.0
7	0.09	9	0.37	0.81	0.94	0.11	0.5
8	0.04	7	0.40	0.85	1.00	0.19	0.4
9	0.04	6	0.30	0.73	0.80	0.19	0.5
10	0.05	6	0.31	0.74	0.82	0.19	0.6
11	0.10	6	0.30	0.73	0.84	0.19	1.1
12	0.05	7	0.32	0.76	0.89	0.19	0.5
13	0.05	7	0.32	0.76	0.89	0.19	0.5
14	0.05	7	0.30	0.73	0.86	0.19	0.5
15	0.05	7	0.32	0.76	0.89	0.19	0.5
16	0.05	7	0.30	0.73	0.86	0.19	0.5
17	0.20	14	0.36	0.80	0.91	0.19	1.6
18	2.04	41	0.33	0.77	0.89	0.17	10.4
19	0.34	12	0.30	0.73	0.84	0.19	2.9
20	0.40	10	0.24	0.66	0.75	0.19	3.7
21	0.16	10	0.23	0.64	0.74	0.19	1.5
22	0.27	10	0.20	0.60	0.68	0.19	2.5
23	0.15	10	0.22	0.63	0.72	0.19	1.4
24	0.06	12	0.21	0.61	0.73	0.19	0.4
25	0.07	7	0.22	0.63	0.70	0.19	0.8
26	0.13	10	0.18	0.57	0.66	0.19	1.2
27	0.04	10	0.21	0.61	0.68	0.19	0.4
28	0.03	12	0.08	0.38	0.41	0.19	0.3
29	0.07	10	0.27	0.69	0.78	0.19	0.7
30	0.05	9	0.21	0.61	0.70	0.19	0.5
31	0.08	10	0.22	0.63	0.70	0.19	0.8
32	0.08	9	0.22	0.63	0.71	0.19	0.8
33	0.34	28	0.27	0.69	0.80	0.19	2.0
34	0.26	21	0.38	0.82	0.96	0.19	1.7
35	0.19	16	0.34	0.78	0.90	0.19	1.4
36	0.08	9	0.29	0.72	0.82	0.19	0.8
37	0.04	9	0.56	1.00	1.14	0.19	0.4
38	0.04	7	0.53	0.97	1.15	0.19	0.4
39	0.04	9	0.22	0.63	0.71	0.19	0.4
40	0.03	9	0.36	0.80	0.91	0.19	0.3
41	0.06	8	0.31	0.74	0.86	0.19	0.5
42	0.11	11	0.17	0.55	0.63	0.19	1.0
43	0.21	10	0.17	0.55	0.63	0.19	1.9
44	0.10	9	0.14	0.50	0.57	0.19	1.0
45	1.57	27	0.42	0.87	1.00	0.19	9.6
46	1.82	20	0.22	0.63	0.72	0.19	12.9
47	0.31	10	0.13	0.48	0.55	0.19	2.9

Overland Velocities

As depicted in Table 1, overland velocities below the end treatments will remain well below erosive levels, which was assumed to be equal to 2.25 fps for a sandy loam, earthen lining under critical conditions (VESCH, Table 5-22 – lowest velocity). Note that the downslope areas will be vegetated and thus will be able to withstand an even higher velocity. To reiterate, even assuming an earthen lining expected velocities are well below erosive levels. To provide additional assurance that the areas below the water bar will remain stable, a check of the velocities for the 100-yr storm was also performed. Even under this extreme storm event, overland velocities also remain below erosive levels (Table 1).

Proposed End Treatment Lengths

Based on this analysis, end treatment lengths from 5 to 13 ft would ensure sheet flow from all of the water bars in this watershed is achieved (note many are much shorter than 5 ft, but that would present constructability issues). The goal now is to apply these results to the remainder of the project where less pervious soil types exist (i.e. C and D soils). There is also a desire to provide a method whereby the end treatment lengths can be selected based on CN and contributing drainage area alone, without performing detailed calculations. There is recognition that use of this simplified process requires built-in factors of safety to ensure sheet flow is always produced, and this has been achieved.

To establish the link between the Rational coefficient (C) and the computed CN's for typical land use within the permanent ROW, consider the following comparison (Table 2):

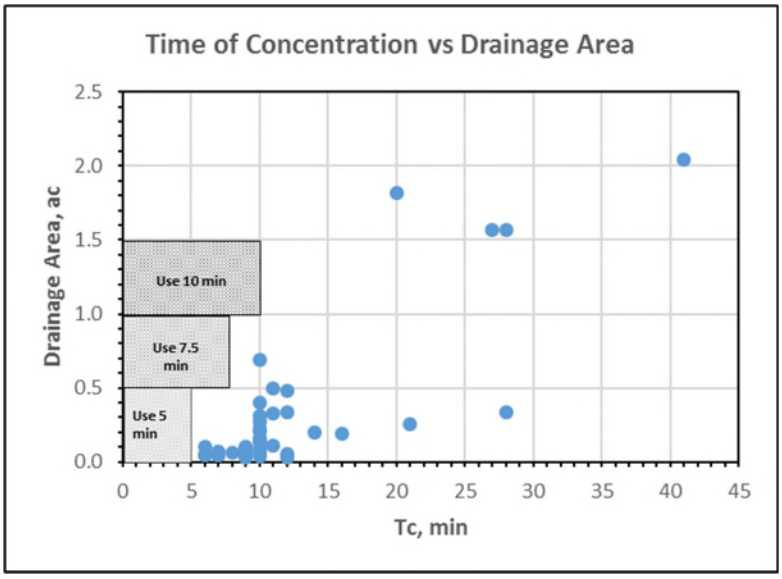
Table 2

		Hydrologic Soil Group			
		A	***B***	***C***	***D***
Woods	**C**	0.08	0.15	0.17	0.21
	CN	30	55	70	77
Meadow	**C**	0.10	0.19	0.22	0.25
	CN	30	**58**	**71**	**78**
Pasture	**C**	0.10	0.22	0.31	0.35
	CN	39	61	74	80

The analysis for this test watershed utilized the actual HSG's, which were B soils in all areas except for Drainage Area A that has A soils. The other parameters used in this analysis include a "meadow" land use with slopes greater than 6% (note all C values in Table 2 represent slopes > 6%). This represents a C factor of 0.19 and a corresponding CN of 58, as shown in Table 3. A CN of 58 is the highest value for this example, so the use of the 0.19 C factor is justified (note a C factor of 0.10 was used in for the first 6 water bars, as shown in Table 1). However, other areas of the project do have higher curve numbers, due primarily to less pervious soil types. This suggests use of C factors of 0.22 and 0.25, as depicted in Table 3, would be more appropriate in those areas and thus these higher values were also considered in this analysis.

In addition to soil type (i.e. CN), another consideration that will impact the lengths of the water bars is the time of concentration. A review of the T_c's in the test watershed suggests a conservative approach would be to assume tiered durations based on the size of the contributing watershed, whereby the selected T_c is less than the computed T_c. The actual values measured for each watershed are presented graphically in Figure 2, along with the assumed T_c value for each drainage area category:

Figure 2



Applying the above CN's and values for the T_c results in the following end treatment lengths:

Table 3

		End Treatment Lengths (ft)		
D.A. (ac)	**T_c (min)**	**CN ≤ 58**	**CN ≤ 71**	**CN ≤ 78**
≤ 0.5	5	6	7	8
0.5 ≤ 1.0	7.5	11	12	14
1.0 ≤ 1.5	10	14	17	19

To add a factor of safety and to simplify constructability, end treatment sizes depicted in Table 3 were rounded up to lengths of 10, 15, and 20 ft (Table 4). Recognizing this resulted in lengths of 10, 15, or 20 ft for all CN's except for those <58 (B soils), a further conservative simplification was made to use the three specified lengths for all land uses. The end result that is **proposed for use throughout the entire project is presented in the "Preferred" column in Table 4**:

Table 4

	End Treatment Lengths (ft)				
D.A. (ac)	**CN ≤ 58**	**CN ≤ 71**	**CN ≤ 78**	**CN > 78**	***Preferred***
≤ 0.5	10	10	10	**Site Specific**	***10***
0.5 ≤ 1.0	15	15	15		***15***
1.0 ≤ 1.5	15	20	20		***20***
> 1.5	20	n/a	n/a		***Site Specific***

For drainage areas of larger than 1.5 ac, or for areas with a CN greater than 71 (selected because a CN of 71 corresponds with a Rational "C" coefficient that results in sizing of end treatments within Table 5 drainage area tiers), a site-specific analysis will be performed to ensure a maximum end treatment

maximum length of 20 ft will be sufficient. This may require the placement of additional water bars, or a longer water bar when the cross-slope angle allows a longer length.

To summarize, the following water bar end treatment lengths (Table 5) will be used for this project:

Table 5

Water Bar End Treatment Level Weir Section Lengths	
D.A. (ac)	**Length (ft)**
≤ 0.5	10
0.5 ≤ 1.0	15
1.0 ≤ 1.5	20
> 1.5*	Site Specific

*or Curve Numbers > 71

Design Basis

As described in this analysis, this proposed methodology provides for end treatment lengths that are extremely conservative. A summary of how this is achieved is provided below:

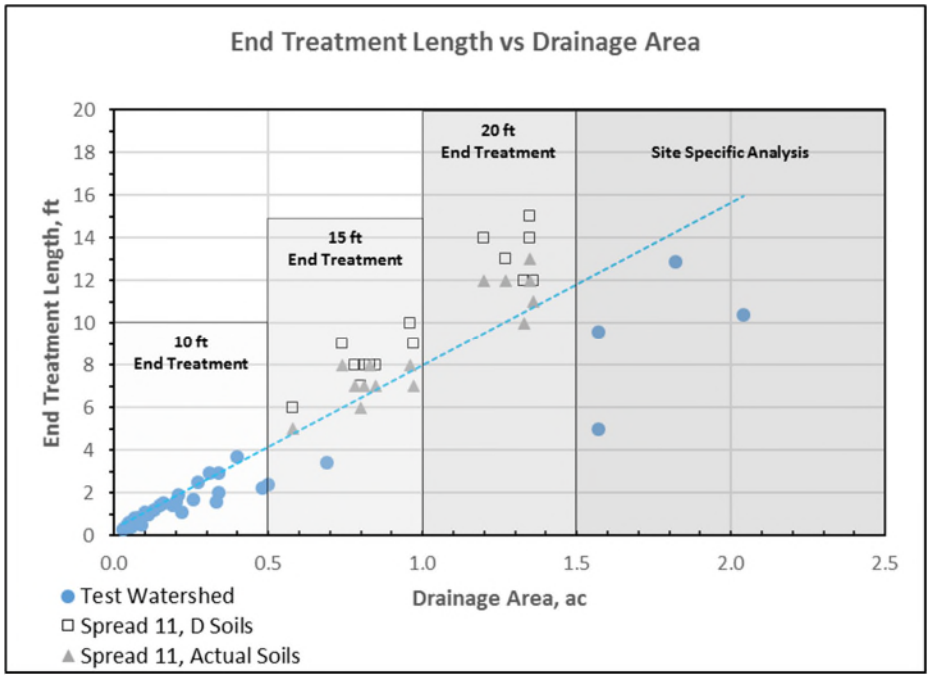
1) In this test watershed, 49% of the end treatment lengths were ≤ 1 ft in length (Table 1), yet the minimum specified end treatment length is 10 ft. In fact, for each drainage area category in this test watershed, the specified end treatment length is significantly longer than necessary to achieve non-erosive sheetflow. However, this test watershed included only one drainage area between 0.5 and 1.5 ac. Therefore, to test the methodology on larger drainage areas, another section of the project (Spread 11) was analyzed. The intent was to provide areas that were not only larger, but that also had "D" soils (most conservative assumption). The review of the project for this analysis did not result in areas that met these criteria. Thus, the sizing methodology was tested on these larger watersheds under 2 scenarios – using actual soil types (mostly "B" soils), as well as assuming all "D" soils. The results are tabulated in Table 6.

Table 6 – Portions of Spread 11

	Waterbar	Drainage Area (ac)	T_c (min)	Slope (ft/ft)	Velocity (fps) 10-yr	Velocity (fps) 100-yr	C	End Treatment Length (ft)
Spread 11 - Assumes D soils	1	0.80	20	0.13	0.48	0.57	0.25	7
	2	1.33	22	0.29	0.72	0.82	0.25	12
	3	0.58	14	0.13	0.48	0.56	0.25	6
	4	0.81	17	0.70	1.12	1.29	0.25	8
	5	0.78	14	0.10	0.42	0.50	0.25	8
	6	0.96	17	0.15	0.52	0.58	0.25	10
	7	0.85	19	0.30	0.73	0.84	0.25	8
	8	0.97	22	0.03	0.23	0.26	0.25	9
	10	0.83	21	0.14	0.50	0.56	0.25	8
	11	1.35	16	0.17	0.55	0.63	0.25	14
	12	1.27	15	0.11	0.44	0.51	0.25	13
	13	1.35	14	0.19	0.58	0.66	0.25	15
	14	1.20	13	0.20	0.60	0.67	0.25	14
	15	0.74	11	0.39	0.84	0.94	0.25	9
	17	1.36	21	0.05	0.30	0.35	0.25	12
Spread 11 - Uses actual soils type	1	0.80	27	0.13	0.48	0.57	0.19	6
	2	1.33	28	0.29	0.72	0.85	0.19	10
	3	0.58	20	0.13	0.48	0.57	0.19	5
	4	0.81	24	0.70	1.12	1.28	0.19	7
	5	0.78	19	0.10	0.42	0.50	0.19	7
	6	0.96	23	0.15	0.52	0.61	0.19	8
	7	0.85	26	0.30	0.73	0.84	0.19	7
	8	0.97	30	0.03	0.23	0.27	0.19	7
	10	0.83	21	0.14	0.50	0.56	0.19	8
	11	1.35	22	0.17	0.55	0.63	0.19	12
	12	1.27	21	0.11	0.44	0.50	0.19	12
	13	1.35	19	0.19	0.58	0.67	0.19	13
	14	1.20	18	0.20	0.60	0.68	0.19	12
	15	0.74	13	0.39	0.84	0.97	0.22	8
	17	1.36	28	0.05	0.30	0.34	0.19	11

The end treatment lengths computed by the sizing methodology, considering both the test watershed and larger drainage areas contained in Spread 11, provides for end treatment lengths that are significantly longer than necessary to provide for non-erosive sheetflow. The results are presented graphically in Figure 3. The trend line depicts all data except the assumed "D" soil types for Spread 11 (i.e. it utilizes actual soils for all depicted Spread 11 data).

Figure 3



For what is likely to be the most commonly encountered drainage area of less than 0.5 ac (based upon this detailed analysis for Spread 8), the installed end treatment length will be a minimum of 2.5 times longer than necessary.

2) The methodology will only be applied for drainage areas of less than 1.5 ac and for soils with a CN below 71. Larger watersheds and drainage areas with a CN > 71 will require site specific analyses to determine the end treatment length. As a result, watersheds that have an increased potential of problematic erosion will be more carefully reviewed on an individual basis.

3) The sheetflow velocities below the end treatments were assessed in this test watershed (10-yr storm) and compared to allowable velocities for bare earth - an extremely conservative approach. Even with this assumption, velocities will remain well below erosive levels. An analysis of the overland velocities for even a 100-yr event was also performed (Table 1) and even under this extreme storm event, velocities remain below erosive levels.

4) While the results provided by the proposed design methodology have been shown to be extremely conservative, the simplicity of the process itself will also facilitate accurate and conservative designs. The methodology allows for the implementation of a rapid, repeatable design process that also facilitates construction without risking damage to the environment. By reducing the need for site specific analyses for each and every end treatment, the chance for errors is significantly reduced.

Adaptive Management

Inherent with any hydrologic calculations is a level of uncertainty. The proposed end treatment length sizing methodology is extremely conservative and therefore mitigates much of this uncertainty. In addition to the conservative sizing methodology, however, there are also post-construction protocols in place that will provide additional assurances that the water bar end treatments will remain stable. In accordance with the guidelines contained in the approved plans for the project, post-construction monitoring and maintenance will be performed until such time as the disturbed pipeline area has been deemed to be permanently stabilized. As outlined in *Section 2.0 General Requirements* of the Project Standards & Specifications, inspections will be performed by DEQ-certified MVP inspectors to ensure any areas of erosion are quickly identified and promptly corrected. If field conditions warrant, the field inspectors can lengthen the water bar end treatment or recommend installation of additional water bar(s) to reduce the contributing drainage area and resulting velocities.

Based on the above (conservative design methodology and the adaptive monitoring and maintenance plan), MVP is confident the water bar end treatments will effectively control stormwater runoff in a manner that meets all state stormwater management requirements.

L:\22000s\22800\22865.01\Admin\04-ENGR\Spread 8 DA delineation\Level Spreader Sizing\012218 Final\2018-01-22_End Treatment Sizing MVP 17.3 FINAL RL.docx

WATER BAR 6 SITE-SPECIFIC ANALYSIS

I. Drainage Area

As shown, the drainage area to Water Bar 6 is 1.57 acres. This is greater than the 1.5 acre-maximum in the *MVP 17.3 Water Bar End Treatment Detail* and, therefore, requires a site-specific analysis to determine the water bar end treatment length.

II. Runoff Coefficient

The flowpath for Water Bar 6 begins as sheet flow in a HSG A wooded area with slopes greater than 6%. Therefore, the runoff coefficient used in the sheet flow time of concentration calculation will be 0.08.

The flowpath exiting the Water Bar 6 end treatment will be along HSG A meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.10.

TABLE 4 - 5b
Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)
Rural Land Uses

STORM FREQUENCIES OF LESS THAN 25 YEARS													
Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE										
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

As shown, the time of concentration for Water Bar 6 is 28 minutes.

TIME OF CONCENTRATION: WATER BAR 6

ID	Description	C	Length (ft)	Slope (ft/ft)	Area (sf)	Wet P (ft)	Velocity (fps)	Tc (hrs)
AB	Sheet flow	0.08	100.0	0.1852	$T_c = 0.225L^{0.42}S^{-0.19}C^{-1.0}$			0.447
Shallow Concentrated Flow							Fig. 3.1, TR-55	T_t=L/(3600V)
BC	Downslope		339.1	0.42			10.41	0.009
CD	Water bar		78.3	0.02			2.28	0.010
Channel Flow								T_t=L/(3600V)
							Total T_c (hr) =	0.465
							Total T_c (min) =	28

IV. Summary

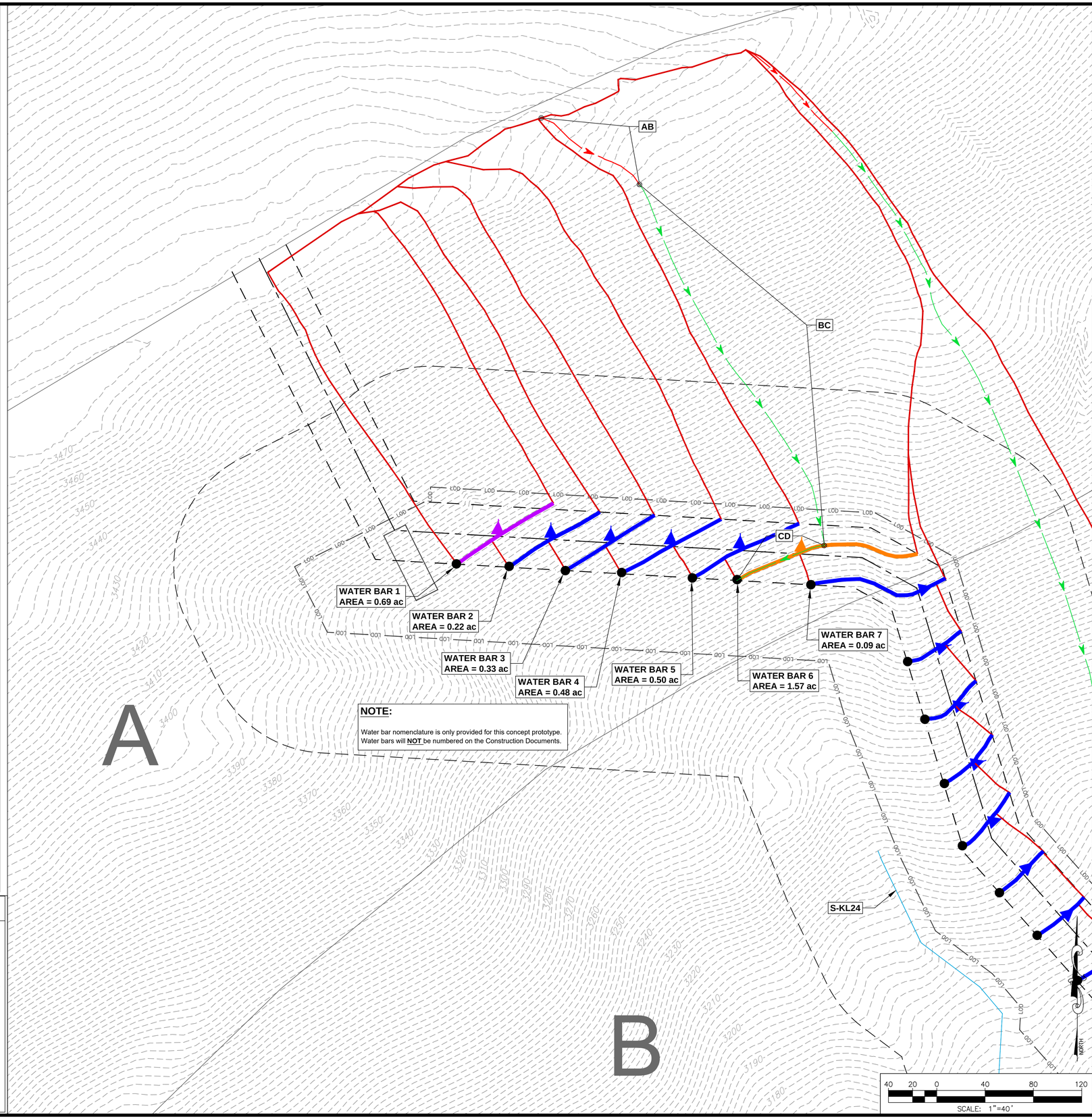
As shown, the water bar end treatment calculator indicates a 5-foot long end treatment will ensure sheet flow conditions leaving Water Bar 6. For ease of construction, the maximum allowable water bar end treatment length of 20 feet will be used for Water Bar 6.

End Treatment Length Calculator

Enter Site Specific Data	T_c =	28	time of concentration to water bar, min
	A =	1.57	water bar drainge area, ac
	S =	0.44	weir discharge overland slope, ft/ft
Computed	i =	3.3	computed from IDF, in/hr
Enter Flow Parameters	C =	0.1	assumes A soils, >6% slope, meadow (conservative)
	C_w =	3.33	weir coefficient (spillway)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft
Computed Weir Length ------>		5.0 ft	
Velocity Check ------>		0.89 fps	

DRAINAGE AREA PLAN LEGEND

- EXISTING CONTOURS - 2' C.I.
- MYSTERY RIDGE ROAD -EXISTING DIRT ROAD-
- FIELD-DELINEATED STREAMS
- HYDROLOGIC SOIL BOUNDARIES
- PROPOSED PIPELINE CENTERLINE
- PERMANENT RIGHT-OF-WAY -MEADOW LAND USE-
- LIMITS OF DISTURBANCE (LOD) / TEMPORARY RIGHT-OF-WAY -BRUSH LAND USE-
- 100' BUFFER FROM LOD
- WATER BAR DRAINAGE AREA (EXCLUDING THOSE IN SERIES)
- TIME OF CONCENTRATION SHEET FLOW
- TIME OF CONCENTRATION SHALLOW CONCENTRATED FLOW
- PERMANENT WATER BAR 10' END TREATMENT
- PERMANENT WATER BAR 15' END TREATMENT
- PERMANENT WATER BAR 20' END TREATMENT
- APPROXIMATE LOCATION OF WATER BAR END TREATMENTS (PENDING FIELD CONDITIONS)



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Post-Construction Water Bar Drainage Area Map

Giles County, Virginia

Stormwater Management Plan

COMMONWEALTH OF VIRGINIA
PROFESSIONAL ENGINEER
MICHAEL S. ROLLAND
Lic. No. 022468
1/2-1-18

REVISIONS

No.	Date	Description	Rev. By	App. By

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Design	Draft	Approved
MAM	MAM	FRG

Sheet #
1 of 5

Computer File Name:
I:\22000s\22800\22865.01\CADD\04-ENGR Drainage Areas\WSSI Drainage Areas.dwg

WATER BAR 12 SITE-SPECIFIC ANALYSIS

I. Drainage Area

As shown, the drainage area to Water Bar 12 is 2.04 acres. This is greater than the 1.5 acre-maximum in the *MVP 17.3 Water Bar End Treatment Detail* and, therefore, requires a site-specific analysis to determine the water bar end treatment length.

II. Runoff Coefficient

The flowpath for Water Bar 12 begins as sheet flow in a HSG A wooded area with slopes greater than 6%. Therefore, the runoff coefficient used in the sheet flow time of concentration calculation will be 0.08.

The flowpath exiting the Water Bar 12 end treatment will be along HSG B meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.19.

TABLE 4 - 5b
Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)
Rural Land Uses

STORM FREQUENCIES OF LESS THAN 25 YEARS													
Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE										
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

As shown, the time of concentration for Water Bar 12 is 41 minutes.

TIME OF CONCENTRATION: WATER BAR 12

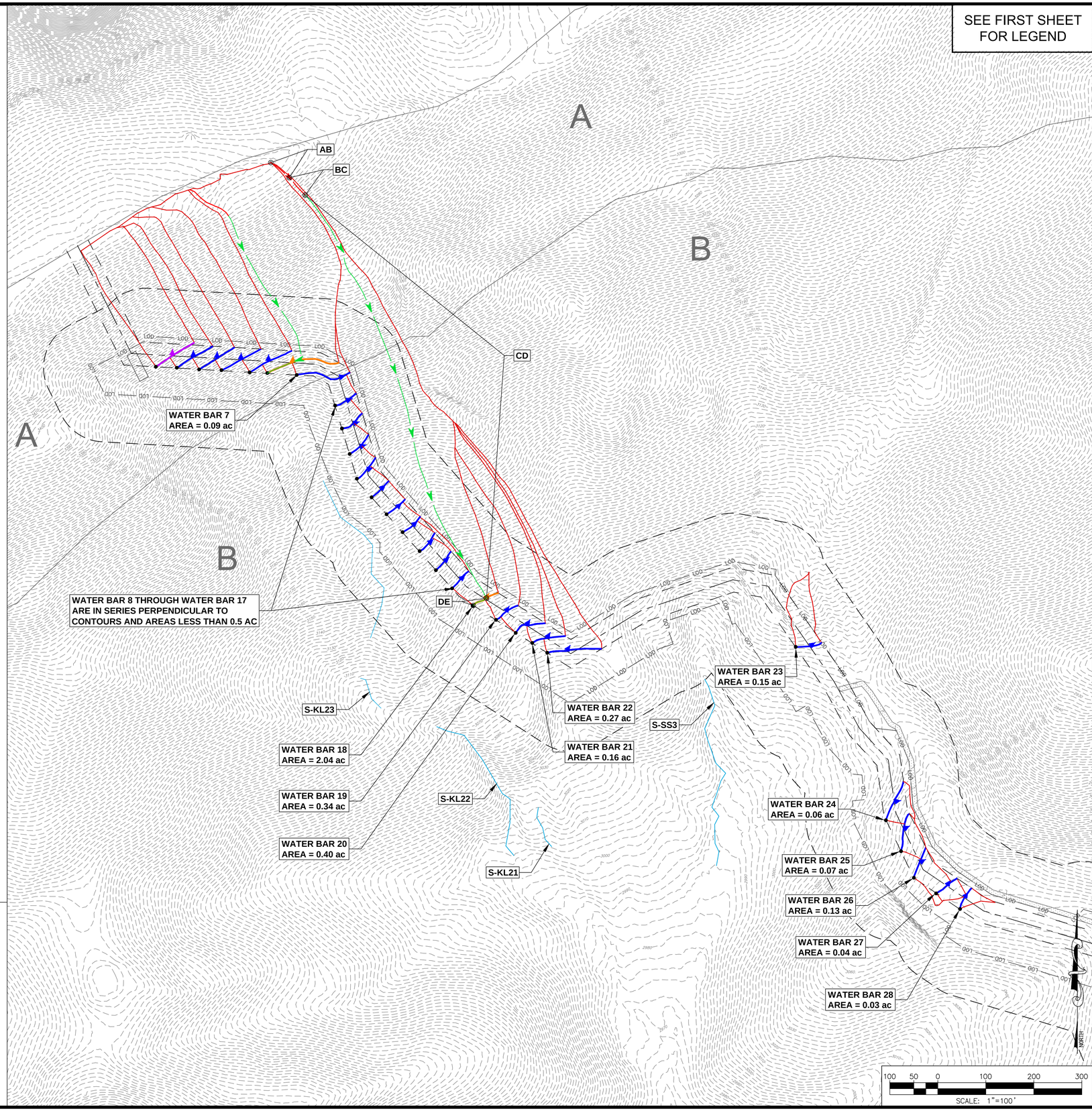
ID	Description	C	Length (ft)	Slope (ft/ft)	Area (sf)	Wet P (ft)	Velocity (fps)	Tc (hrs)
AB	Sheet flow 1	0.08	50.0	0.14	T_{ci} 0.225L$^{0.42}$S$^{-0.19}$C$^{-1.0}$			0.352
BC	Sheet flow 2	0.08	50.0	0.36				0.294
Shallow Concentrated Flow							Fig. 3.1, TR-55	T_t=L/(3600V)
CD	Downslope		930.6	0.345			9.47	0.027
DE	Water bar		31.9	0.02			2.28	0.004
Channel Flow								T_t=L/(3600V)
							Total T_c =	0.678
							Total $T_{c\,(min)}$ =	41

IV. Summary

As shown, the water bar end treatment calculator indicates a 10.4-foot long end treatment will ensure sheet flow conditions leaving Water Bar 12. For ease of construction, the maximum allowable water bar end treatment length of 20 feet will be used for Water Bar 12.

End Treatment Length Calculator

Enter Site Specific Data	T_c =	41	time of concentration to water bar, min
	A =	2.04	water bar drainge area, ac
	S =	0.33	weir discharge overland slope, ft/ft
Computed	i =	3.2	computed from IDF, in/hr
Enter Flow Parameters	C =	0.17	assumes A/B soils, >6% slope, meadow (conservative)
	C_w =	3.33	weir coefficient (spillway)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft
Computed Weir Length ------>		**10.4 ft**	
Velocity Check ------>		**0.77 fps**	



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Post-Construction Water Bar Drainage Area Map

Giles County, Virginia

Stormwater Management Plan

REVISIONS

No.	Date	Description	Rev. By:	App. By:

SCALE: As Noted

DATE: January 22, 2018

Horizontal Datum: NAD 83

Vertical Datum: NAVD 88

Boundary and Topo Source: Holland Engineering, Inc.

Design	Draft	Approved
MAM	MAM	FRG

Sheet #

2 of 5

Computer File Name:
I:\2200s\2200\2260.01\CAD\E&S ENGR Drainage Areas
WSSI Drainage Areas.dwg

SEE FIRST SHEET FOR LEGEND

WATER BAR 28
AREA = 0.03 ac

WATER BAR 29
AREA = 0.07 ac

WATER BAR 30
AREA = 0.05 ac

WATER BAR 31
AREA = 0.08 ac

WATER BAR 32
AREA = 0.08 ac

WATER BAR 33
AREA = 0.34 ac

WATER BAR 34
AREA = 0.26 ac

WATER BAR 35
AREA = 0.19 ac

WATER BAR 36
AREA = 0.08 ac

WATER BAR 37
AREA = 0.08 ac

WATER BAR 38
AREA = 0.04 ac

WATER BAR 39
AREA = 0.04 ac

WATER BAR 40
AREA = 0.03 ac

WATER BAR 41
AREA = 0.06 ac

WATER BAR 42
AREA = 0.11 ac

WATER BAR 43
AREA = 0.21 ac

WATER BAR 44
AREA = 0.10 ac

NORTH

40 20 0 40 80 120
SCALE: 1"=40'

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Boundary and Topo Source: Holland Engineering, Inc.

Design	Draft	Approved
MAM	MAM	FRG

Sheet #

3 of 5

Computer File Name:

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WATER BAR 45 SITE-SPECIFIC ANALYSIS

I. Drainage Area

As shown, the drainage area to Water Bar 45 is 1.57 acres. This is greater than the 1.5 acre-maximum in the *MVP 17.3 Water Bar End Treatment Detail* and, therefore, requires a site-specific analysis to determine the water bar end treatment length.

II. Runoff Coefficient

The flowpath for Water Bar 45 begins as sheet flow in a HSG B wooded area with slopes between 2% and 6%. Therefore, the runoff coefficient used in the sheet flow time of concentration calculation will be 0.11.

The flowpath exiting the Water Bar 45 end treatment will be along HSG B meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.19.

TABLE 4 - 5b
Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)
Rural Land Uses

STORM FREQUENCIES OF LESS THAN 25 YEARS													
Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

As shown, the time of concentration for Water Bar 45 is 27 minutes.

TIME OF CONCENTRATION: WATER BAR 45

ID	Type of Flow	C	Length (ft)	Slope (ft/ft)	Area (sf)	Wet P (ft)	Velocity (fps)	Tc (hrs)
AB	Sheet flow	0.11	100.0	0.04	T_c, $0.225L^{0.42}S^{-0.19}C^{-1.0}$			0.435
Shallow Concentrated Flow							Fig. 3.1, TR-55	T_t=L/(3600V)
BC	Downslope		466.5	0.22			7.62	0.017
CD	Water bar		42.1	0.02			2.28	0.005
Channel Flow								T_t=L/(3600V)
							Total T_c =	0.457
							Total T_c (min) =	27

IV. Summary

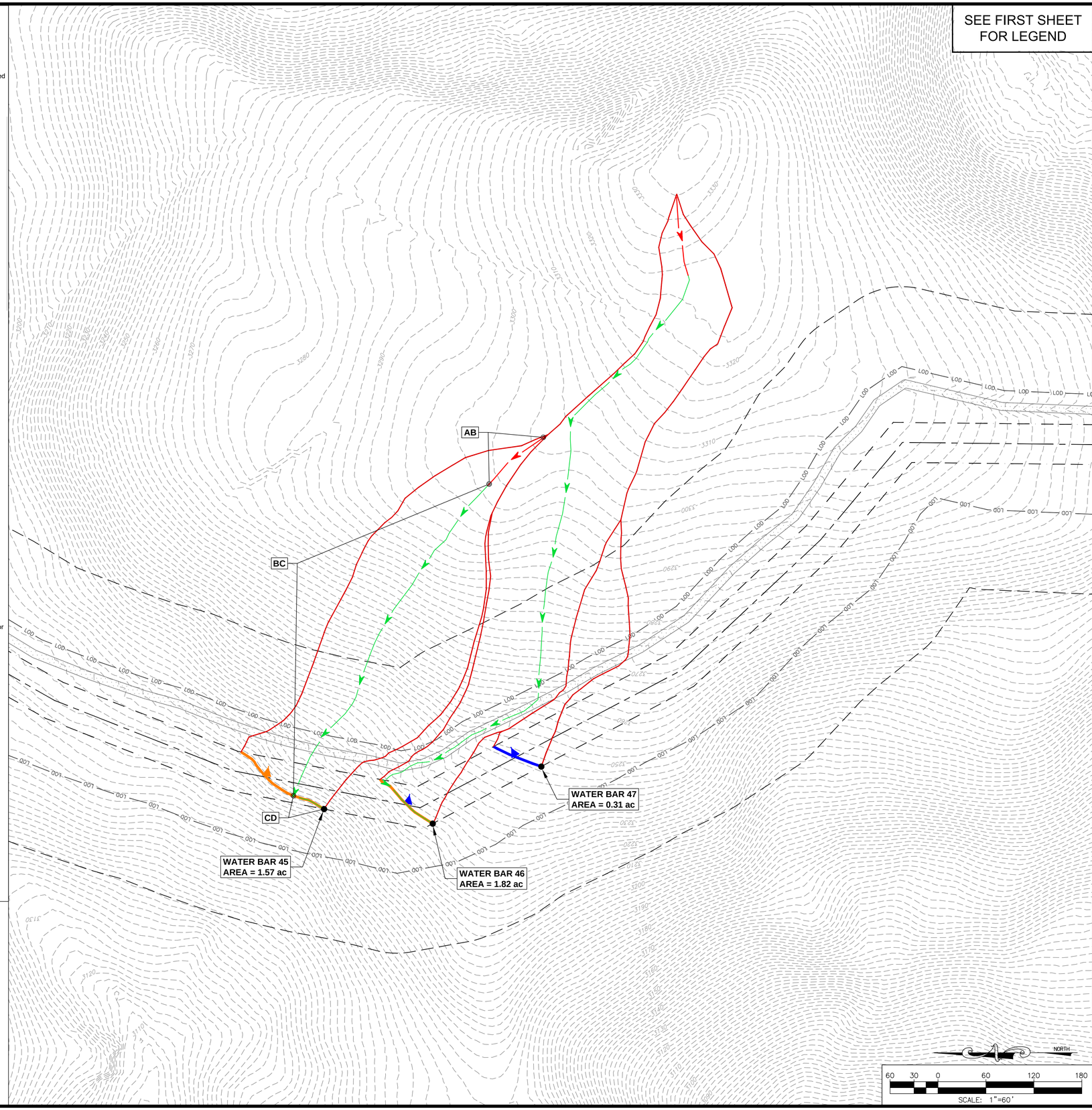
As shown, the water bar end treatment calculator indicates a 9.6-foot long end treatment will ensure sheet flow conditions leaving Water Bar 45. For ease of construction, the maximum allowable water bar end treatment length of 20 feet will be used for Water Bar 45.

End Treatment Length Calculator

Enter Site Specific Data	T_c =	27	time of concentration to water bar, min
	A =	1.57	water bar drainge area, ac
	S =	0.42	weir discharge overland slope, ft/ft
Computed	i =	3.4	computed from IDF, in/hr
Enter Flow Parameters	C =	0.19	assumes B soils, >6% slope, meadow (conservative)
	C_w =	3.33	weir coefficient (spillway)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **9.6 ft**

Velocity Check ------> **0.87 fps**



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Post-Construction Water Bar Drainage Area Map

Giles County, Virginia

Stormwater Management Plan

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Boundary and Topo Source: Holland Engineering, Inc.

Design	Draft	Approved
MAM	MAM	FRG

Sheet #

4 of 5

Computer File Name:

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Water Bar 46 SITE-SPECIFIC ANALYSIS

I. Drainage Area

As shown, the drainage area to Water Bar 46 is 1.82 acres. This is greater than the 1.5 acre-maximum in the *MVP 17.3 Water Bar End Treatment Detail* and, therefore, requires a site-specific analysis to determine the water bar end treatment length. This plan assumes the existing Mystery Ridge Road drainage ditch will empty into Water Bar 46. Field conditions may warrant re-sizing the water bar end treatment length.

II. Runoff Coefficient

The flowpath for Water Bar 46 begins as sheet flow in a HSG B wooded area with slopes greater than 6%. Therefore, the runoff coefficient used in the sheet flow time of concentration calculation will be 0.15.

The flowpath exiting the Water Bar 46 end treatment will be along HSG B meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.19.

TABLE 4 - 5b
Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)
Rural Land Uses

STORM FREQUENCIES OF LESS THAN 25 YEARS													
Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE										
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

As shown, the time of concentration for Water Bar 46 is 20 minutes.

TIME OF CONCENTRATION: WATER BAR 46

ID	Description	C	Length (ft)	Slope (ft/ft)	Area (sf)	Wet P (ft)	Velocity (fps)	Tc (hrs)
AB	Sheet flow	0.15	100.0	0.09	T_{cx} 0.225L$^{0.42}$S$^{-0.19}$C$^{-1.0}$			0.275
Shallow Concentrated Flow							Fig. 3.1, TR-55	T_t=L/(3600V)
BC	Downslope		816.4	0.12			5.62	0.040
CD	Water bar		82.0	0.02			2.28	0.010
Channel Flow								T_t=L/(3600V)
							Total T_c =	0.325
							Total T_c (min) =	20

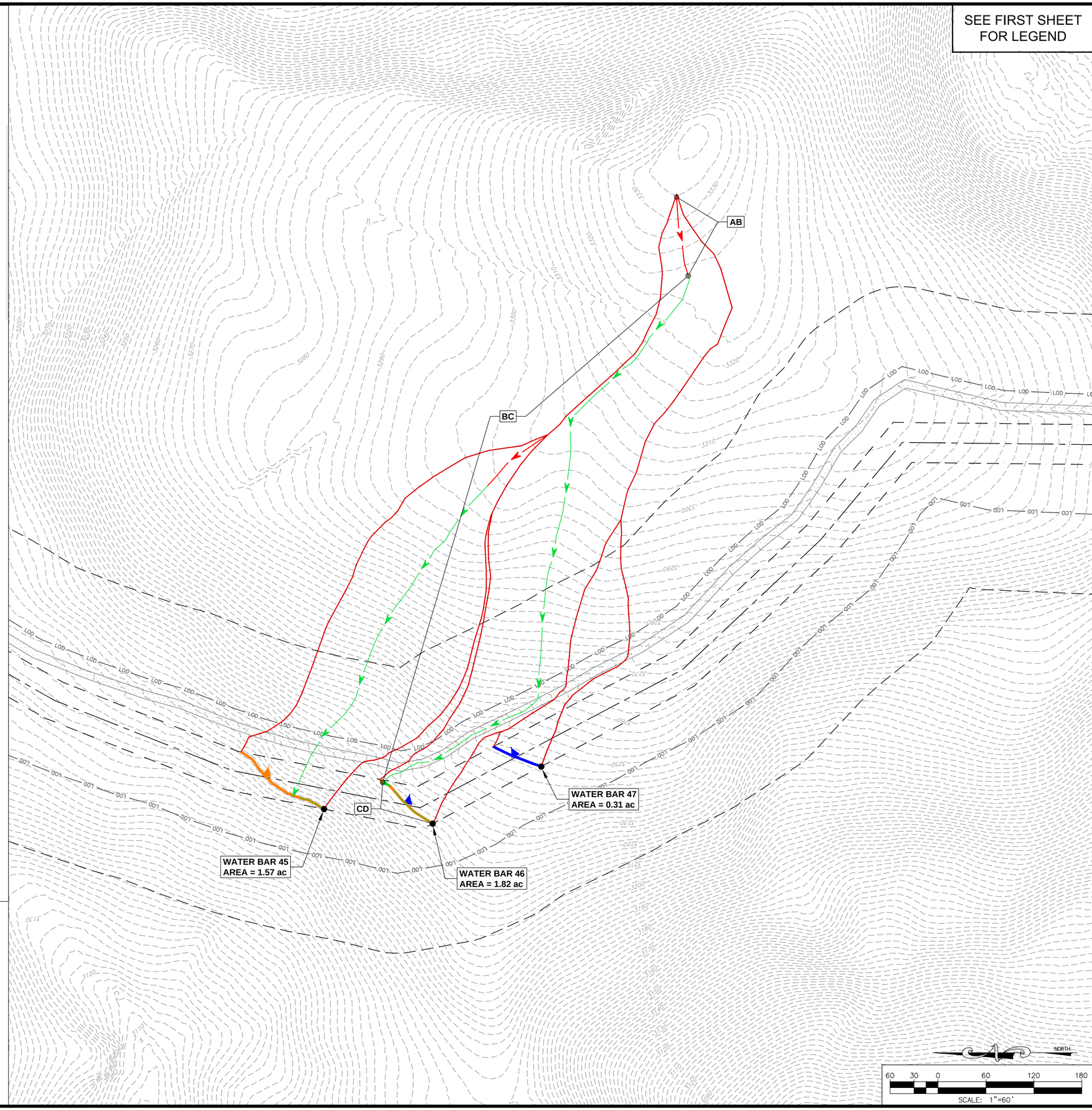
IV. Summary

As shown, the water bar end treatment calculator indicates a 12.9-foot long end treatment will ensure sheet flow conditions leaving Water Bar 46. For ease of construction, the maximum allowable water bar end treatment length of 20 feet will be used for Water Bar 46.

End Treatment Length Calculator

Enter Site Specific Data	T_c =	20	time of concentration to water bar, min
	A =	1.82	water bar drainge area, ac
	S =	0.22	weir discharge overland slope, ft/ft
Computed	i =	4.0	computed from IDF, in/hr
Enter Flow Parameters	C =	0.19	assumes B soils, >6% slope, meadow (conservative)
	C_w =	3.33	weir coefficient (spillway)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **12.9 ft**
Velocity Check ------> **0.63 fps**



Wetland Studies and Solutions, Inc. a DAVEY company
5300 Wellington Branch Drive • Suite 100
Gainesville, Virginia 20155
Phone: 703-679-5600 • Fax: 703-679-5601
www.wetlandstudies.com

Post-Construction Water Bar Drainage Area Map

Giles County, Virginia

Stormwater Management Plan

REVISIONS

No.	Date	Description	Rev. By	App. By

SCALE: As Noted

DATE: January 22, 2018

Horizontal Datum: NAD 83

Vertical Datum: NAVD 88

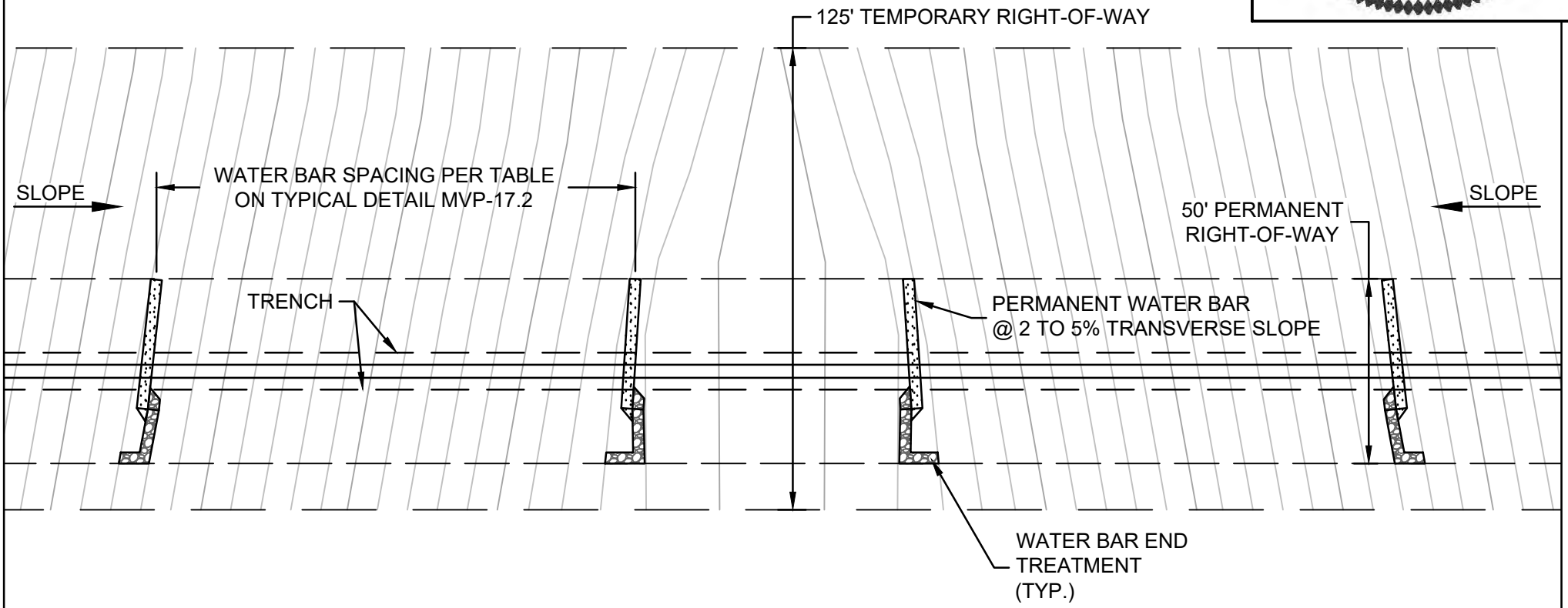
Boundary and Topo Source: Holland Engineering, Inc.

Design	Draft	Approved
MAM	MAM	FRG

Sheet #
5 of 5

Computer File Name:
L:\22000s\22000\22865.01\CADD\04-ENGR\Drainage Areas WSSI Drainage Areas.dwg

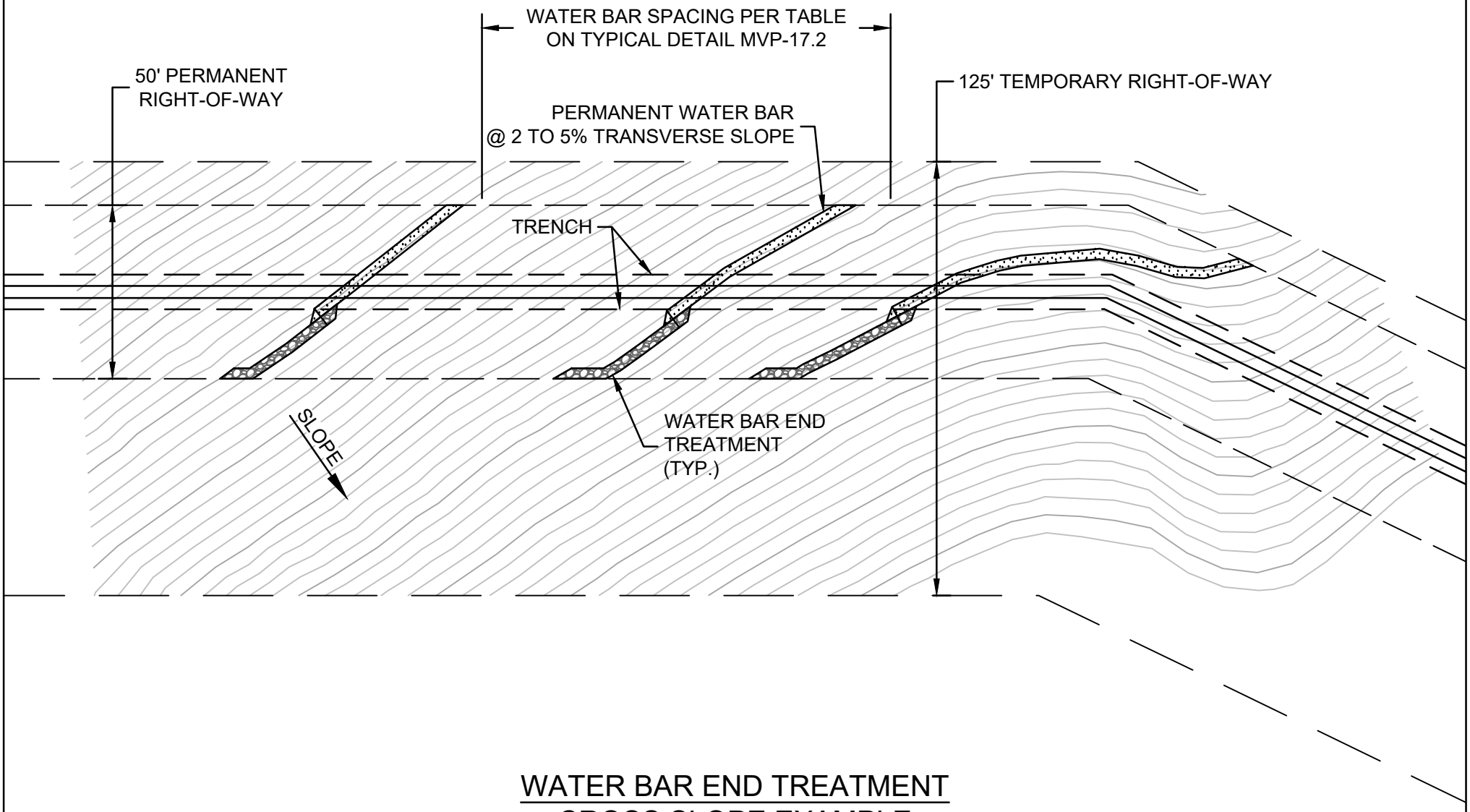
COMMONWEALTH OF VIRGINIA
MICHAEL S. ROLBAND
Lic. No. 022458
1/22/18
PROFESSIONAL ENGINEER



WATER BAR END TREATMENT
PERPENDICULAR TO SLOPE EXAMPLE

NOT TO SCALE

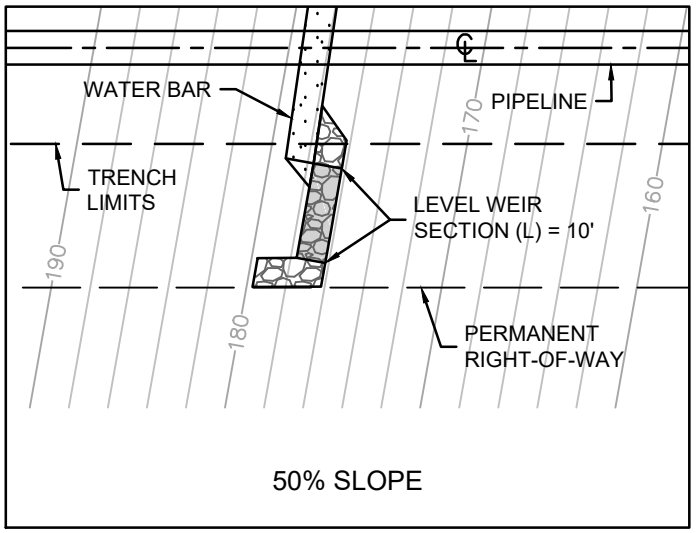
DATE: 1/22/18



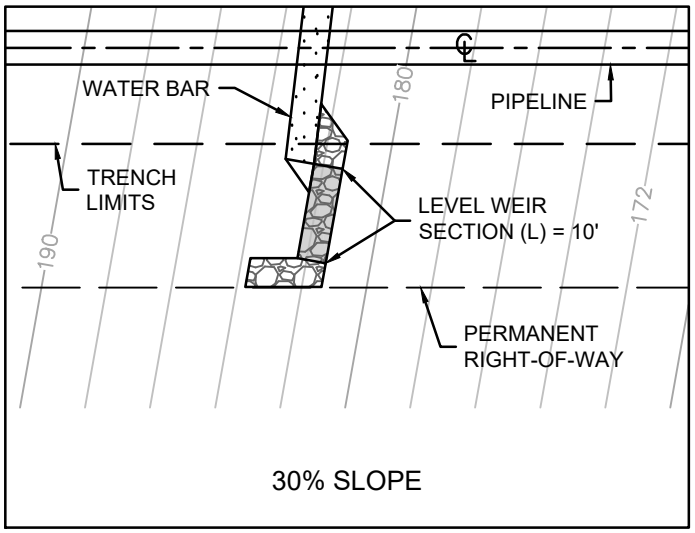
WATER BAR END TREATMENT
CROSS SLOPE EXAMPLE

NOT TO SCALE

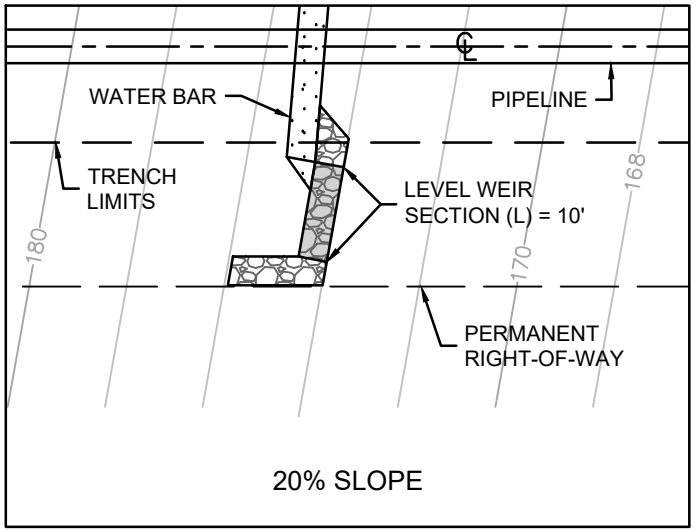
DATE: 1/22/18



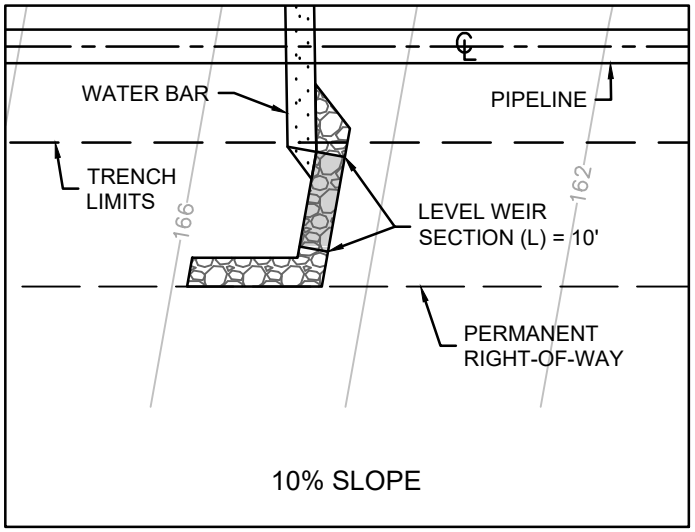
50% SLOPE



30% SLOPE

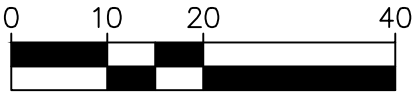


20% SLOPE



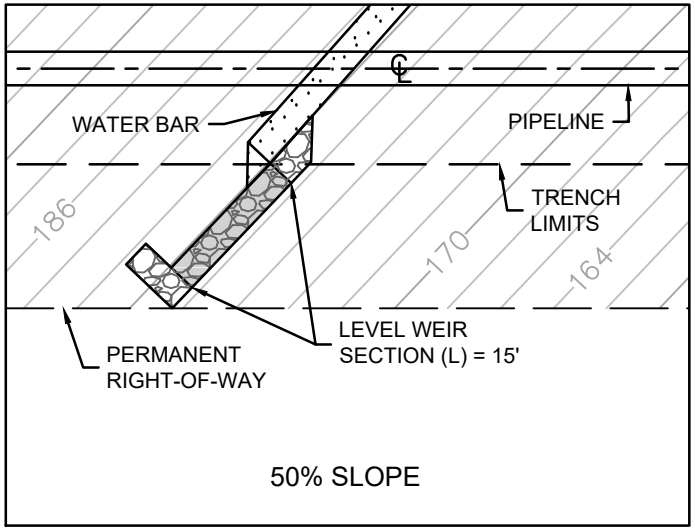
10% SLOPE

DETAILED EXAMPLES - PERPENDICULAR TO SLOPE CONDITION

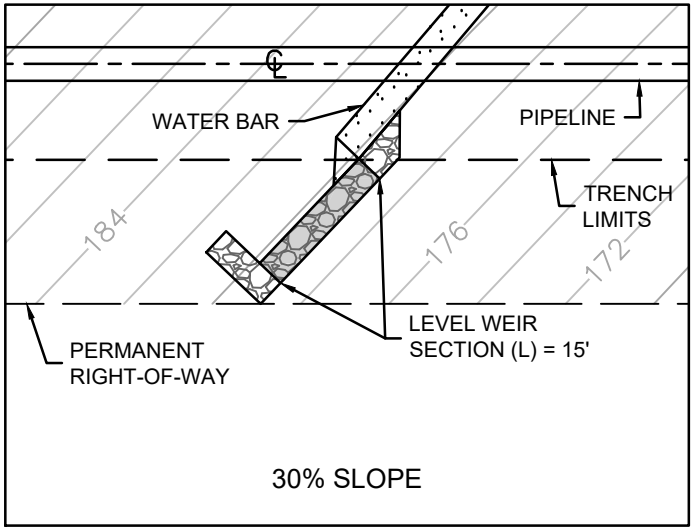


1”=20’

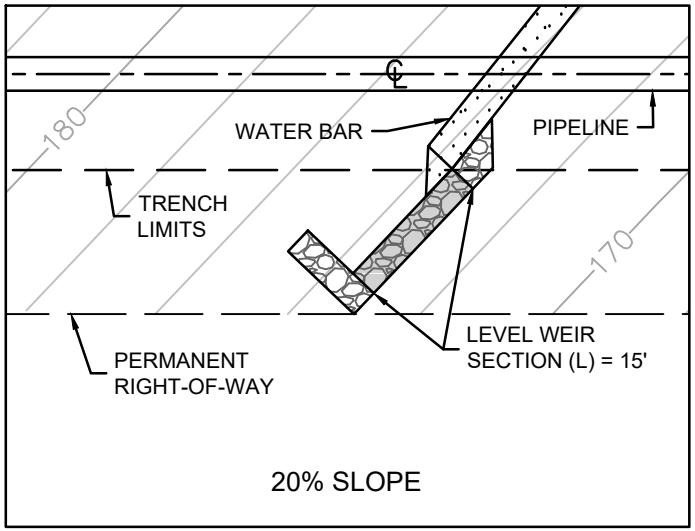
DATE: 1/22/18



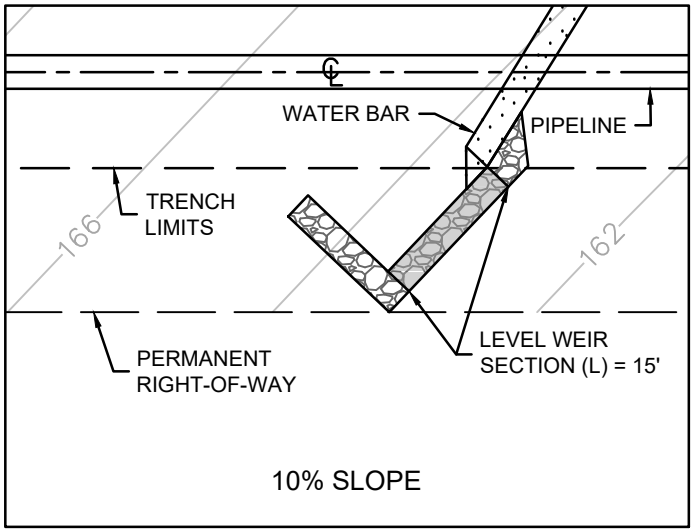
50% SLOPE



30% SLOPE

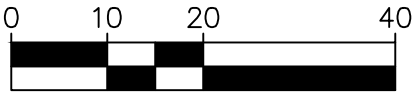


20% SLOPE



10% SLOPE

DETAILED EXAMPLES - CROSS SLOPE CONDITION

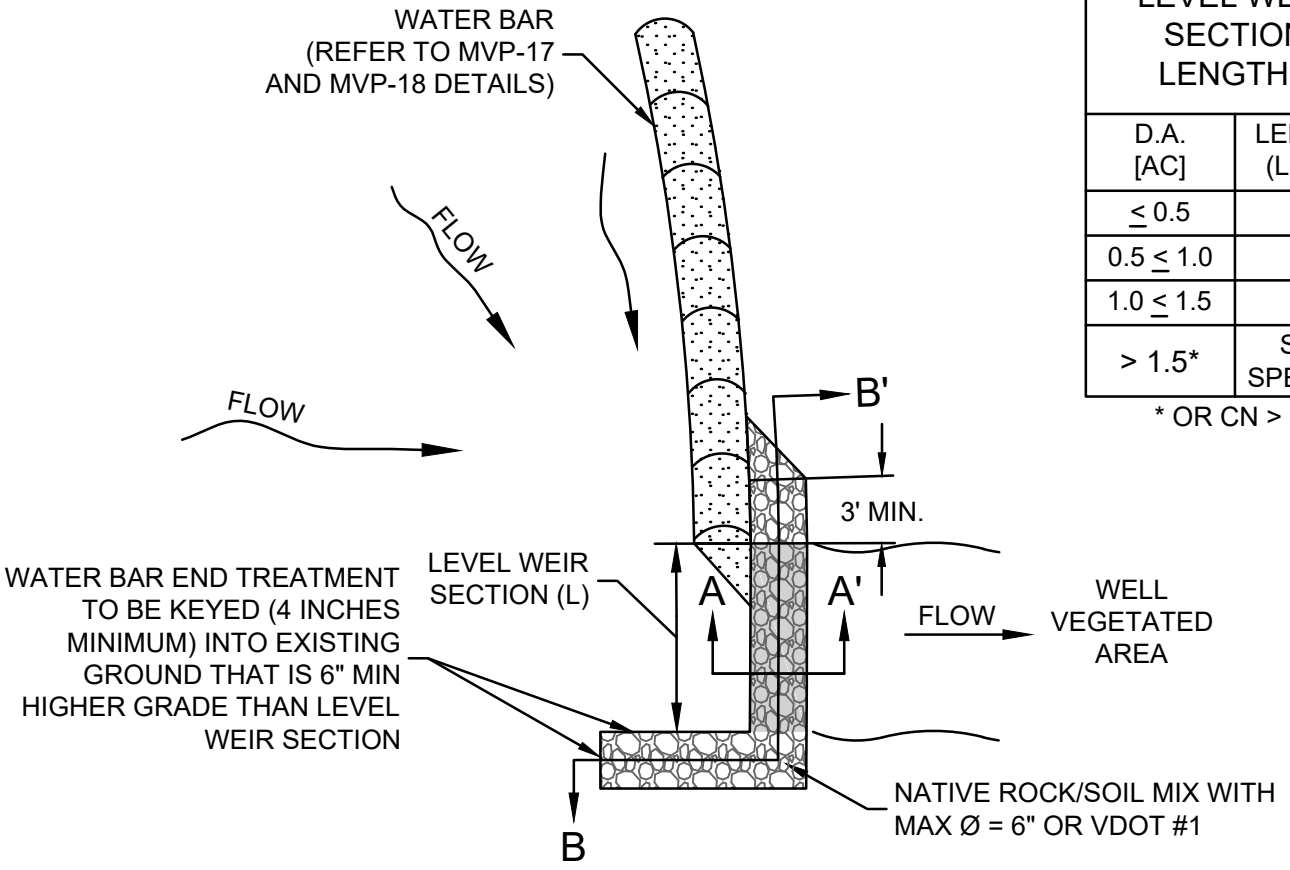


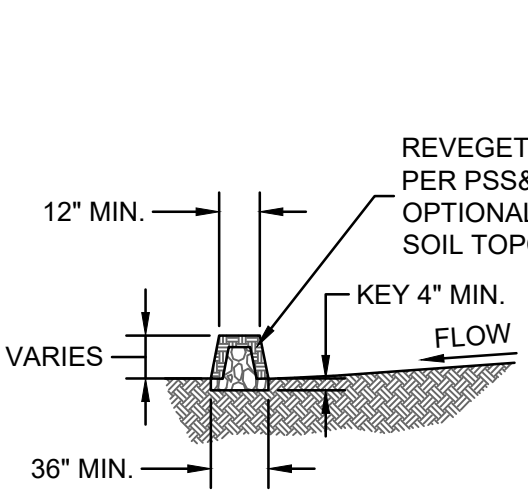
1”=20’

DATE: 1/22/18

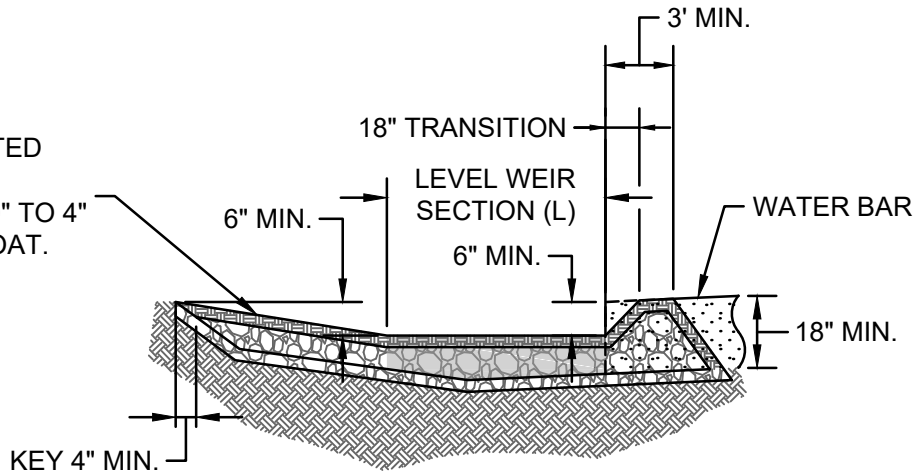
LEVEL WEIR SECTION LENGTHS	
D.A. [AC]	LENGTH (L) [FT]
≤ 0.5	10
$0.5 \leq 1.0$	15
$1.0 \leq 1.5$	20
> 1.5*	SITE SPECIFIC

* OR CN > 71





XS: A-A'



XS: B-B'

WATER BAR
END TREATMENT DETAIL

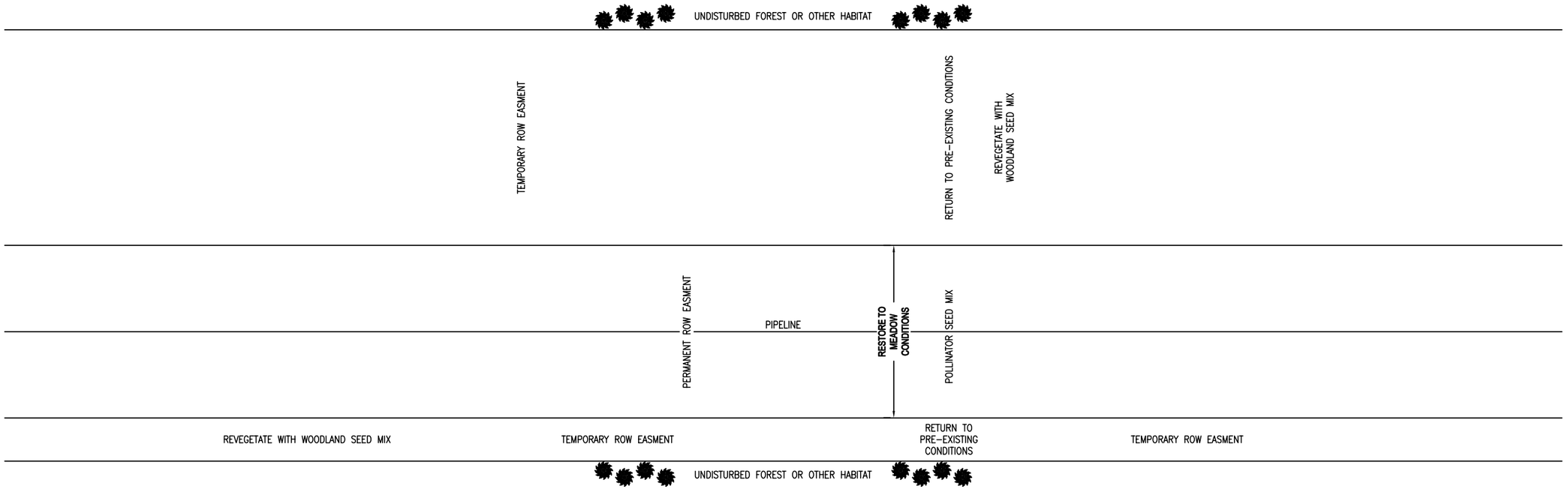
NOT TO SCALE

DATE: 1/22/18

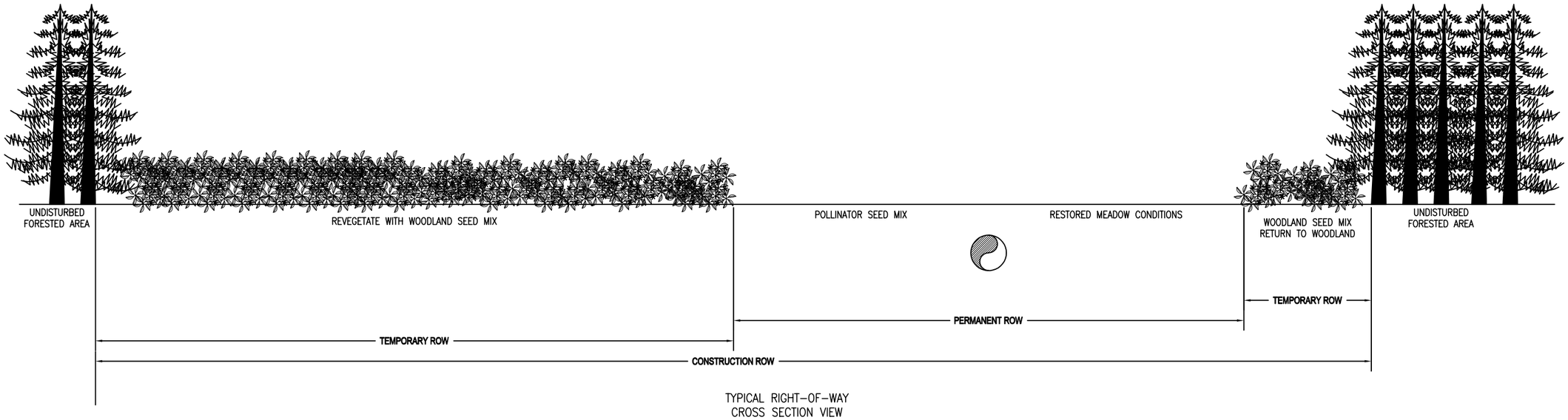
APPENDIX C – ROW RESTORATION AND SEQUENCE OF CONSTRUCTION FIGURES

The following figures present the general technical approach Mountain Valley intends to apply for projects covered by the Standards & Specifications.

Project or site-specific conditions may warrant departures from these general figures. Any such departures will be documented and explained in plans submitted to DEQ for review and approval.



TYPICAL RIGHT-OF-WAY
PLAN VIEW



TYPICAL RIGHT-OF-WAY
CROSS SECTION VIEW

REFERENCE DRAWINGS		NO.	DATE	REVISION	BY	CHK	APPD	NO.	DATE	REVISION	BY	CHK	APPD
DRAWING NUMBER	DRAWING TITLE	–						–					
–		–						–					
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–		–						–					

TO THE BEST OF MY KNOWLEDGE, ALL COMPONENTS OF THIS DRAWING ARE DESIGNED IN ACCORDANCE WITH APPLICABLE GUIDELINES AND SPECIFICATIONS

– MECHANICAL DESIGN ENGINEER — – DATE

– ELECTRICAL DESIGN ENGINEER — – DATE

NOTE: ANY CHANGES TO THE DESIGN SHOWN ON THIS DRAWING MUST BE APPROVED BY THE DESIGN ENGINEER.

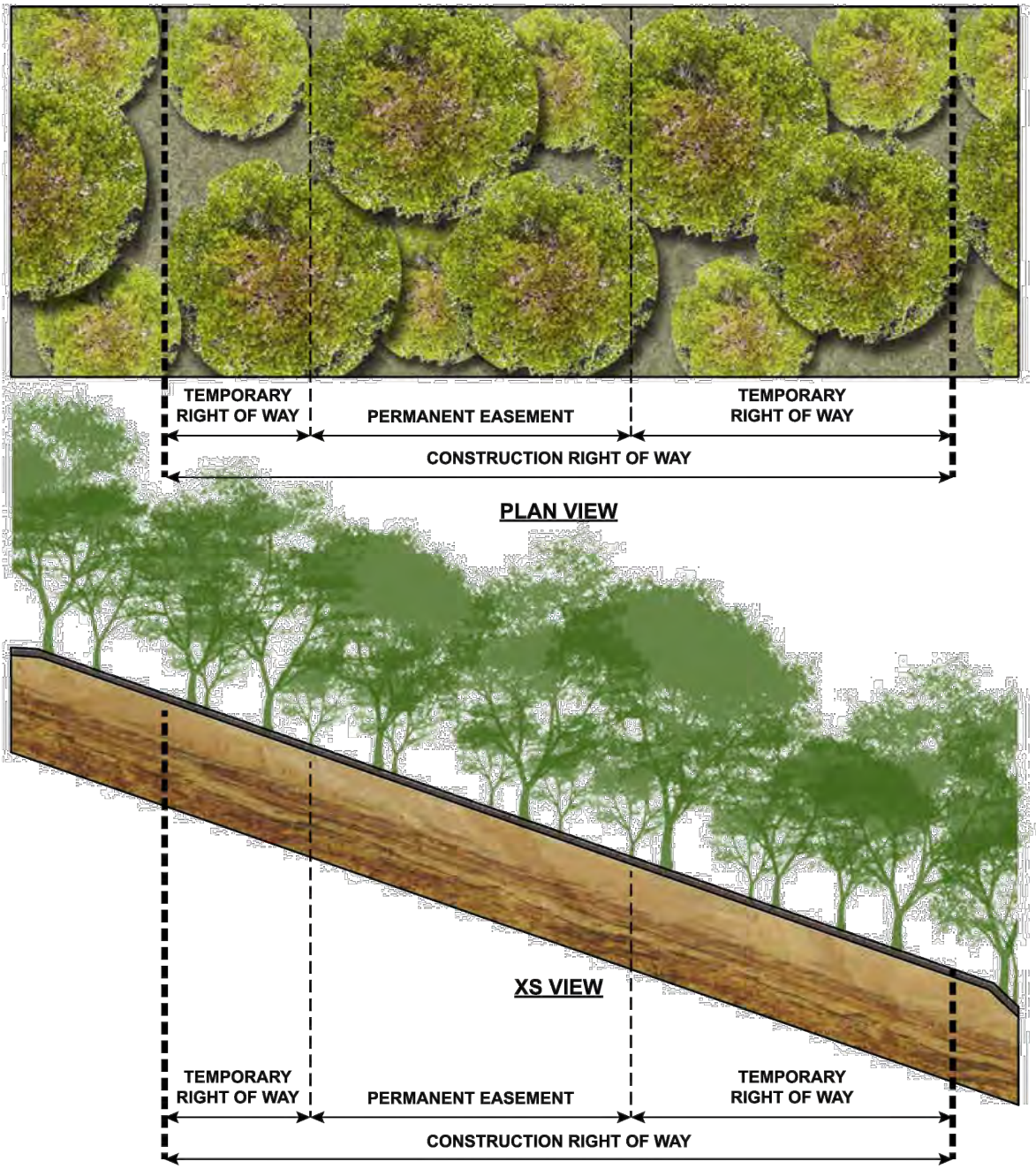
Mountain Valley PIPELINE, LLC

PROJECT ID: –

DRAWING SCALE: NTS

DRAWING TITLE:
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY
TYPICAL RIGHT-OF-WAY RESTORATION PLAN
FORESTED HABITAT
DETAIL RENDERING

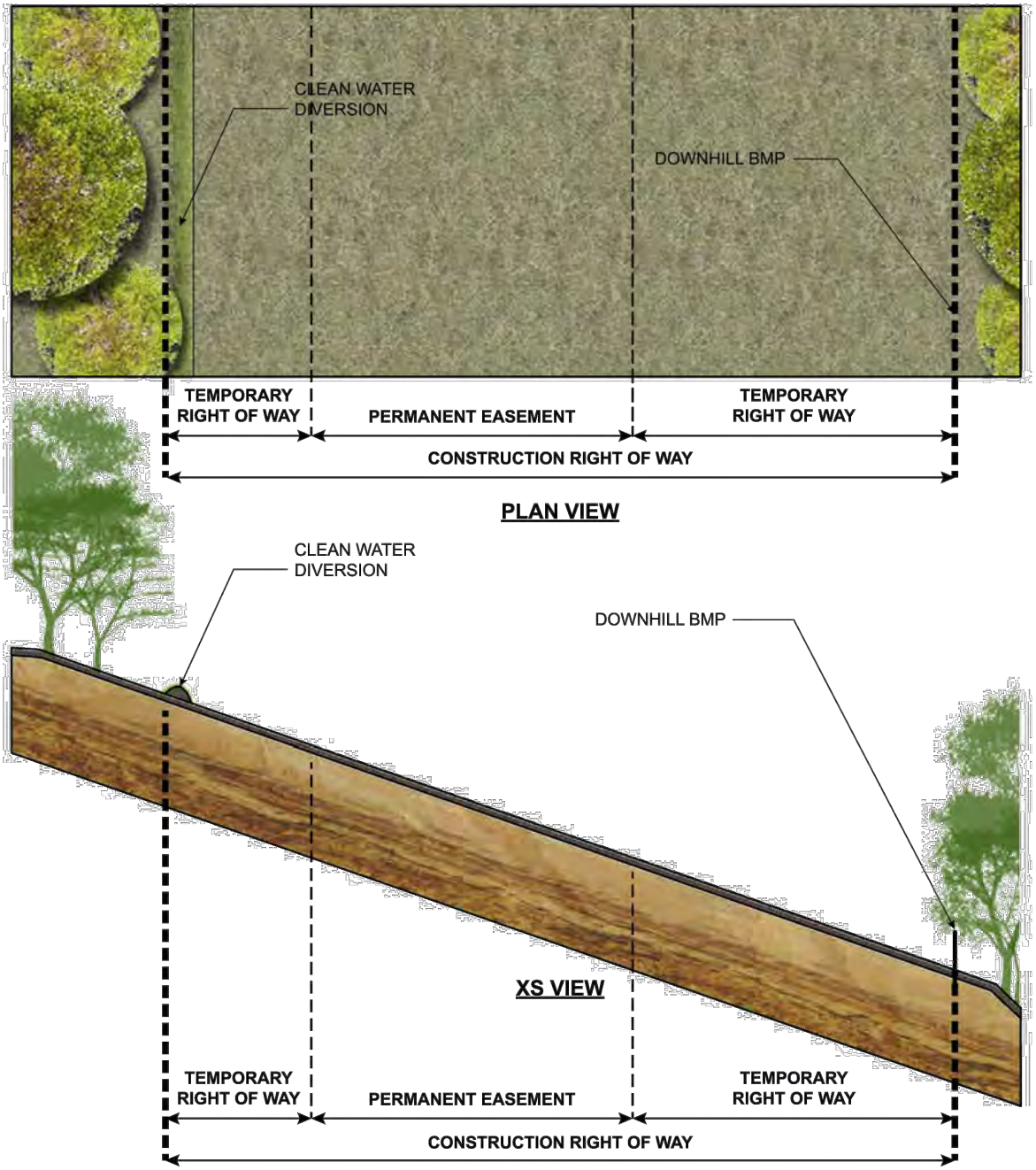
FACILITY	STATE	IDENTIFICATION	SERIES	SHEET	REVISION
PL	V	DR	04	01	P



CONSTRUCTION ACTIVITIES DURING STEP 1

- SURVEY AND STAKE CONSTRUCTION ROW

DRAWN	DATE 12/19/17	Mountain Valley PIPELINE	ENVIRONMENTAL DETAIL
CHECKED	DATE 12/19/17		CONSTRUCTION SEQUENCE STEP 1 OF 14
APP'D	DATE 12/19/17		
SCALE N.T.S.	SHEET 1 OF 1		
JOB NO.			
PROJECT ID: MVP – VA PORTION		DESIGN ENGINEERING	DRAWING NO. MVP–ES56.1 / REV. P



CONSTRUCTION ACTIVITIES DURING STEP 2

- CLEAR CONSTRUCTION ROW
- INSTALL PERIMETER E&S CONTROLS
- SEED AND MULCH CLEAN WATER DIVERSION
- FOLLOWING GRUBBING AND PRIOR TO TOPSOIL SEGREGATION, INSTALL TEMPORARY DIVERSION PER MVP–ES56.2A UTILIZING THE SPACING CONTAINED ON MVP–17.2

DRAWN	DATE 12/19/17
CHECKED	DATE 12/19/17
APP'D	DATE 12/19/17
SCALE N.T.S.	SHEET 1 OF 1
JOB NO.	
PROJECT ID: MVP – VA PORTION	

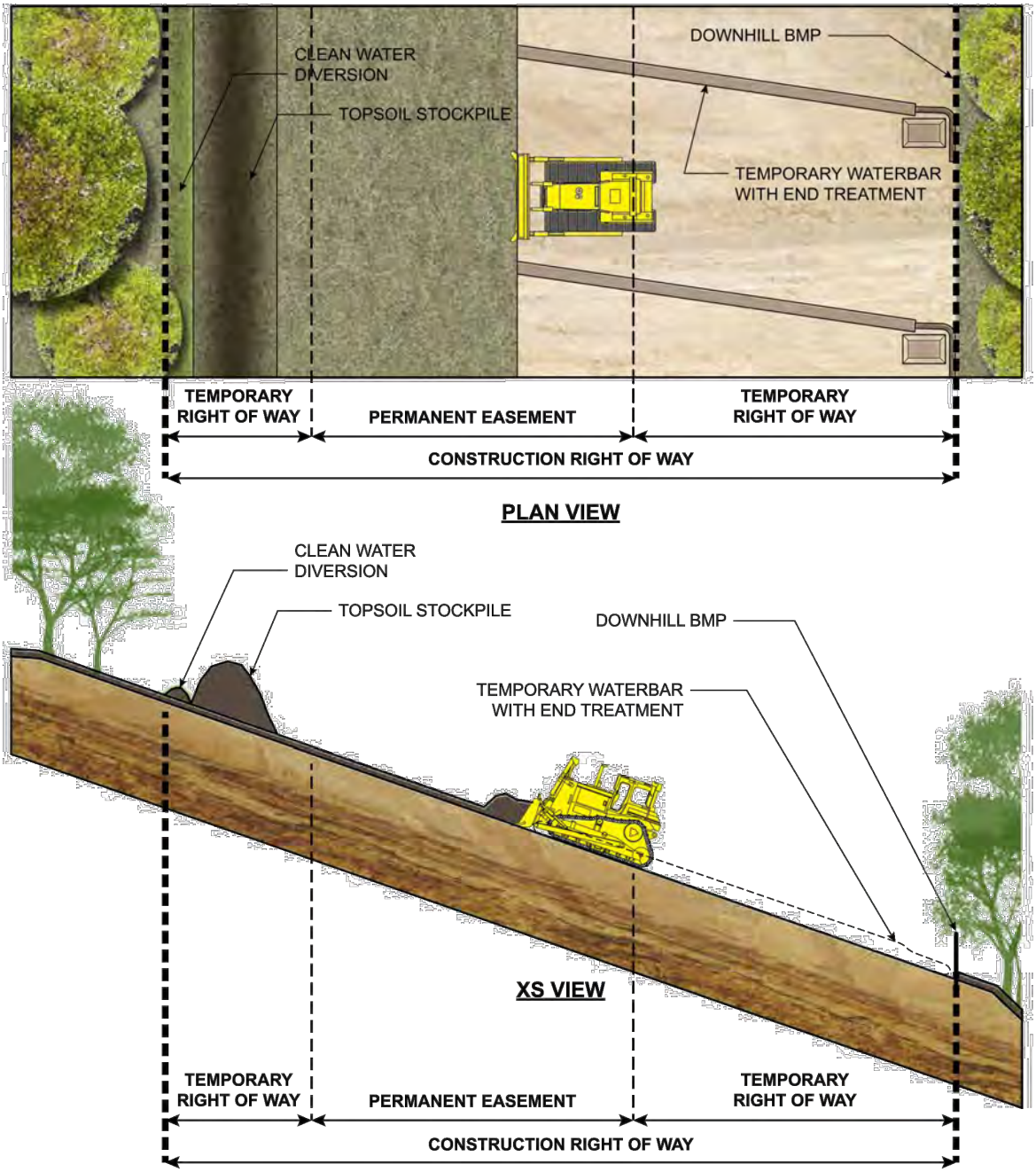
Mountain Valley PIPELINE

DESIGN ENGINEERING

ENVIRONMENTAL DETAIL

CONSTRUCTION SEQUENCE
STEP 2 OF 14

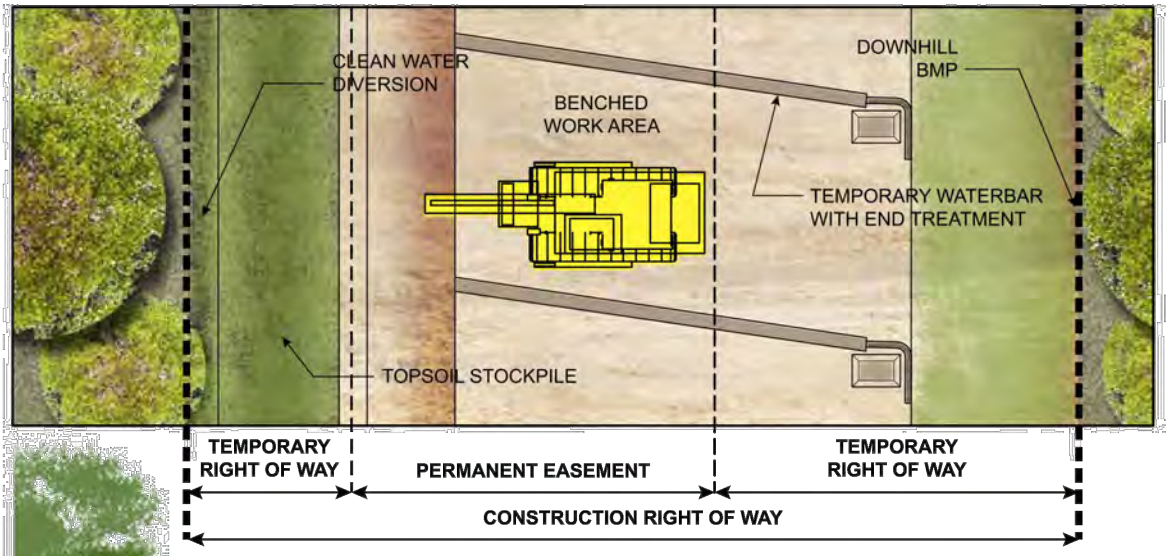
DRAWING NO.	REV.
MVP–ES56.2	P



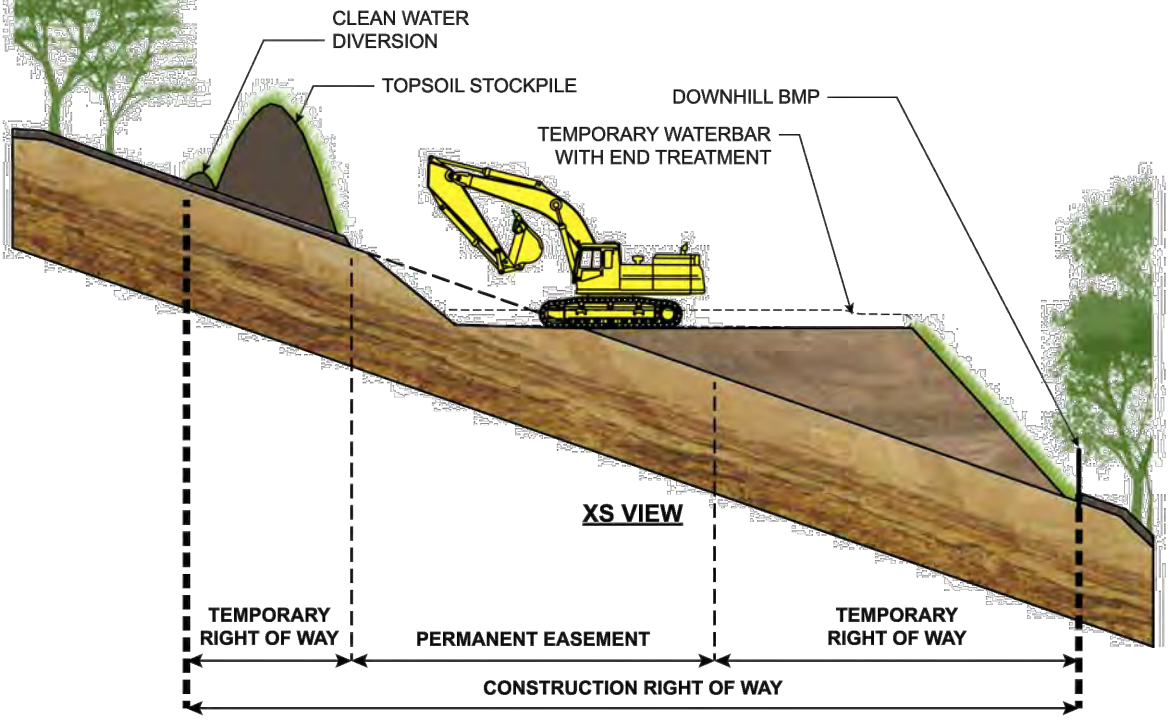
CONSTRUCTION ACTIVITIES DURING STEP 3

- STRIP AND STOCKPILE TOPSOIL FROM CONSTRUCTION ROW
- SEED AND MULCH TOPSOIL STOCKPILE
- WATERBARS INSTALLED AT THE END OF EACH DAY FOLLOWING EARTH DISTURBANCE

DRAWN	DATE 12/19/17	Mountain Valley PIPELINE	ENVIRONMENTAL DETAIL
CHECKED	DATE 12/19/17		CONSTRUCTION SEQUENCE STEP 3 OF 14
APP'D	DATE 12/19/17		
SCALE N.T.S.	SHEET 1 OF 1		
JOB NO.			
PROJECT ID: MVP – VA PORTION		DESIGN ENGINEERING	DRAWING NO. MVP–ES56.3 / REV. P



PLAN VIEW



XS VIEW

CONSTRUCTION ACTIVITIES DURING STEP 4

- BENCH WORK AREA
- TEMPORARY SEED AND MULCH FILL SLOPE
- TEMPORARY WATERBAR IS REMOVED AT THE START OF EACH WORK DAY IN AREAS OF ACTIVE CONSTUCTION. IT IS REINSTALLED AT THE END OF EACH DAY PRIOR TO LEAVING THE SITE.

DRAWN	DATE 12/19/17
CHECKED	DATE 12/19/17
APP'D	DATE 12/19/17
SCALE N.T.S.	SHEET 1 OF 1
JOB NO.	
PROJECT ID: MVP – VA PORTION	

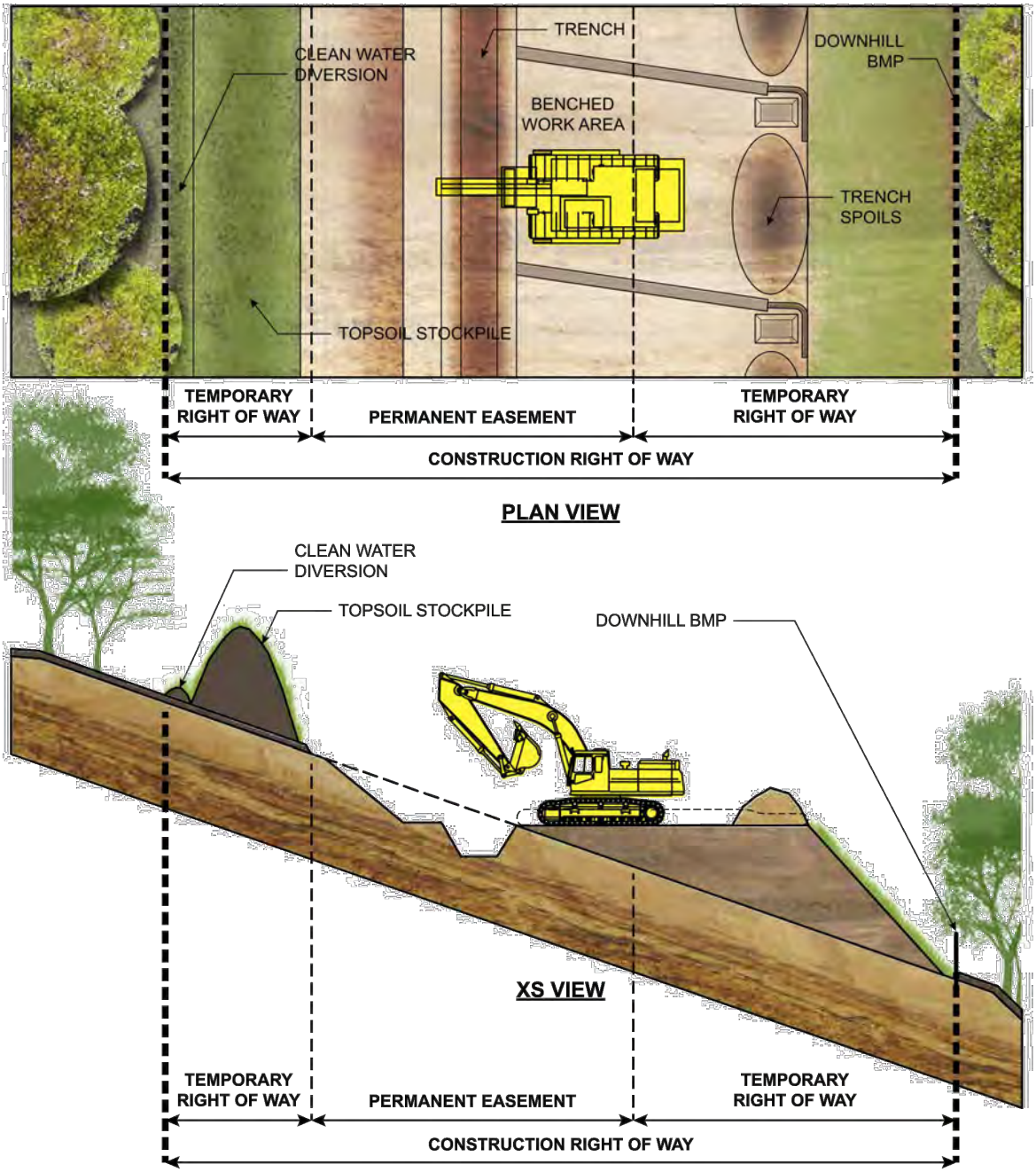
Mountain Valley PIPELINE

DESIGN ENGINEERING

ENVIRONMENTAL DETAIL

CONSTRUCTION SEQUENCE
STEP 4 OF 14

DRAWING NO.	REV.
MVP–ES56.4	P



CONSTRUCTION ACTIVITIES DURING STEP 5

- EXCAVATE TRENCH
- TEMPORARY SEED AND MULCH SPOIL STOCKPILE
- TEMPORARY WATERBARS ARE RE-INSTALLED AT THE END OF EACH DAY ONCE EARTH DISTURBING ACTIVITIES HAVE COMMENCED

DRAWN	DATE 12/19/17
CHECKED	DATE 12/19/17
APP'D	DATE 12/19/17
SCALE N.T.S.	SHEET 1 OF 1
JOB NO.	
PROJECT ID: MVP – VA PORTION	

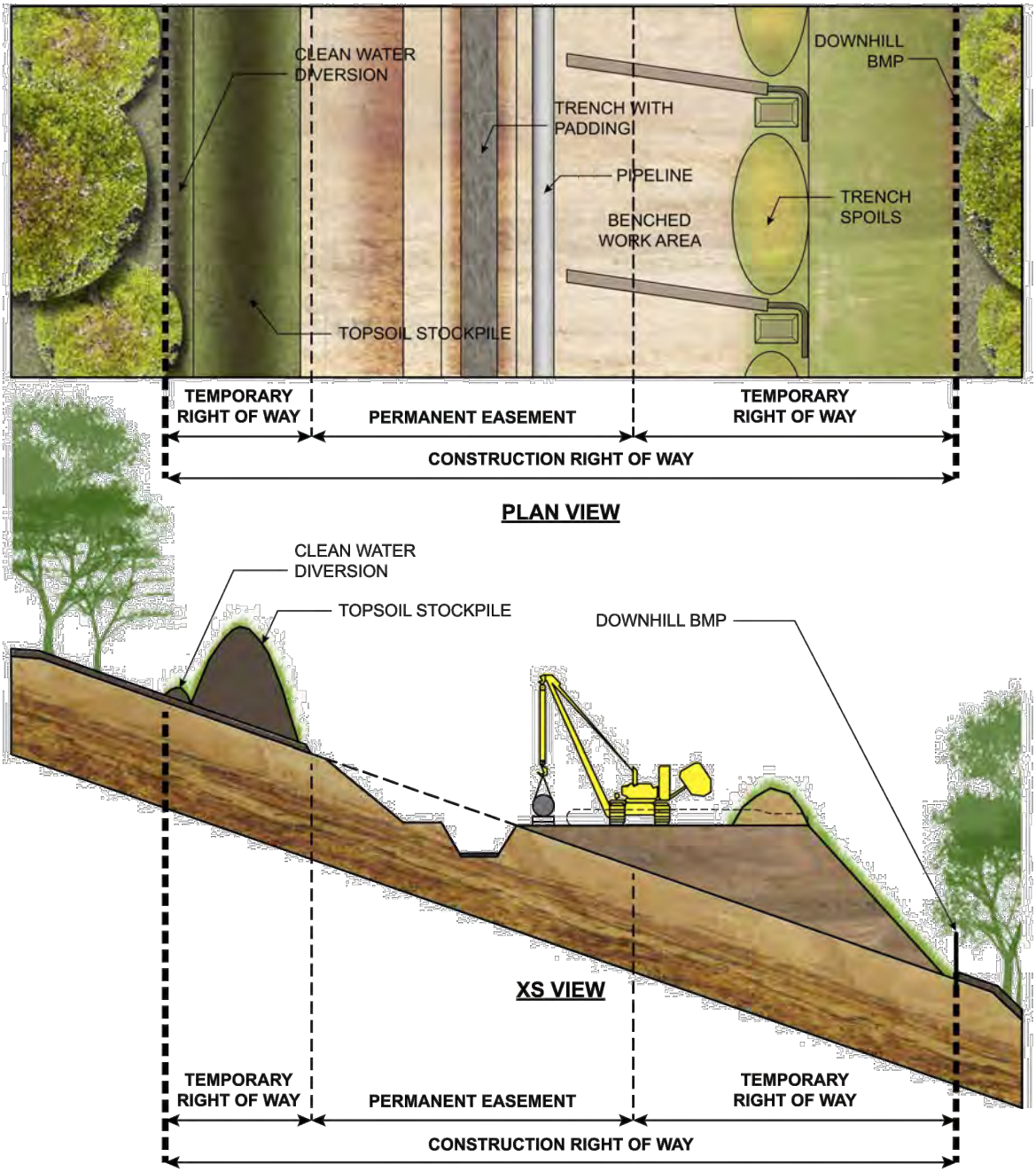
Mountain Valley PIPELINE

DESIGN ENGINEERING

ENVIRONMENTAL DETAIL

CONSTRUCTION SEQUENCE
STEP 5 OF 14

DRAWING NO.	REV.
MVP–ES56.5	P



CONSTRUCTION ACTIVITIES DURING STEP 6

- PAD TRENCH BOTTOM, STRING AND FIELD BEND PIPE
- LINE-UP, INITIAL WELDING
- AS-BUILT FOOTAGE
- X-RAY INSPECTION, WELD REPAIR
- COAT FIELD WELDS
- INSPECTION AND REPAIR OF COATING
- TEMPORARY WATERBARS ARE RE-INSTALLED AT THE END OF EACH DAY ONCE EARTH DISTURBING ACTIVITIES HAVE COMMENCED

DRAWN	JK	DATE	04/01/20
CHECKED	RE	DATE	04/01/20
APP'D	DJW	DATE	04/01/20
SCALE	N.T.S.	SHEET	1 OF 1
JOB NO.			
PROJECT ID:	MVP – VA PORTION		

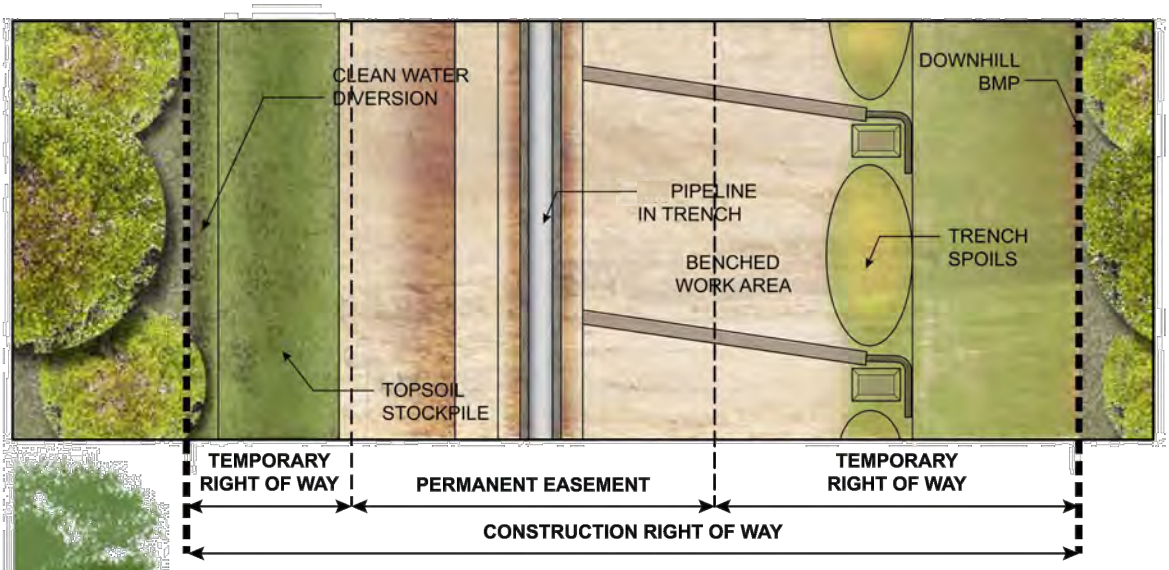
Mountain Valley PIPELINE

DESIGN ENGINEERING

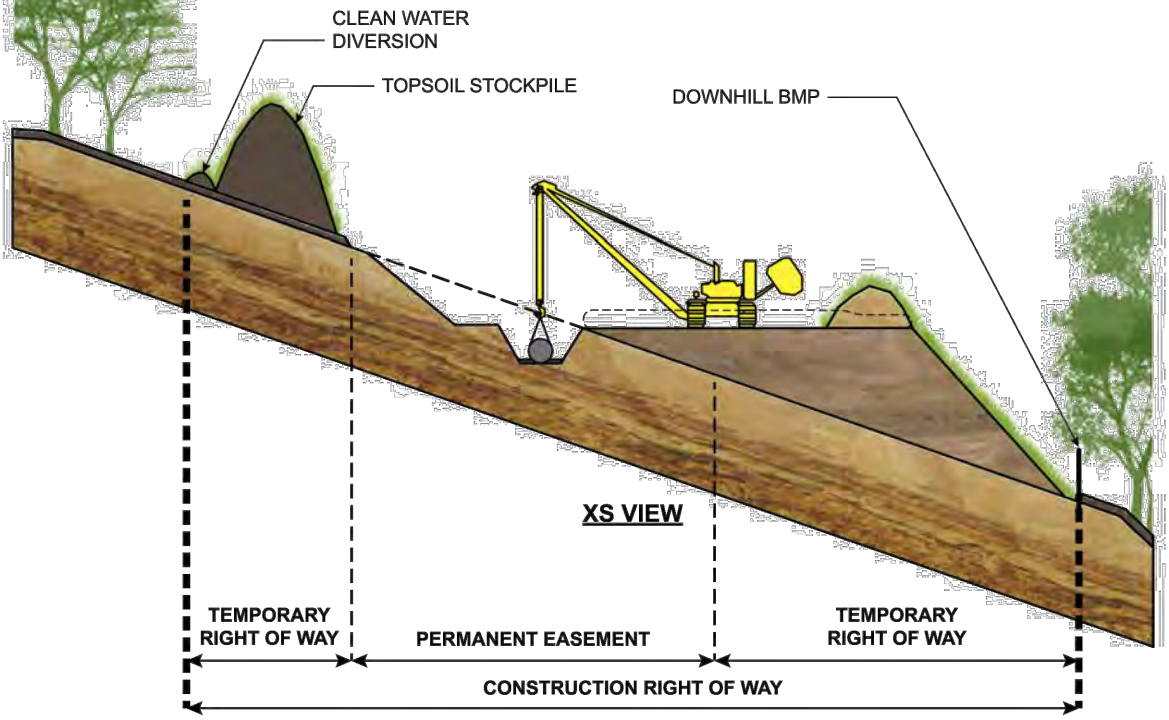
ENVIRONMENTAL DETAIL

CONSTRUCTION SEQUENCE
STEP 6 OF 14

DRAWING NO.	REV.
MVP–ES56.6	P



PLAN VIEW



XS VIEW

CONSTRUCTION ACTIVITIES DURING STEP 7

- LOWER PIPE INTO TRENCH
- AS-BUILT SURVEY
- TEMPORARY WATERBARS ARE RE-INSTALLED AT THE END OF EACH DAY ONCE EARTH DISTURBING ACTIVITIES HAVE COMMENCED

DRAWN	JK	DATE	04/01/20
CHECKED	RE	DATE	04/01/20
APP'D	DJW	DATE	04/01/20
SCALE	N.T.S.	SHEET	1 OF 1
JOB NO.			
PROJECT ID:	MVP – VA PORTION		

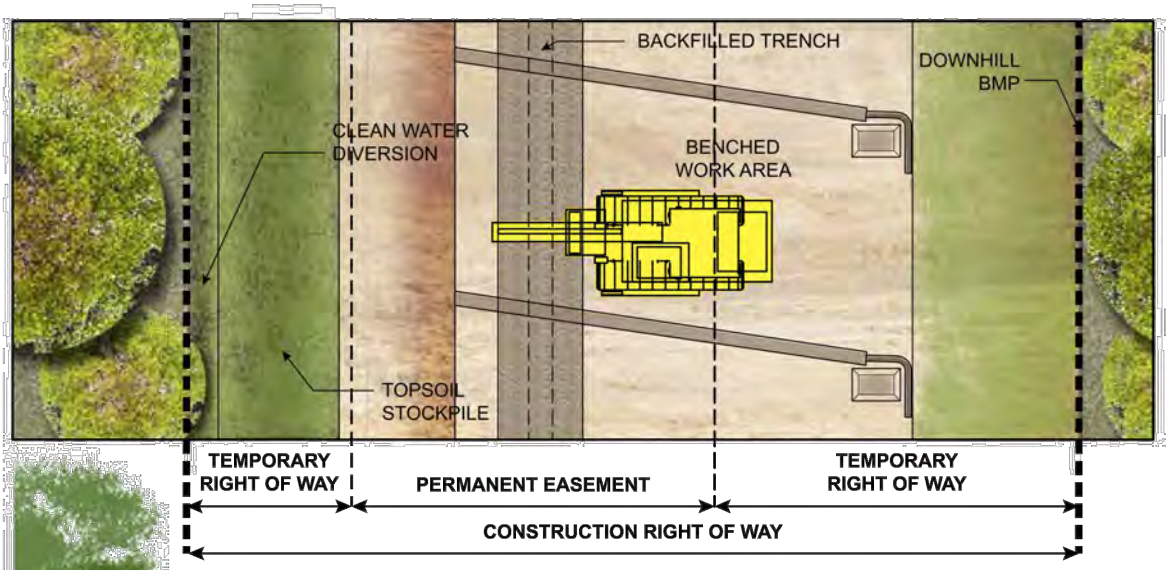
Mountain Valley PIPELINE

DESIGN ENGINEERING

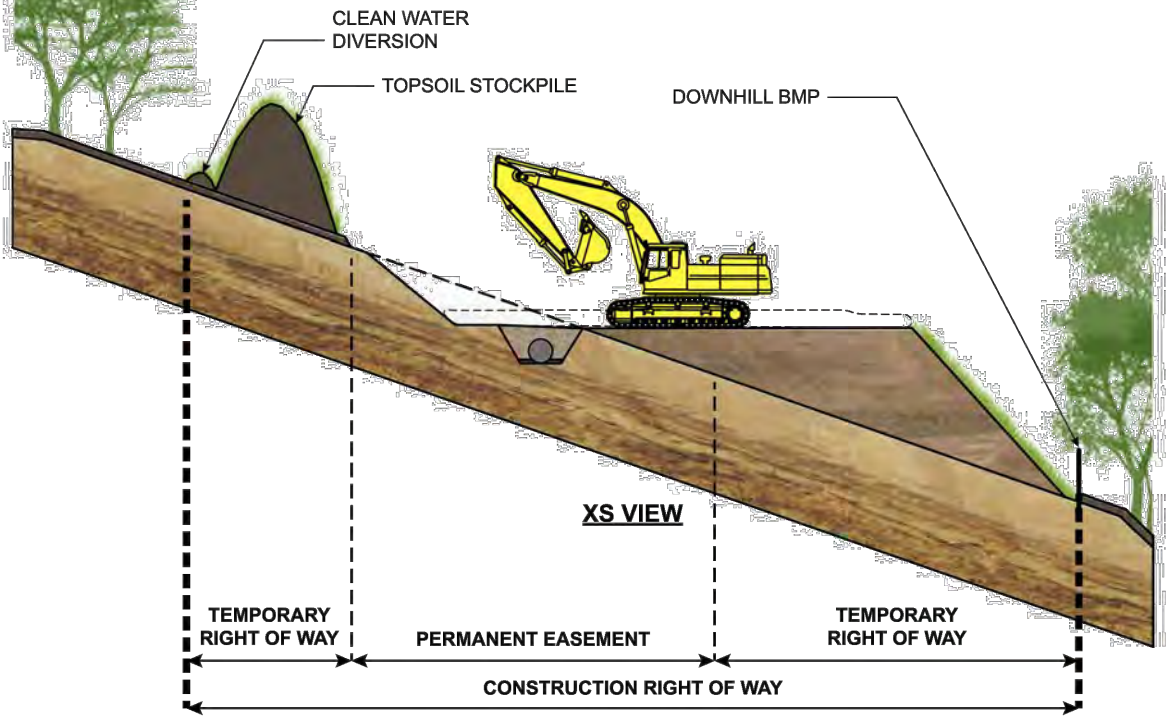
ENVIRONMENTAL DETAIL

CONSTRUCTION SEQUENCE
STEP 7 OF 14

DRAWING NO.	REV.
MVP–ES56.7	P



PLAN VIEW

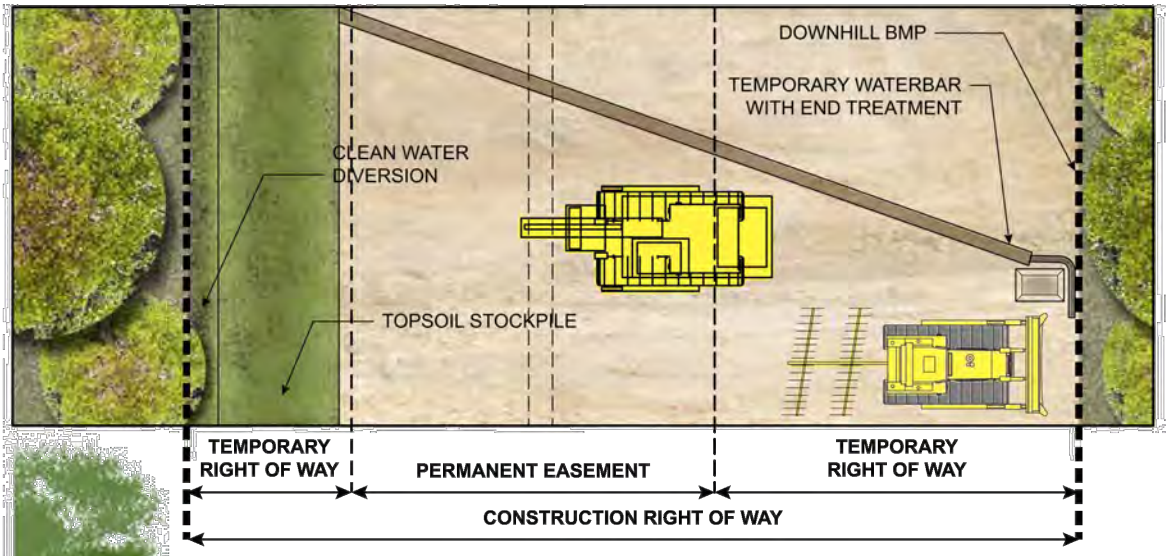


XS VIEW

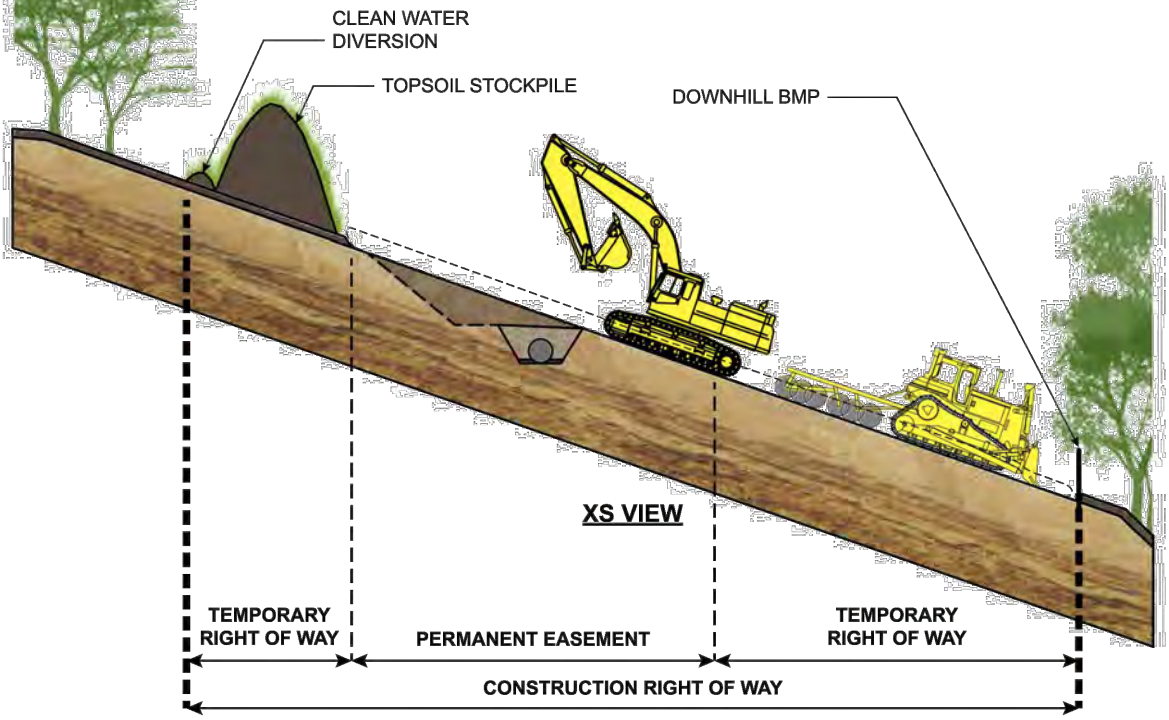
CONSTRUCTION ACTIVITIES DURING STEP 8

- BACKFILL TRENCH
- HYDROSTATIC TESTING
- TEMPORARY WATERBARS ARE RE-INSTALLED AT THE END OF EACH DAY ONCE EARTH DISTURBING ACTIVITIES HAVE COMMENCED

DRAWN	DATE 12/19/17	Mountain Valley PIPELINE DESIGN ENGINEERING	ENVIRONMENTAL DETAIL CONSTRUCTION SEQUENCE STEP 8 OF 14
CHECKED	DATE 12/19/17		
APP'D	DATE 12/19/17		
SCALE N.T.S.	SHEET 1 OF 1		
JOB NO.			
PROJECT ID: MVP – VA PORTION			DRAWING NO. MVP–ES56.8 / REV. P



PLAN VIEW

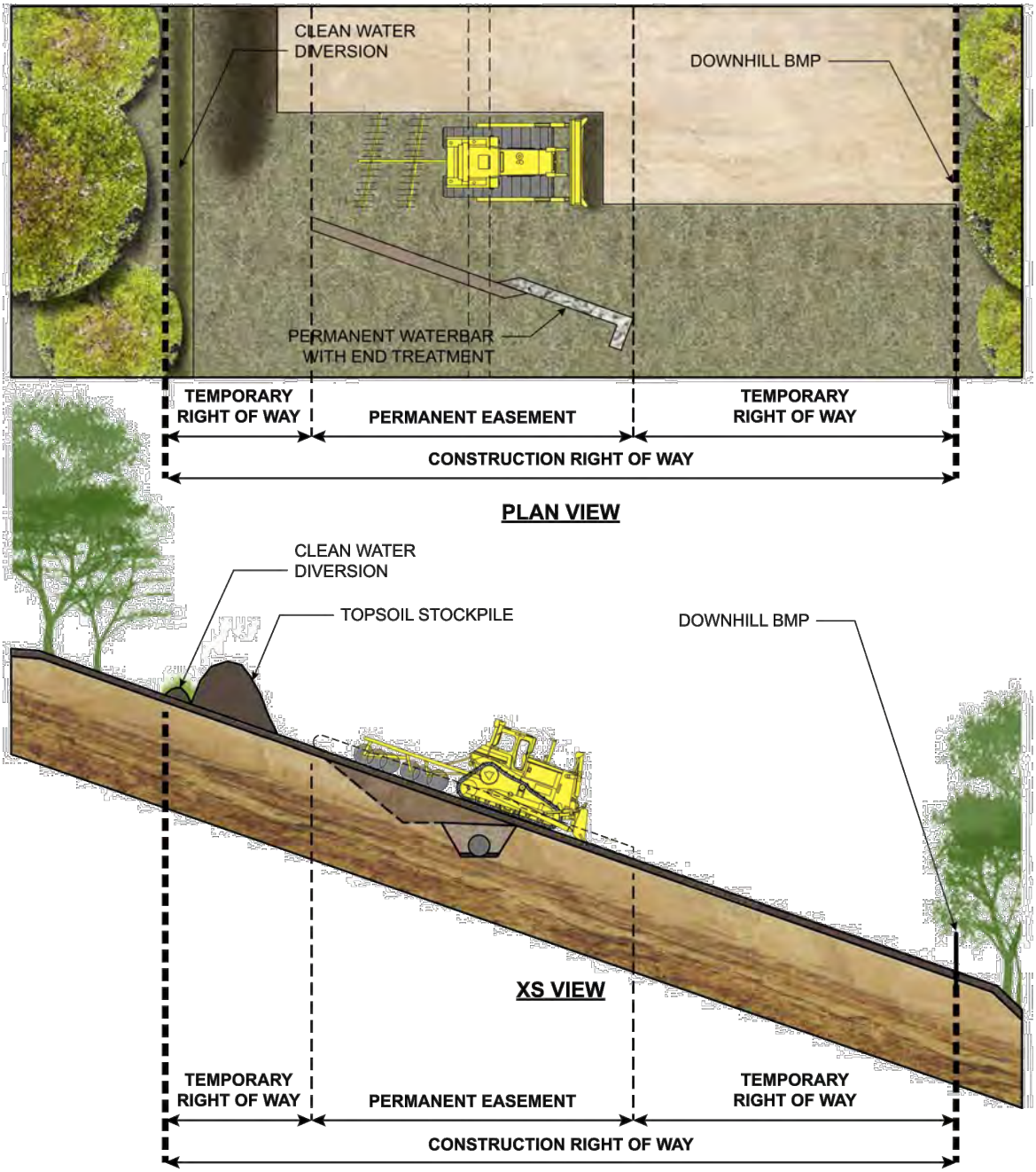


XS VIEW

CONSTRUCTION ACTIVITIES DURING STEP 9

- BACKFILL WORK AREA
- DISK SUBSOIL
- TEMPORARY WATERBARS ARE RE-INSTALLED AT THE END OF EACH DAY ONCE EARTH DISTURBING ACTIVITIES HAVE COMMENCED

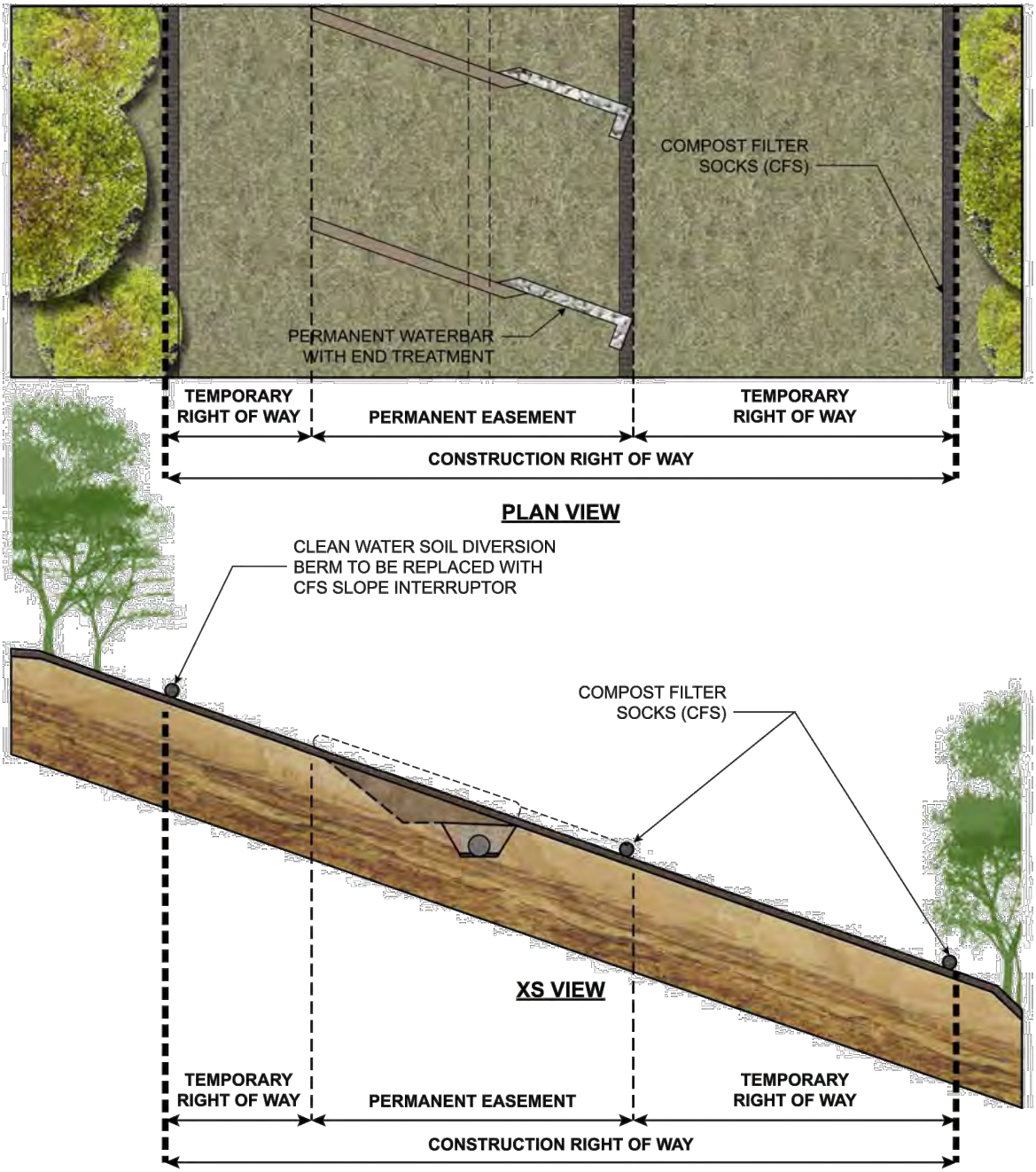
DRAWN	DATE 12/19/17	Mountain Valley PIPELINE	ENVIRONMENTAL DETAIL
CHECKED	DATE 12/19/17		CONSTRUCTION SEQUENCE STEP 9 OF 14
APP'D	DATE 12/19/17		
SCALE N.T.S.	SHEET 1 OF 1		
JOB NO.			
PROJECT ID: MVP – VA PORTION		DESIGN ENGINEERING	DRAWING NO. MVP–ES56.9 / REV. P



CONSTRUCTION ACTIVITIES DURING STEP 10

- RESPREAD TOPSOIL AND DISK
- FINAL CLEAN-UP
- INSTALL PERMANENT WATERBARS

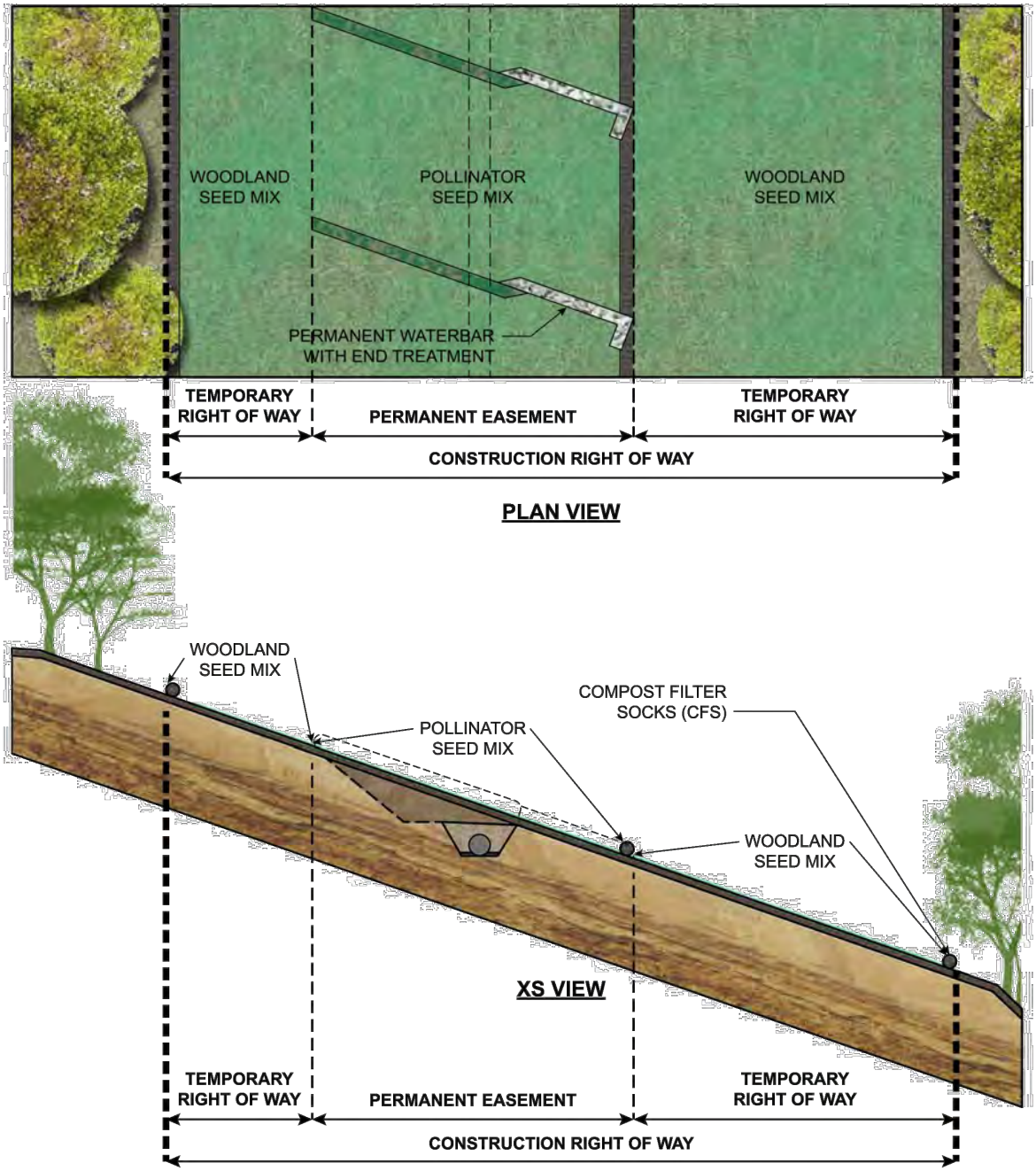
DRAWN	DATE 12/19/17	Mountain Valley PIPELINE	ENVIRONMENTAL DETAIL
CHECKED	DATE 12/19/17		CONSTRUCTION SEQUENCE STEP 10 OF 14
APP'D	DATE 12/19/17		
SCALE N.T.S.	SHEET 1 OF 1		
JOB NO.			
PROJECT ID: MVP – VA PORTION		DESIGN ENGINEERING	DRAWING NO. MVP–ES56.10 / REV. P



CONSTRUCTION ACTIVITIES DURING STEP 11

- REMOVE CLEAN WATER DIVERSION ANS REPLACE WITH 12" CFS
- REMOVE DOWNHILL BMP AND REPLACE WITH 12" CFS
- FOR SLOPES >30% INSTALL 12" CFS AT DOWNHILL PERMANENT EASEMENT BOUNDARY AS WELL
- AREAS WITH 3:1 OR STEEPER SLOPES WILL HAVE HECP APPLIED

DRAWN	DATE 12/19/17	Mountain Valley PIPELINE	ENVIRONMENTAL DETAIL
CHECKED	DATE 12/19/17		CONSTRUCTION SEQUENCE STEP 11 OF 14
APP'D	DATE 12/19/17		
SCALE N.T.S.	SHEET 1 OF 1		
JOB NO.			
PROJECT ID: MVP – VA PORTION		DESIGN ENGINEERING	DRAWING NO. MVP–ES56.11 / REV. P



CONSTRUCTION ACTIVITIES DURING STEP 12

- APPLY PERMANENT SEED AND MULCH
- SEE MVP STANDARDS AND SPECIFICATIONS (MVP-ES11.1 - MVP-ES11.7, MVP-ES12.1 - MVP-ES12.3)

DRAWN	DATE 12/19/17
CHECKED	DATE 12/19/17
APP'D	DATE 12/19/17
SCALE N.T.S.	SHEET 1 OF 1
JOB NO.	
PROJECT ID: MVP – VA PORTION	

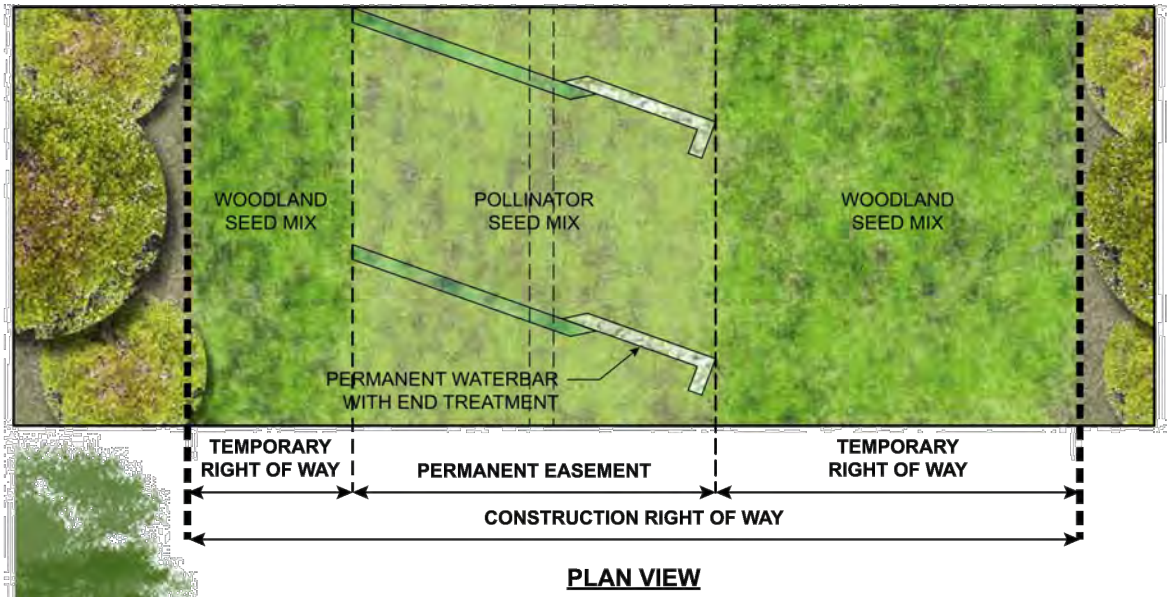
Mountain Valley PIPELINE

DESIGN ENGINEERING

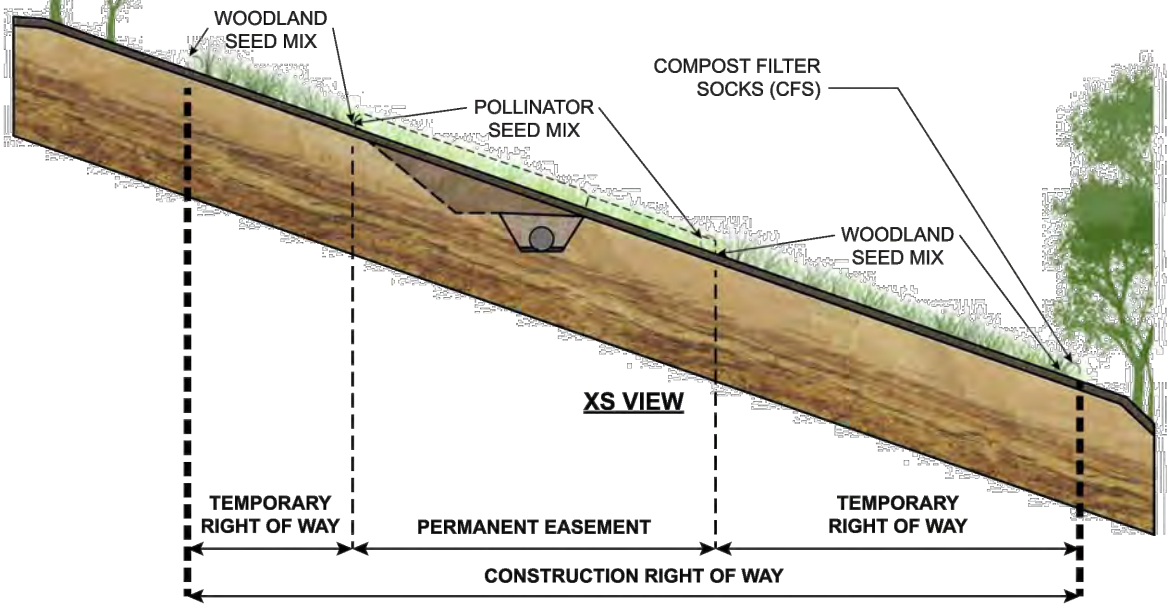
ENVIRONMENTAL DETAIL

CONSTRUCTION SEQUENCE
STEP 12 OF 14

DRAWING NO.	REV.
MVP–ES56.12	P



PLAN VIEW

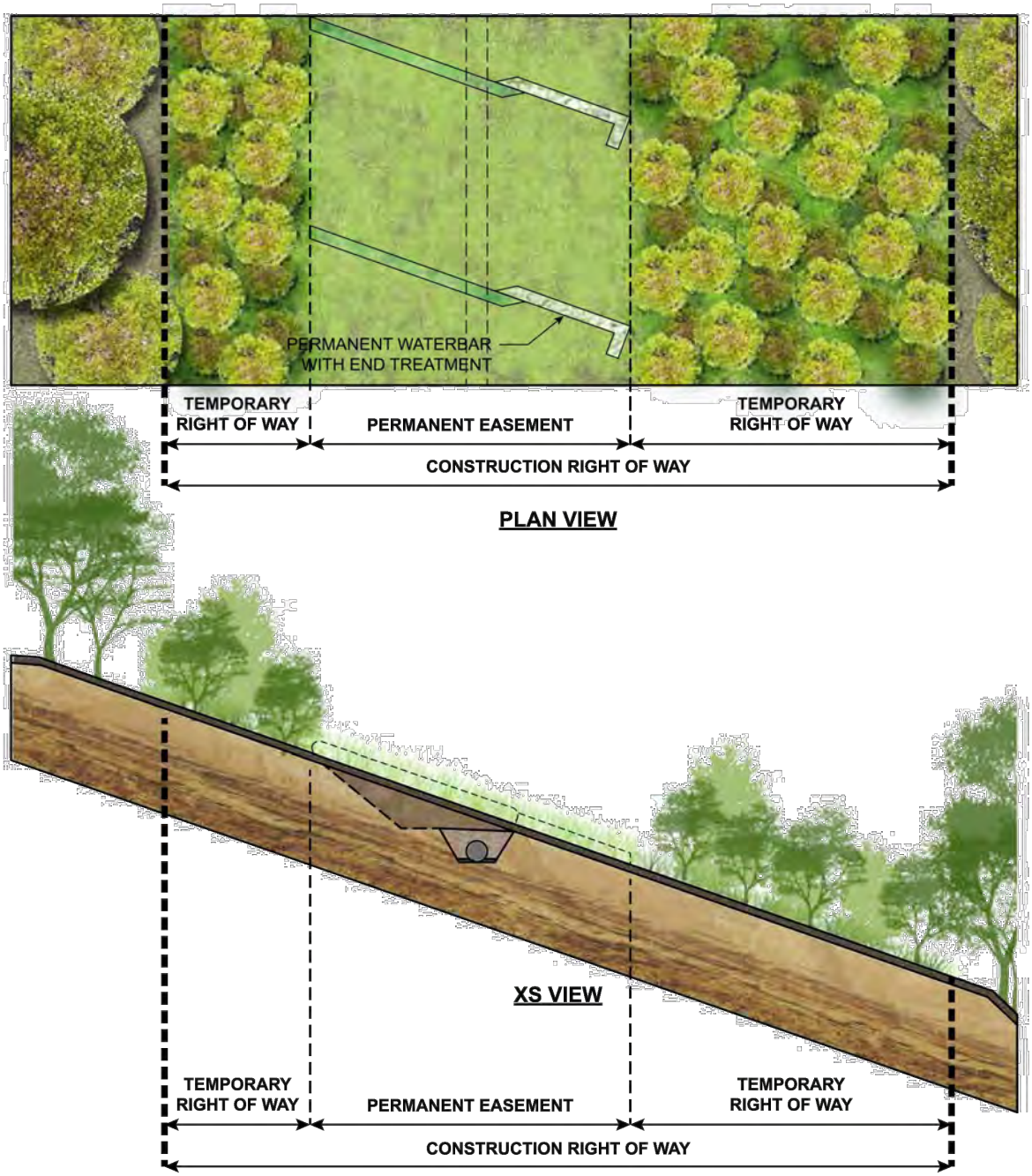


XS VIEW

CONSTRUCTION ACTIVITIES DURING STEP 13

- REMOVE CFS AND DISTRIBUTE COMPOST
- RESEED AS NEEDED

DRAWN	DATE 12/19/17	Mountain Valley PIPELINE	ENVIRONMENTAL DETAIL
CHECKED	DATE 12/19/17		CONSTRUCTION SEQUENCE STEP 13 OF 14
APP'D	DATE 12/19/17		
SCALE N.T.S.	SHEET 1 OF 1		
JOB NO.			
PROJECT ID: MVP – VA PORTION		DESIGN ENGINEERING	DRAWING NO. MVP–ES56.13 / REV. P



CONSTRUCTION ACTIVITIES DURING STEP 14

- MAINTAIN PERMANENT EASEMENT AS POLLINATOR MEADOW

DRAWN	DATE 12/19/17	Mountain Valley PIPELINE	ENVIRONMENTAL DETAIL
CHECKED	DATE 12/19/17		CONSTRUCTION SEQUENCE STEP 14 OF 14
APP'D	DATE 12/19/17		
SCALE N.T.S.	SHEET 1 OF 1		
JOB NO.			
PROJECT ID: MVP – VA PORTION		DESIGN ENGINEERING	DRAWING NO. MVP–ES56.14 / REV. P

APPENDIX D – KARST MITIGATION PLAN

The following provides project-specific information for the Mountain Valley H-605 Pipeline.

Karst Mitigation Plans will be developed for other projects if required by FERC with FERC maintaining approval and enforcement authority.

KARST MITIGATION PLAN

(Revised for Implementation Plan - Trenchless Crossing)

Prepared for:

Mountain Valley PIPELINE

Mountain Valley Pipeline

2200 Energy Drive, 2nd Floor

Canonsburg, PA 15317

October 31, 2017 (Original IP-20)

Revised June 7, 2022 (IP Trenchless Crossing)

Prepared by:

Draper Aden Associates

Engineering • Surveying • Environmental Services

DAA Project Number: B14188B-01 / B14188B-21 / 017558

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TABLE OF CONTENTS

1.0 INTRODUCTION

This **Karst Mitigation Plan** addresses the assessment and mitigation of potential hazards associated with land disturbance in karst terrain to support Mountain Valley Pipeline (MVP) construction, and post-construction monitoring. Hazards include the potential to impact sensitive karst features during construction, as well as potential hazards presented to pipeline construction and operation associated with karst terrain.

Karst feature assessment and mitigation efforts that are covered in this Plan will take place within the limits of land disturbance (LOD) along the MVP alignment (including trenchless crossings) underlain by karst terrain (**Figure 1**). The LOD is identified in this Plan as an area within the MVP construction easement where ground cover is removed or altered through MVP construction activities (clearing and grubbing, trenching, blasting, boring or drilling), and trenchless crossings.

The post-construction monitoring portion of this Plan is designed to surveil the alignment for potential land subsidence that may be associated with an activated subsurface karst feature once reclamation actives are completed and the pipeline is brought into operation. Potential mitigation measures are also discussed in this Plan.

Karst terrain occurs from southern Summers County, West Virginia into Roanoke County, Virginia along an approximately 33-mile corridor (although karst terrain is not contiguous) within which the MVP alignment is proposed for construction (**Figure 1**). Note that karst terrain is not continuous throughout the karst zone illustrated in **Figure 1**. The Appalachian Plateau and Valley and Ridge geologic provinces are characterized by Mississippian to Ordovician age sedimentary bedrock, with folding and ancient thrust faulting resulting in a complicated distribution of rock types through this region. Siliciclastic sedimentary bedrock that does not form karst terrain is interbedded, or otherwise in contact with karst-forming carbonate bedrock.

The **Karst Hazards Assessment** (provided under separate cover) for the MVP alignment in karst terrain included a desk top review using public and proprietary data sources extending a minimum of 0.25-mile from either side of the currently proposed MVP alignment. A more detailed assessment was made through field confirmation of karst features within a minimum of 150 feet

from the proposed MVP alignment on parcels where landowner permission was granted to access the property.

Avoidance of a karst feature constitutes the first and foremost recommendation for mitigating impact. If an identified karst feature cannot be reasonably avoided, or if a previously unidentified karst feature is encountered or forms during construction, this **Karst Mitigation Plan** provides recommendations for impact mitigation and feature stabilization.

MVP will deploy a **Karst Specialist (KS)** prior to, and during construction to confirm, monitor, and mitigate if necessary, existing karst features, and to assess and mitigate previously unidentified karst features that are encountered or observed to form during MVP land disturbance and construction.

1.1 Regulatory Framework

Land disturbance for natural gas pipeline construction and installation constitutes a construction practice that is regulated under federal and state laws for stormwater management and erosion and sediment control (ESC). Construction within karst terrain carries additional regulations to protect caves. The following summarizes the regulatory programs currently in-place in Virginia and West Virginia that will apply to pipeline construction in karst terrain.

In Virginia, ESC is governed by the Erosion & Sediment Control Law (§62.1-44.15:51 et seq) and the Erosion & Sediment Control Regulations (9VAC25-840) and falls under the purview of the Virginia Department of Environmental Quality (DEQ). Note that effective July 2, 2013, DEQ assumed stormwater permitting responsibilities from the Virginia Department of Conservation and Recreation. These laws and regulations serve to let the State regulate construction ESC in compliance with the Clean Water Act NPDES Permit program. Specifically, construction stormwater discharges are covered by the General VPDES permit for discharges of stormwater from construction activities, which requires that the Erosion Control/Stormwater regulations are followed for applicable sites. In normal cases, Erosion & Sediment Control regulations are triggered if land disturbance exceeds 10,000 square feet, and stormwater regulations are triggered if land disturbance exceeds one acre.

West Virginia also administers stormwater general permits through the West Virginia Department of Environmental Protection (WVDEP). Activities that disturb more than one (1) acre but less than three (3) acres are required to comply with the terms of the General Permit by completing a "Notice of Intent" form, while projects disturbing greater than three (3) acres must submit a site registration application form. For projects disturbing between three (3) and 99 acres, the form must be submitted to DEP at least 60 days prior to starting the project. Sites disturbing 100 acres or more, discharge to Tier 3 waters, have an initial grading construction phase of one (1) year or greater, or a common plan of development greater than 10 acres must submit the form at least 100 days prior to starting the project.

Virginia codified a law for protecting caves (the Virginia Cave Protection Act, Code of Virginia Section 10.1-1000 to 1008); there is no corresponding law that specifically protects karst.

The Virginia Department of Conservation and Recreation, a division of the Department of Environmental Quality, includes a Karst Protection Coordinator branch. Coordination with the Karst Protection Coordinator is described in more detail in this plan.

West Virginia also has a state law designed to protect caves (West Virginia Cave Protection Act, West Virginia Code - Chapter 20, Article 7A-1 through 7A-6) but does not address karst protection measures in general.

There are no specific laws or regulations governing blasting to remove shallow bedrock for pipeline trench construction. Nonetheless, a blasting plan will be prepared by the qualified blasting contractor and the Plan enforced to mitigate impacts to structures, sensitive features, and water resources in karst resulting from blasting.

1.2 Overview of Potential Karst Hazards

The term "karst" refers to a type of landform or terrain that is characterized by the presence of sinkholes, caverns, irregular "pinnacled" bedrock surface, and springs. The development of karst terrain is a result of the presence of soluble bedrock such as limestone, dolomite, marble or gypsum. Any landscape that is underlain by soluble bedrock has the potential to develop a karst terrain landform.

The most prevalent type of karst feature observed at the ground surface along the proposed MVP alignment in karst terrain (**Figure 1**) are sinkholes. Sinkholes fall into two broad categories, termed "vault-collapse" sinkholes, or "cover-collapse" sinkholes. Vault-collapse type sinkholes (i.e., where a cavern "vault" or roof has failed catastrophically) are relatively rare in karst terrain along the proposed MVP alignment. However, cover-collapse type sinkholes are more commonly observed.

Cover-collapse sinkholes typically develop by the raveling of overburden into solution channels within the bedrock mass, in which water is the transport medium for the movement of the fines. The natural raveling process is generally slow such that sinkhole development generally occurs over a long time span. However, various changes at a site can sometimes lead to the sudden and unanticipated development of sinkholes.

The most common changes that may initiate sinkhole development are:

1. Increase or redirection of overland or subsurface water flow paths, which accelerates the raveling of fines;
2. Removal of vegetation cover and topsoil (i.e., stripping and grubbing), which can reduce the cohesive strength of overburden that overlies a conduit; and
3. Sudden changes in the elevation of the water table (such as drought, over-pumping of wells, or quarry dewatering), which removes the neutral buoyancy of the water supporting a conduit plug, and may result in rapid collapse.

As noted earlier, caves, pinnacled bedrock and karst springs are also observed within karst terrain underlying the proposed MVP alignment and are addressed later in this plan.

1.3 Karst Hazards Assessment

MVP deployed KS team to evaluate the karst terrain of southern West Virginia and southwestern Virginia through which the proposed MVP alignment will traverse. The KS team holds qualifications of, or work under the direction of, a professional geologist having direct work experience with karst hydrology and geomorphic processes. The KS team has over 70 years of combined direct field experience evaluating karst features in the vicinity of the proposed MVP alignment.

The KS team provided a detailed inventory in the **Karst Hazards Assessment** (provided under separate cover) of karst features within a minimum 0.25-mile of the centerline of the currently proposed MVP alignment and other Project components (e.g., access roads, temporary workspaces, etc.,). The KS team evaluated publicly available and proprietary karst feature data to inventory karst features. Direct field observations (where property access was granted) was used to confirm the desktop review and evaluate the terrain for additional, previously undocumented karst features.

Recommendations were provided to MVP on the locations of sensitive karst features, or areas that are particularly susceptible to karst formation but had limited mapping and field reconnaissance. For these specific karst areas, the KS team recommended that geophysical remote sensing techniques (e.g., electrical resistivity, ground penetrating radar, etc.,) be used, and if necessary invasive borings be completed, to further elucidate a karst feature or a discrete area suspected to have subsurface karst formations. In response to the karst feature assessment, MVP made alignment adjustments to avoid sensitive karst areas. Alignment adjustments therefore reduce the corresponding recommendations for remote sensing and invasive boring evaluations.

Karst features located in the final alignment are minor in nature and extent (e.g., cover-collapse sinkholes). These features will be confirmed and monitored by the KS team prior to and during construction (discussed below) and if necessary stabilized. Formation of a significant karst feature during construction would be monitored and evaluated by the KS. Additional site evaluation (including geophysical remote sensing and invasive borings) may be recommended by the KS to evaluate potential that the feature serves as a conduit to groundwater and if necessary to support mitigation measures (discussed later in this report).

2.0 KARST TERRAIN INSPECTION PRIOR TO AND DURING CONSTRUCTION

MVP deployed a KS team prior to tree clearing and complete a **Level 1** inspection of karst features in the LOD (see **Appendix A** for Karst Feature Inspection Form). The final MVP alignment accommodated for karst feature avoidance recommendations. Therefore, a karst feature located within the LOD is likely to be minor in its extent and nature and a candidate for mitigation and stabilization prior to disturbance.

The KS will consult with MVP Construction to determine the recommended course of action prior to land disturbance in the vicinity of the feature. It is anticipated that the most common karst feature requiring mitigation for MVP construction will be cover-collapse sinkholes (discussed below). Karst feature stabilization will, if necessary, be completed in conjunction with recommendations from the appropriate state agency (Virginia Department of Conservation and Recreation, Karst Protection; West Virginia Department of Environmental Protection).

MVP will deploy an on-site KS team during construction activities (clearing and grubbing, trenching, blasting, trenchless crossing) within karst terrain. The role of the KS is to observe construction activities to assist in limiting potential negative impacts, and to inspect, assess and if necessary mitigate karst features that are encountered or form during construction in conjunction with recommendations from the appropriate state agency (Virginia Department of Conservation and Recreation, Karst Protection; West Virginia Department of Environmental Protection).

Two or more KS will be available to conduct multiple inspections in karst terrain where MVP Construction crews may be working at different locations simultaneously.

2.1 Level 1 Inspection of a Karst Feature

A **Level 1 Inspection** of a karst feature will entail observation and documentation of the following ground and feature characteristics:

1. soil subsidence;
2. rock collapse;
3. sediment filling;
4. swallet (sinking stream) or notable increased surface water infiltration;
5. spring / seep / flooding;
6. cave or void space;

7. clogging; and/or other changes in morphology or function that might indicate potential impact to the epikarst stratum caused by the work.

The inspection will be recorded on a Karst Feature Inspection Form (**Appendix A**), including digital photographs, GPS coordinates and reference to the nearest MVP milepost.

If any of the representative changes listed above are observed at a karst feature, the KS will complete a **Level 2 Inspection** (discussed below).

2.2 Level 2 Inspection of a Karst Feature

The **Level 2 Inspection** will be conducted as follows, and recorded on a Karst Feature Inspection Form provided in **Appendix A**.

The KS will examine the suspected karst feature to identify potential connectivity to the subterranean environment and risk for impacting groundwater quality. The choice of characterization methods will be proposed to MVP by the KS, and will include any combination of (but not be limited to):

1. visual assessment and physical inspection;
2. geophysical survey;
3. track drill probes;
4. infiltration or dye trace testing; or
5. other techniques utilized to facilitate subsurface characterization of karst features.

If the karst feature does not appear to have connectivity to the subterranean environment and risk for impacting groundwater quality, the KS will provide MVP Construction with a recommendation on stabilization measures for the feature (see Section 3.1 of this Plan), and construction activities will continue after the feature is stabilized.

If it is determined that the feature has connectivity to the subterranean environment and potential to impact groundwater, the KS will consult with MVP Construction regarding appropriate mitigation. Mitigation activities would be conducted in conjunction with recommendations from the appropriate state agency (Virginia Department of Conservation and Recreation, Karst Protection; West Virginia Department of Environmental Protection).

In addition:

- The KS will contact Mr. Wil Orndorff, DCR Karst Protection (540-230-5960; Wil.Orndorff@dcr.virginia.gov) within 24 hours of observing a new karst feature within the LOD, to alert DCR of the karst feature and proposed mitigation activities. DCR may request to review the feature prior to further disturbance.

- The KS will contact Mr. Nick Schaer, Program Development Geologist, WVDEP (304-926-0499 ext. 1510; Nick.a.schaer@wv.gov) within 24 hours of observing a new karst feature within the LOD, to alert DEP of the karst feature and proposed mitigation activities. DEP may request to review the feature prior to further disturbance.

Mountain Valley's KS will be available to meet with DCR staff or WVDEP staff no later than 24 hours following a staff request.

A weekly **Level 1 Inspection** of the stabilized or mitigated feature will be completed and documented by the KS on a Karst Feature Inspection Form (**Appendix A**) while construction activities (clearing and grubbing, trenching, blasting, trenchless crossing) are on-going within 150 feet of the feature.

Mitigation or stabilization activities will be documented upon completion in a report prepared by the KS, to be delivered to MVP.

2.3 Agency Coordination

Mountain Valley will coordinate with the Virginia DCR to identify areas with high potential for stream loss. Should the potential for or an actual stream loss occur, the karst specialists will coordinate with the MVP Environmental Inspectors, construction personnel and the Virginia DCR to develop a site-specific plan to avoid the loss or mitigate the issue.

3.0 MANAGEMENT OF NEWLY IDENTIFIED KARST FEATURES

If a suspected karst feature is intercepted during work activities, or forms within the LOD during construction activities (clearing and grubbing, trenching, blasting, boring or drilling), the KS will conduct a combined **Level 1** and **Level 2 Inspection** of the feature.

Suspected karst features include:

1. Sinkhole;
2. Spring;
3. Bedrock enclosed conduit(s) or void;
4. Solution pocket that extends beyond visual examination range (and therefore may be open);
5. Soil void;
6. Highly fractured karst bedrock;

The KS will follow the procedural outlines listed above for **Level 1** and **Level 2 Inspections**.

3.1 Sinkhole Stabilization

Sinkholes are common surficial geomorphic expressions of karst terrain. If a sinkhole is located within the proposed LOD and cannot be reasonably avoided, the sinkhole will be stabilized prior to construction in accordance with recommendations provided by the KS, and in conjunction with recommendations from the appropriate state agency (Virginia Department of Conservation and Recreation, Karst Protection; West Virginia Department of Environmental Protection).

A weekly **Level 1 Inspection** (described below) of the stabilized feature will be completed and documented by the KS (see **Appendix A** for Karst Feature Inspection Form) while construction activities (clearing and grubbing, trenching, blasting, boring or drilling) are on-going within 150 feet of the feature.

Mitigation activities will be documented upon completion in a report prepared by the KS, to be delivered to MVP.

See the following sections of this report for activities to be followed under this Mitigation Plan for karst features other than sinkholes that are located within the MVP LOD.

4.0 MEASURES TO AVOID IMPACTS TO THE KARST AQUIFER AND ENVIRONMENT

The following procedures will be used during pipeline construction activities (clearing and grubbing, trenching, blasting, boring or drilling) to limit potential impact to karst features and related water resources.

1. Protect known and/or future mapped recharge areas of cave streams and other karst features (see **Karst Hazards Assessment** provided under separate cover to identify the relevant construction area where these features are located) by following relevant conservation standards, specifically those pertaining to stream and wetland crossings, erosion and sediment control, and spill prevention, containment, and control.
2. MVP construction activities (clearing and grubbing, trenching, blasting, boring or drilling) will be conducted in a manner that minimizes alteration of existing grade and hydrology of karst features:
    a. In linear excavations adjacent to karst features, spoils will be stockpiled and managed up-slope of the excavation, and runoff controlled according to the MVP project-specific stormwater management and ESC Plan (under separate cover).
    b. Surface water control measures, including, but not limited to diversion (direct water flow into trench or off right-of-way areas past the area of concern), detention or collection and transportation, will be utilized to prevent construction-influenced surface water from free flowing into karst features.
    c. Karst features will not be utilized for the disposal of water.
3. Blasting will be conducted in a manner that will not compromise the structural integrity or alter the karst hydrology of known or inferred subsurface karst structures. If rock is required to be hammered or blasted, the following parameters will be adhered to:
        a. The excavation will be carefully inspected for voids or other openings, or signs of enhanced secondary porosity.
        b. If the rock removal intercepts an open or clay-filled void, cave, or other signs of enhanced secondary porosity, see previous section of this plan for **Level 1** and **Level 2 Inspections**.
        c. Blasting will be conducted by a qualified blasting contractor, in accordance with the contractors written and approved blasting plan.

d. If a track drill is used to prepare the hole(s) for the explosive charge(s) and the boring encounters an open or clay-filled void, cave, or other signs of enhanced secondary porosity, see previous section of this plan for **Level 1** and **Level 2 Inspections**.

4. Comply with requirements of project Spill Prevention, Control, and Countermeasures Plan (SPCC) prepared by Contractor (under separate cover). During construction, if the KS observes unexpected conditions that may affect a karst feature, the KS will re-examine and enhance if necessary the procedures and BMPs designed to protect karst features. The following general guidelines will be incorporated into the SPCC for construction practices in karst terrain:

   a. To reduce the risk of groundwater contamination, equipment will not be parked or left idling for extended periods of time (more than 12 hours), refueled or serviced within 100 feet of any karst feature.
   b. Equipment refueling will not be performed within flagged or marked buffer areas of streambeds, sinkholes, fissures, or areas draining into these or other karst features, except by hand-carried cans (5 gallon maximum capacity) when necessary.
   c. Equipment servicing and maintenance areas will be sited outside of flagged or marked buffer areas of streambeds, sinkholes, fissures, or areas draining into these or other karst features.
   d. Prevent runoff resulting from construction equipment washing operations to directly enter any karst feature by locating these operations outside of the buffer area.
   e. Mountain Valley will also restrict equipment storage and fueling from occurring upgradient (with respect to surface water flow) from the 100-foot karst feature exclusion buffer to further limit potential for impacts.
   f. Hazardous materials, chemicals, fuels, lubricating oils, and petroleum products will not be stored within 100 feet of any karst feature.
   g. All equipment will be checked by a construction inspector daily for leaks prior to beginning work in karst areas. If any leaks are observed, or damaged or defective equipment is discovered, drip pans and other containment will be deployed immediately and the equipment removed or repaired as soon as practical.
   h. If a reportable spill (reportable volume will be defined in the project-specific SPCC Plan) occurs within a karst feature or water body, refer to the project-specific SPCC Plan.

5. The intent of ESC and related Best Management Practices (BMPs) is to confine project-related disturbance to the LOD, protect sensitive karst features, and minimize erosion and enhance revegetation in those areas. In addition to ESC BMPs for standard pipeline construction, which includes specifications by regulatory agencies, additional BMPs will be implemented as specified by the KS.
    a. The KS and EI will be on site during all phases of construction, and they have the responsibility to determine if mitigation measures provide sufficient protection of the identified features given site conditions. The KS and EI have the authority to adjust and improve BMP protection around these resources to address changes in conditions.
    b. To provide additional protection throughout the project, Mountain Valley will also inspect the environmental controls throughout the project area once every seven days or after a 0.25-inch rain event.
6. Discharge of hydrostatic testing water in karst areas will be avoided if practicable. If circumstances require hydrostatic testing water to be discharged in karst areas, the KS will recommend a discharge location in consideration of the following guidelines:
    a. Do not discharge hydrostatic testing water directly into flagged or marked buffer areas of karst features or channels or surface features that flow towards karst feature(s).
    b. Where possible, discharge hydrostatic test water down-gradient of karst features unless on-the-ground circumstances (e.g., manmade structures, terrain, and other sensitive resources) prevent such discharge.
        i. If those circumstances occur, discharge water into uplands greater than 500 feet from flagged or marked buffer areas of karst features unless on-the ground circumstances (e.g. manmade structures, terrain, other sensitive resources) prevent such discharge.
        ii. If i.) above is not practicable, discharge water as far from flagged or marked karst features as practical and utilize additional sediment and water flow control devices to minimize effects.
    c. Control the rate and volume of discharge to prevent land erosion, sediment mobilization and ponding of water.

5.0 POST-CONSTRUCTION MONITORING

After pipeline construction and land reclamation are completed, Mountain Valley will implement a monitoring program within karst terrain to surveil for potential land subsidence that may be associated with activation of a subsurface karst feature. The monitoring program will provide early-warning detection of subtle ground movement and trigger Mountain Valley's post-construction landform evaluation and mitigation procedures in karst terrain, as described below. Recommendations for mitigation are discussed in Section 5.3, below. More specific mitigation measures will depend upon the results of the monitoring program, and the Mountain Valley KS team's field observations on actual conditions.

Mountain Valley will construct the pipeline with safeguards to prevent impacts to, and from, karst terrain, as discussed above. Mountain Valley does not consider it sound practice to establish a construction area that requires repeated interim measures to maintain stability.

5.1 Light Detection and Ranging (LiDAR) Surveys

Mountain Valley will utilize aerial Light Detection and Ranging (LiDAR) surveys on a prescribed periodic basis (discussed below) to monitor the ROW for changes in ground topography that could be indicators of potential land subsidence due to activation of a subsurface karst feature.

LiDAR works by emitting multiple laser pulses over the same area, such that some pulses are reflected off intermediate surfaces (i.e. variable height vegetation, buildings, power lines, etc.) and some of the pulses find the underlying ground surface. The resulting data are processed to classify data that represent the ground surface (i.e., generate a bare Earth model), providing a detailed topographic and geomorphic landform model to detect subtle changes in ground morphologies.

A progression of LiDAR data collected over time over the ROW in karst terrain will be compared to previous surveys in order to identify whether subtle landform chances are occurring that could correspond with possible land subsidence. The sequential LiDAR models of the area of concern will be configured as a "heat map" to more clearly identify changes in geomorpholgy. If ground subsidence is perceived via LiDAR monitoring (analysis is discussed below), direct inspection by the Mountain Valley KS team will take place to assess the potential for sinkhole or other karst

feature formation. The intent is to mitigate subtle landform movements before a larger failure could occur.

5.2 Monitoring Schedule

Mountain Valley will conduct semiannual aerial LiDAR monitoring of the ROW in karst terrain during an initial two-year period after construction is complete, rendering four (4) sequential LiDAR surveys during the first two years after construction. This spans a critical period of time post-construction to confirm that land reclamation is established, and that karst terrain underlain by the ROW is stable. Continued monitoring described below will confirm these conclusions over the long-term.

If karst terrain in the ROW is demonstrated to be stable by sequential LiDAR monitoring data for the initial two years of semiannual monitoring (described above), the frequency of LiDAR survey will be reduced to annually for another two consecutive years. This will provide six (6) LiDAR monitoring events over the span of four years in order to detect potential land subsidence.

If the ROW in karst terrain is demonstrated to be stable by sequential LiDAR monitoring data for the combined four years of monitoring (i.e., the initial two years of semiannual monitoring, followed by two years of annual monitoring), the frequency of LiDAR surveys will be further reduced to a five-year periodicity throughout the life of the pipeline.

As each new sequential LiDAR survey is completed (see monitoring schedule above), the data will be processed and compared to all historical LiDAR data for the ROW available at the time to produce a "heat map" of potential ground movement over time.

If karst terrain reclamation is required in the ROW, Mountain Valley will remediate the area per the KS team's recommendations and include the repaired area specifically in its routine monitoring schedule to document that land stability was achieved.

5.3 Slope Stability Mitigation Measures

If land subsidence is detected by the LiDAR monitoring program, Mountain Valley will engage the Mountain Valley KS team to complete field inspection and verification and confirm actual

conditions and governing reasons for the topographic changes. Recommendations for remedial measures will be provided to Mountain Valley based on the KS team inspection observations.

Once Mountain Valley has received recommendations from the KS team, Mountain Valley will contact Mr. Wil Orndorff, DCR Karst Protection (540-230-5960; Wil.Orndorff@dcr.virginia.gov) to alert DCR of potential karst feature activation and proposed mitigation activities. DCR may request to review the feature prior to further disturbance. If the karst feature is observed in West Virginia, Mountain Valley will also contact Mr. Nick Schaer, Program Development Geologist, WVDEP (304-926-0499 ext. 1510; Nick.a.schaer@wv.gov).

Once Mountain Valley has received recommendations from the KS team, and notified the agency(ies), Mountain Valley will implement planned remedial activities. Specific remedial measures will depend upon the nature and extent of potential land subsidence. Examples of potential redial measures could include:

- If subsidence is confirmed in surficial backfill in the ROW (which may or may not be associated with subsurface karst), enhanced backfill compaction (or replacement with engineered materials), enhanced water management, and aggressive revegetation will be implemented.

- If subsidence in native earth material outside of the ROW is confirmed, the KS team inspectors will provide recommendations to Mountain Valley for remediation measures such as sinkhole stabilization measures discussed earlier in this Plan.

- If subsidence may have resulted in pipe stress, a stress relief excavation may be required to allow the pipeline to rebound to the non-stress condition prior to subsidence. Stress relief excavations typically start in the middle of the area where land movement is observed and extend in either direction until no rebound is observed, and generally continue for a minimum of an additional 50 feet. Surveys may be required during the excavation work to track pipeline rebound, and to confirm before and after pipeline location and elevation. Stress relief excavations would only be contemplated for relatively large-scale movement scenarios.

- Mountain Valley may also consider installing strain gauges on the pipeline during stress-relief excavation. The strain gauges would monitor potential accumulated pipeline strain in the future if land subsidence continues. Strain gauge monitoring would be conducted manually on a yearly basis, unless LiDAR monitoring under the post-remediation timeframe continues to identify large-scale slope movement, in which case the strain gauges will be monitored on a six-month basis. Strain gauges would only be contemplated for relatively large-scale movement scenarios.

FIGURE 1 – KARST ZONE

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

FIGURE NUMBER 1
Karst Zones

October 2017

Draper Aden Associates
Engineering • Surveying • Environmental Services

Approximately 24.0 miles of karst terrain is traversed by the proposed route.
~10.6 Miles of Limestone
~13.4 Miles of Dolomite

It is encountered in non-contiguous areas across the Counties of Summers, Monroe, Giles, Craig, and Montgomery.

Summers
Monroe
Greenbrier
Greenbrier
Greenbrier
Alleghany
Craig
Botetourt
Roanoke
Salem
Montgomery
Pulaski
Giles
Mercer
Mercer
Mercer
MP-180
MP-190
MP-200
MP-210
MP-220
MP-230
MP-240

Legend

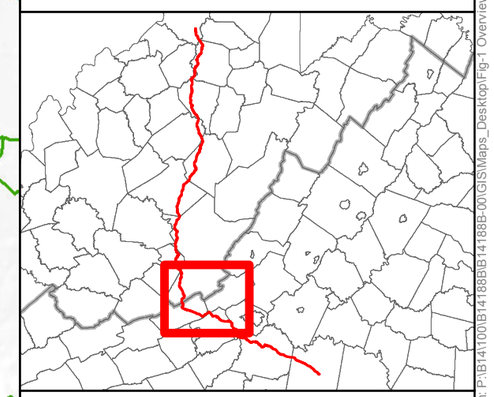
MVP Proposed Route
with Mile Posts

Karst Areas

Rock Type

Limestone

Dolomite



Karst Regions adapted from 1968 Geological Map of West Virginia. 1:250,000. West Virginia Geological and Economic Survey.
Digital Representation of the 1993 Geologic Map of Virginia; 1:500,000
U.S. Geological Survey, 2003; (Virginia Division of Mineral Resources Publication 174)
Geologic Map of Giles County, Virginia, 1986. Ed. E.K.Rader and T.M.Gathright II

N

1:225,000

NAD 1983 UTM 17N

0 2 4 6 8 Miles

Service Layer Credits:

Background hillshade: Shuttle Radar Topography Mission 90m DEM; NASA

Document Path: P:\B14\100\B14188B\B14188E-00\GIS\Maps_Desktop\Fig-1 Overview Karst Zones v5r1.mxd

APPENDIX A - KARST FEATURE INSPECTION FORM

Date:_____ Karst Specialist:_____ MVP Milepost:_____

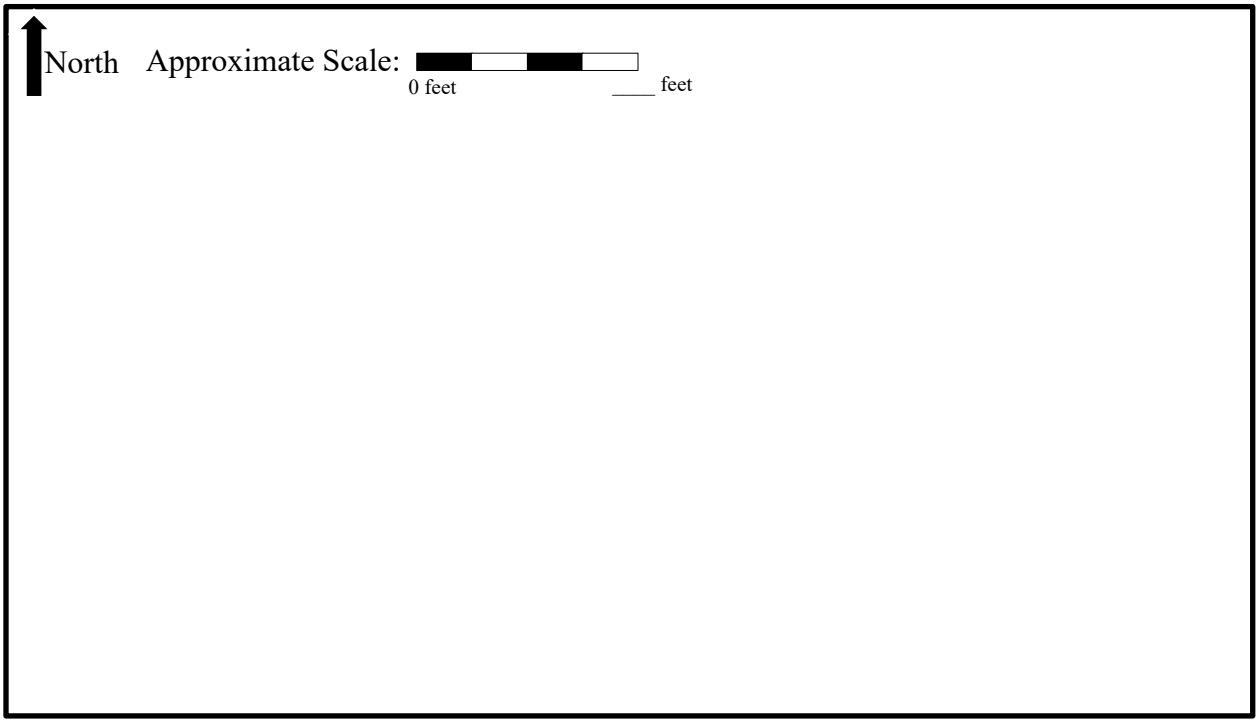
GPS Coordinates (X, Y; coordinate system):_____

Digital image documentation:

Photo #	View toward (circle):	Description:
	North South East West	
	North South East West	
	North South East West	
	North South East West	

Continue on next page if necessary.

Sketch:



Level 1 Inspection: Check characteristics observed:

____ soil subsidence ____ rock collapse ____sediment filling

____ swallet / notable increased surface water infiltration ____spring / seep or flooding

____ clogging; and/or other changes in morphology or function that might indicate potential impact to the epikarst stratum caused by the work.
Description:_____
_____
_____

Recommend Level 2 Inspection? (circle one) **Yes / No**

Level 2 Inspection: Check inspection method(s):

_____ visual assessment _____ geophysical survey _____ track drill probes

_____ infiltration or dye trace testing

_____ other: _____

Mitigation recommended? (circle one) **Yes / No**

Summarize recommended mitigation method(s):

_____
_____
_____
_____

KS contact Wil Orndorff, DCR (540-230-5960)? **Yes / No** Date_____ Time_____

DCR Inspection requested? (circle one) **Yes / No**

KS contact Nick Schaer, WVDEP (304-926-0499)? **Yes / No** Date_____ Time_____

WVDEP Inspection requested? (circle one) **Yes / No**

Notes:

_____
_____