| Job Steps | Hazards | Controls | RAC |
|---|---|---|---|
| | | • Provide handwashing station or hand sanitizer and use often. Soap is preferable to hand sanitizers when it is available. Sanitizers can break down the skin making an individual more prone to chemical and biological exposures.<br>• Clean high-contact surfaces daily with disinfectant. | |
| Site-specific tasks: Multiple operators in equipment, multiple drivers of work vehicles, sharing ice cooler, sharing hand tools, sharing analog instruments, sharing portable toilet | Possible infection or spread of infection | • Limit operators and decontaminate equipment and vehicles twice daily.<br>• Pack water in personal backpacks and small coolers.<br>• Each team member will have a personal shovel and instrument to use for job duration.<br>• Portable toilet commonly touched surfaces will be cleaned after each use. | L |
| Confirmed infection | Infection of others<br><br>Logistical issues related to managing infected personnel far from home | • Personnel who develop symptoms like fever, cough, or shortness of breath that might indicate infection are to self-quarantine and notify the SSHO. SSHO is to notify PM and Corporate lead entity. SSHO may not release the name of quarantined personnel to others without authorization from Corporate lead entity.<br>• Subcontractor and Government personnel who develop symptoms like fever, cough, or shortness of breath that might indicate infection should notify the SSHO and follow guidance within their Corporate HR policies.<br>• APTIM's PM, in concert with senior management, will provide coordination and support to facilitate quarantine. If infected person is local the person will be asked to self-quarantine at home or go to a hospital if seriously ill. If infected person is not local, the person may have to quarantine in a hotel, unless seriously ill. If/when this occurs it will be reported up the chain and situation-specific responses will be determined.<br>• If suspected infected personnel must be within 6 feet of other personnel (in a car, for instance) the suspected infected individual and any personnel within a 6 foot radius should wear an N95 if available, face covering or surgical mask.<br>• If an employee tests positive for COVID-19, they should follow HGL's requirements for sick leave, benefits, and return to work. Subcontractors and Government personnel are directed to follow guidance within their Corporate HR policies regarding employee leave. In addition, before returning to the project site the site worker must provide the SSHO with documentation of a negative test, a note from a doctor, or a state or local testing facility.<br>• Contact Tracing: All of the people that the positive testing employee had sustained contact with for more than 10 minutes (within a 6 foot distance) will be made aware of their potential for exposure and will be told to do daily self-checks and monitor their symptoms and temperature. | L |
| Restricting Job Site Visitors | Possible Exposure by Unvetted Visitor | • Restrict the number of visitors to the job site, including the trailer or office.<br>• All visitors should be screened in advance. If the visitor can answer "yes" to any of the following questions (without identifying which question applies), the visitor will not be permitted to access the facility. The questions are:<br>  ○ Have you been asked to self-quarantine since December 2019? | L |

| Job Steps | Hazards | Controls | RAC |
|---|---|---|---|
| | | ○ Have you been in close contact with any person(s) who has been asked to self-quarantine since December 2019?<br>○ Have you experienced a recent onset of any illness-related symptoms, such as fever, cough, or shortness of breath?<br>○ Have you traveled outside of North America in the past 14 days?<br>○ Have you been in close contact with any person(s) who have traveled outside of North America in the last 14 days?<br>○ Have you been in close contact with any person(s) who has been diagnosed with COVID-19? | |
| Site clean-up and demobilization | Possible infection or spread of infection<br>Employee stopped or prevented from traveling home due to state restrictions due to stay at home orders | • Decontaminate equipment before shipping to home office.<br>• Decontaminate GPS units before returning.<br>• Clean boots, work clothes, and gear used at work prior to travel home to prevent further exposure and spread.<br>• Plan ahead for specific state restrictions personnel will travel through during demobilization and provide a letter stating employee is essential personnel. | **L** |

| Equipment to be Used | Training Requirements/Competent or Qualified Personnel name(s) | Inspection Requirements |
|---|---|---|
| Personal Protective Equipment - Level D:<br><br>Hard hat<br>Safety glasses<br>Safety-toed boots<br>Work gloves/chemical resistant gloves<br><br>Equipment:<br><br>As needed for task | Competent Person (CP) / Qualified Person (QP):<br><br>TBD - CP/SSHO<br>TBD - CP/First Aid and CPR<br><br>Training Requirements (as determined by SSHO):<br><br>Tailgate meetings<br>Emergency procedures<br>Hazard communication | Daily site safety inspection (SSHO) – TBD<br><br>Housekeeping (daily)<br>Hand washing station or hand sanitizer solution available and used.<br>Distancing being practiced.<br>Do any personnel show signs of infection?<br>SSHO to notify Project Manager and HR of any reports of signs of infection immediately. SSHO is not to provide names of involved personnel to others without authorization from HR. |

# ATTACHMENT 2

# AMS HEALTH AND SAFETY PROCEDURES

AMS-710-02-PR-02700, Non-Commercial Motor Vehicle Safety
AMS-710-02-PR-05700, Mechanized and Marine Equipment
AMS-710-02-PR-03900, Commercial Motor Vehicle Safety
AMS-710-02-PR-01610, Utility Contact Prevention
AMS-710-02-PR-01500, Control of Hazardous Energy
AMS-710-01-PR-00300, Bloodborne Pathogens
AMS-710-05-PR-00400, Stop Work Authority
AMS-710-04-PR-00300, Hazardous Waste Operations
AMS-710-05-PR-01700, Work Area Hazard Assessment
AMS-710-02-PR-03000, Personal Protective Equipment
AMS-710-02-PR-03500, Respiratory Protection Program
AMS-710-02-PR-06400, Permit to Work
AMS-710-01-PR-05000, Medical Surveillance Program
AMS-710-01-PR-01000, Sanitation and Potable Water
AMS-710-02-PR-01600, Excavation and Trenching
AMS-710-01-FM-04201, COVID-19 Control Plan
AMS-710-02-FM-05701, Mechanized and Marine Equipment Inspection Report
AMS-710-01-PR-00600, Heat Stress Prevention and Control

| PROCEDURE |
|---|
| **Procedure Number:** |
| **AMS-710-02-PR-02700** |
| **Revision:** |
| **1** |
| **Procedure Owner:** |
| **HSE** |
| **Issuing Authority:** |
| **VP HSE & Security** |
| **Approval Date:** |
| **3/4/2019** |


# NON-COMMERCIAL MOTOR VEHICLE SAFETY

| Rev | Changes | Approved | Date |
|---|---|---|---|
| 1 | Clarification regarding the use of the point system for existing employees, sections 4.2.3, 4.2.5-4.2.7. | M. Hetzler | 3/4/2019 |
| 0 | Initial Issue | M. Hetzler | 2/22/2019 |

**Parent Document:** N/A

# NON-COMMERCIAL MOTOR VEHICLE SAFETY

## 1.0 PURPOSE

The purpose of this Procedure is to establish the minimum requirements for using non-commercial motor vehicles on APTIM sites and driving on company business. More stringent regulatory agency or client procedures may supersede these requirements. Each project is responsible for identifying the most stringent procedure and including those requirements in the site-specific safety plan. The most stringent of the requirements shall be adhered to.

The following deliverables are defined within this procedure:

| Deliverable | Producer | Customer |
|---|---|---|
| Vehicle Inspection Form AMS-710-02-FM-02701 | Driver | Site Files / Equipment Services Group |
| Motor Vehicle Procedure Acknowledgement Form AMS-710-02-FM-02702 | Driver / Supervisor | HR Personnel Files |
| Notice of Citation Form AMS-710-02-FM-02704 | Driver | HSE Rep and HR Personnel Files |
| Request for Check of Driving Record Form AMS-710-02-FM-02705 | Driver / Site Manager /HR Representative / Hiring Manager | Supervisor, HSE Rep, and MVR Coordinator |
| Training | Drivers | Site Files / Learning Management System |

## 2.0 SCOPE

This procedure addresses the operation of non-regulated over-the-road vehicles (e.g., cars, trucks, and vans with gross weight of 10,000 lbs or less) by Company authorized drivers. On-site mobile equipment, rough terrain vehicles, golf carts, and similar utility vehicles are not covered in this procedure.

This procedure applies to all APTIM employees, contractors, and subcontractors associated with an APTIM site who operate a motor vehicle on behalf of APTIM (e.g. company- owned, rented, or leased by APTIM or its clients – hereafter referred to as “company vehicle”). In addition, this procedure applies to the use of personal vehicles on company business.

The requirements for operating Commercial Motor Vehicles (i.e. those which typically require a Commercial Driver’s License and/or are regulated by DOT) can be found in the Commercial Motor Vehicle Safety Procedure (AMS-710-02-PR-03900).

- It should be noted that the requirements of AMS-710-02-PR-03900 apply to non-commercial vehicles when the combined Gross Vehicle Weight Rating (GVWR) or Gross Combination Weight Rating (GCWR) of the vehicle and its load/attachments exceed 10,000 pounds.

- Any vehicle, no matter how small, hauling hazardous materials in quantities requiring placards is defined as a Commercial Motor Vehicle, and the driver requires a Commercial Driver's License with proper endorsements.

## 3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure:

- APTIM Human Resources
- APTIM Managers
- APTIM Supervisors
- APTIM Employees
- APTIM Equipment Services Group
- APTIM Contractors
- APTIM Subcontractors

## 4.0 PROCEDURE

4.1.1 All personnel who operate a company vehicle and those operating a personal vehicle for business purposes (all hereby referred to as "driver(s)") shall be familiar with this procedure and certify acceptance of the requirements by completing Motor Vehicle Procedure Acknowledgement Form (AMS-710-02-FM-02702).

4.1.2 Company vehicles are to be utilized exclusively for business purposes and occupied by authorized passengers as defined in this procedure.

4.1.3 Drivers shall have a valid driver's license for the area in which they are operating a vehicle. Any person with a suspended license is prohibited from driving any company vehicle.

4.1.4 Drivers shall comply with all local, state, and federal traffic regulations.

4.1.5 Drivers are personally responsible for any and all citations incurred by violating traffic regulations. Citations issued while driving a company vehicle or a personal vehicle while on company business shall be reported using the Notice of Citation Form (AMS-710-02-FM-02704).

4.1.6 Drivers shall be familiar with and abide by all laws and regulations applicable to the operation of their vehicle and should not drive motor vehicles in areas (i.e. other countries) where they are unsure of or inexperienced in local driving rules and regulations.

4.1.7 Drivers shall use cell phones/cellular devices in accordance with Cellular Device Use Procedure (AMS-710-02-PR-05600).

4.1.8 Drivers shall notify their supervisor immediately of any event that might alter their driver's license status, to include suspension or revocation of driver's license.

4.1.9 Where applicable, requests for reinstatement of denied or revoked driving privileges can be made to the appropriate SBU HSE Lead.

4.1.10 Smoking in company-owned, leased, or rented vehicles is prohibited.

4.1.11 No pets are allowed in company-owned, leased, or rented vehicles.

4.1.12 Failure to comply with this procedure may result in disciplinary action up to and including termination.

**4.2 Driver Qualification and Status**

4.2.1 New hire candidates (including non-APTIM personnel) may be subject to a Motor Vehicle Record background check (MVR), based on the position for which he/she is applying, prior to driving for APTIM business purposes.

4.2.2 The applicable hiring manager, HR Rep, or other APTIM personnel shall complete a Request for Check of Driving Record Form (AMS-710-02-FM-02705) and provide a copy to an MVR Coordinator.

4.2.2.1 MVR Coordinators shall perform the following steps:

4.2.2.2 Generate an MVR.

4.2.2.3 Evaluate results and render a decision based on the Driving Record Point System shown in section 4.2.3.

4.2.2.4 Communicate results back to the MVR requestor.

4.2.3 Drivers shall be evaluated in accordance with the Driving Record Point System shown in the table below.

| Description of Violation | Assigned Point Value |
|---|---|
| Non-Moving: vehicular equipment deficiency, no seatbelt use, failure to secure load. | 1 |
| Moving: speeding (less than 15 miles per hour over limit, disobey traffic control signal, failure to signal, tailgating, use of cell phone while driving. | 2 |
| At-fault accident | 3 |

| | |
|---|---|
| Major citations: speeding (15 mph or more over limit, reckless driving, suspended license for driving violation, speed contest, open alcohol container (Non-Work Related). | 6 |
| Driving under the influence (Non-Work Related), Hit and run (leaving the scene of an accident), Refusal to submit to testing. | 8 |
| Driving under the influence (DWI/DUI) Work Related, Work Related Open Alcohol Container | Ineligible / Termination |

| **Driving Privilege Status Description** | **Past 12 Months** | **Past 24 Months** |
|---|---|---|
| Can drive without restriction. | 0-3 points | 0-5 points |
| Can drive with understanding of probationary status. | 4-6 points | 6-8 points |
| Not eligible for company driving privileges for 12 months. | 7-11 points | 9-15 points |
| Not eligible for company driving privileges. | 12 points or more | 16 points or more |

4.2.4 Pre-Employment Driving Record Point System

4.2.4.1 If a new hire candidate has accumulated three points or less in the last 12 months or five points or less in the last 24 months per date of MVR, they shall be given the privilege to drive motor vehicles on company business without restrictions.

4.2.4.2 If a new hire has accumulated four to six points in the last 12 months or six to eight points in the last 24 months, they shall be placed on probation for a period of 12 months. They shall be afforded the privilege to drive motor vehicles on company business during this probationary period. Any driving infractions (e.g., speeding tickets, at-fault accidents, and any other citations) accumulated during this probationary period shall result in termination of the privilege to drive a motor vehicle on company business.

4.2.4.3 If the new hire candidate has accumulated seven to eleven points in the last 12 months or nine to fifteen points in the last 24 months, they shall not be eligible for company driving privileges. Employment can only be offered with the strict understanding of denial of the privilege to drive motor vehicles on company business. After the first 12 months of employment, the employee can petition the appropriate SBU President and SBU HSE Lead for reconsideration of driving privileges. An MVR will be generated at this time.

4.2.4.4 If a new hire candidate is expected to drive a vehicle to fulfill the responsibilities of his/her role and there has been an accumulation of twelve points or more in the last 12 months or sixteen points or more in the last 24 months, the candidate shall not be hired.

4.2.5 Existing Drivers

4.2.5.1 Requiring drivers to maintain an acceptable driving record is a risk mitigation measure utilized by the company for continued driving privileges. Accordingly, each affected driver's MVR traffic record may be subject to periodic review to ensure compliance with state and federal regulations, as well as company policy.

4.2.5.2 The applicable APTIM Manager/Supervisor or HSE Representative may initiate the MVR process by completing a Request for Check of Driving Record Form (AMS-710-02-FM-02705) and submitting the form to the HSE Representative.

4.2.5.3 Drivers shall provide verbal and written notice to their supervisor of traffic or vehicular citations in accordance with 4.2.6 - 4.2.7.

4.2.6 Work Related Traffic Violations

4.2.6.1 Drivers shall provide verbal and written notice to their supervisor of citations involving company vehicles within 24 hours of the event. This applies to citations occurring during business hours and non-business hours.

4.2.6.2 This verbal notice shall be followed by the driver completing a Notice of Citation Form (AMS-710-02-FM-02704), which shall be forwarded to the respective SBU HSE Lead or designee.

4.2.7 Non-Work Related Traffic Violations

4.2.7.1 It is not necessary for drivers to report non-work related citations to their supervisor as they occur, with the exception of Driving Under the Influence (DWI/DUI).

4.2.7.2 However, drivers have the responsibility to keep track of their non-work related vehicular citations and utilize established evaluation criteria, as described in the table shown in section 4.2.3, to determine if their overall traffic citations exceed acceptable company limits.

4.2.7.3 Additionally, if a driver's overall MVR record (work related or not) exceeds the company's established points system criteria, the driver shall verbally inform their supervisor as soon as practical, but no longer than the following business day after the occurrence.

4.2.7.4 Continued employment may only be extended with the strict understanding of denial/revocation of the privilege to drive company vehicles, or personal vehicles on company business. After the first 12 months following driving privilege revocation, the driver can petition their respective SBU President and SBU HSE Lead for reconsideration of driving privileges.

4.2.8 Drivers assigned a company vehicle are responsible to ensure that other drivers are qualified in accordance with this procedure before operating the vehicle. Failure to do so may result in disciplinary action up to and including termination.

### 4.3 Incident Reporting

4.3.1 Drivers shall report all vehicle citations and incidents while driving a company vehicle or personal vehicle incurred while on company business to their supervisor, or responsible APTIM personnel, as soon as possible, but not later than 24 hours after the occurrence.

4.3.2 Incidents involving company vehicles or personal vehicles being used for business purposes shall be reported in accordance with the Incident Reporting Procedure (AMS-710-05-PR-02300).

### 4.4 Use of Personal Vehicles for Business Purposes

4.4.1 Personal vehicles shall only be used for company business on APTIM sites if approved by the Site Manager or his designee.

4.4.2 Drivers using personal vehicles for Company business, other than on project sites, shall not be reimbursed for any damage sustained by or to their vehicle. The Company also assumes no liability for any incident while operating personal vehicles.

4.4.3 Drivers using personal vehicles on Company business shall maintain liability coverage that meets or exceeds statutory minimum limits. Drivers are recommended to maintain the following limits: $100,000 per person, $300,000 per occurrence, and $25,000 property damage.

### 4.5 Vehicle Inspection & Maintenance

4.5.1 All drivers shall perform a visual 360 degree walk around prior to each use.

4.5.2 All company vehicles shall be inspected, at a minimum, on a weekly basis by using the Vehicle Inspection Form (AMS-710-02-FM-02701). Completed Inspection forms shall be sent to the Equipment Services Group.

4.5.3 Drivers that have been assigned a company vehicle shall ensure that the vehicle is maintained in accordance with manufacturer specifications. The Driver Responsibility sheet in each vehicle outlines the services to be rendered at prescribed mileage intervals.

4.5.4 Drivers using a personal vehicle are responsible to ensure that the vehicle is maintained in accordance with manufacturer specifications and applicable federal, state, and local requirements.

### 4.6 Impaired Driving

4.6.1 Personnel shall not operate a vehicle for company business when mental or physical impairment might interfere with their ability to operate the vehicle in a safe manner.

4.6.2 Personnel shall not operate a vehicle for company business while impaired, intoxicated or under the influence of alcohol or illegal drugs as outlined in the Substance Abuse Program Procedure (AMS-710-01-PR-03600).

4.6.3 Personnel shall not operate a vehicle for company business while under the influence of medication that may interfere with motor vehicle operation.

4.6.4 Personnel shall not operate a vehicle for company business when under conditions of extreme stress, fatigue, or any other physical or mental impairment that may hinder safe vehicle operation.

**4.7 Driver Safety Notification Sticker**

4.7.1 A safety notification bumper sticker shall be applied to all US/Canada based company vehicles in an effort to ensure continued compliance with driving safety regulations.

4.7.2 The notification service shall be managed by a third party fleet safety management company and shall serve as the recipient of all calls that are placed concerning unsafe driving behavior. The Equipment Services Group shall serve as the first point of contact as it pertains to notifications that are received from the third party company who administers the bumper sticker safety call in service.

4.7.3 Upon receiving a report from the third party administrator, the Equipment Services Group shall contact the respective SBU HSE Lead or designee. The SBU HSE Lead or designee shall then contact the affected driver's supervisor concerning the complaint and provide an Employee Counselling Record (AMS-710-05-FM-00201), where applicable. All third party reports should be closed out by the driver's supervisor as instructed on the report.

4.7.4 Upon verification that the report was made in error or the caller statement was verified to be unsubstantiated, the SBU HSE Lead or designee should request the report be removed from the system. Reports can only be removed from the system with final authorization from the SBU HSE Lead or designee.

4.7.5 Deemed the primary/responsible operator of the vehicle, it is the responsibility of the driver to ensure that the sticker remains on the vehicle and is legible at all times. If the vehicle is project or program assigned and there is no designated primary operator, then the Project/Site Manager shall be considered the primary/responsible party.

4.7.6 The primary/responsible party shall contact the Equipment Services Group immediately upon recognizing that the sticker is defaced or removed so a new one can be applied. Failure on the part of the primary operator to ensure that a legible sticker remains on the vehicle shall result in disciplinary action up to and including revocation of vehicle usage or possible termination of employment.

### 4.8 Global Positioning System

4.8.1 Global Positioning System (GPS) speed and location gathering devices may be installed in company vehicles. The company utilizes data generated by these devices to track vehicle use, substantiate reports of unsafe driving, and monitor driving behavior.

4.8.2 Unsafe and unlawful driving behavior (i.e. excessive speeding), reported by GPS devices shall be investigated to evaluate the circumstances. Where applicable, the driver may be subject to disciplinary action up to and including termination of employment per the HSE Disciplinary Action Procedure (AMS-710-05-PR-00200).

4.8.3 Drivers caught disabling, tampering, or refusing to drive Company vehicles equipped with GPS shall be subject to disciplinary action up to and including immediate termination.

### 4.9 Transporting Personnel and Materials

4.9.1 Personnel shall not be used to support or steady loads while a vehicle is in motion.

4.9.2 Truck running boards shall not be ridden by personnel.

4.9.3 Drivers and passengers shall be seated with arms and legs inside the vehicle.

4.9.4 Personnel shall mount and dismount vehicles only when stopped and the gear in park. For manual transmissions, the gear shall be set based on manufacturer's recommendations with the parking brake engaged.

4.9.5 Personnel shall vacate all vehicles that are being loaded by a crane, backhoe, shovel, loader, or other equipment and shall move away from the vehicle during loading.

4.9.6 Loads extending beyond the bed of a truck or wagon shall be flagged and marked appropriately.

4.9.7 If left overnight, loads extending beyond the bed of a truck or wagon shall be flagged and marked appropriately (i.e. cones, reflective tape, etc.).

4.9.8 Drivers are responsible for safe loading, unloading, and securing of cargo.

4.9.9 Load shall not exceed manufacturer's specifications.

4.9.10 Where passengers are permitted to ride in the bed of trucks, the following requirements shall be met:

- Seats shall be firmly attached or passengers shall sit flat on the bed of the truck and shall not lean against the tailgate. Passengers shall keep their arms and legs inside the boundaries of the truck.
- The maximum speed at which the vehicle may travel on site is 10 mph, unless posted signage dictates a lower speed.

- At a minimum, passengers shall wear safety glasses unless the bed of the truck is enclosed.
- The weight of the people and their materials/tools shall not exceed the weight capacity of the vehicle.
- Passengers shall not be transported on the back of flatbed trucks.

4.9.11 Vehicles shall not be left running while unattended.

4.9.12 If a vehicle is parked on an incline or grade, the parking brake shall be engaged and wheels properly chocked.

4.9.13 When repair work or maintenance of any sort is performed on any vehicle, the parking brake shall be engaged.

### 4.10 Safety Features and Supplies

All company vehicles used on site shall be equipped in accordance with state and local laws and regulations. The Company also requires the following equipment:

4.10.1 First-aid Kit (when necessary due to the set-up of the site)

4.10.2 Snow tires and chains where conditions warrant

4.10.3 A minimum 2 1/2 pound ABC-rated fire extinguisher

### 4.11 Training

To help equip employees with the knowledge and skills of defensive driving, the following has been established:

4.11.1 New Hire Training - personnel expected to be driving a company vehicle or driving a personal vehicle on company business shall be required to complete a standard/initial defensive driver training program. This typically will apply to professional employees and certain craft employees, based upon roles and responsibilities.

4.11.2 Refresher Training – APTIM drivers will be required to complete a “refresher” defensive driver training program once every 2 years.

4.11.3 Post-Incident Training – Employees involved in an incident while driving on company business may be required to take post-incident training.

4.11.4 In the event one of APTIM’s clients has an established Driver Qualification program that meets or exceeds the company approved defensive driver training as approved by Corporate HSE, then the employee is only required to complete one training.

4.11.5 Recordkeeping - All training forms and supporting documentation shall be retained in the company’s learning management system.

## 5.0 TERMINOLOGY

Key terms within the context of the procedure. Terminology is to be listed in a table as shown below:

| Term | Definition |
|---|---|
| Authorized Passengers | Authorized passengers in APTIM Company Vehicles are limited to:<br>• Company employees or employees of all subsidiaries<br>• Consultants or subcontractors to the Company when on Company business<br>• Company clients or potential clients, Company vendors, and other on legitimate Company business |
| Company Vehicle | Any motor vehicle that is owned, leased, rented, provided by a Client or otherwise provided by or through Company |
| Company | APTIM and its subsidiaries and affiliates |
| Driver | Individuals who are assigned a company vehicle or drive a company- owned/leased/rented vehicle, or personal vehicle, on Company business. |
| Motor Vehicle | Motor vehicle means motorized over-the-road vehicles to include: any passenger vehicle, cars, trucks used upon the highway for transporting passengers and/or property, as well as driving of company vehicles on site locations. This includes personal vehicles operated on company business. |
| Motor Vehicle Operator (MVO) | Individuals who are assigned a company vehicle or drive a company- owned/leased/rented vehicle, or personal vehicle, on Company business. |
| Motor Vehicle Report (MVR) | Motor Vehicle Report or MVR is a report from a driver's license agency that shows a list of violations and accident history. |
| Project Assigned Employees | Any employee that is assigned to a field operations project position. This designation includes: Project Managers, Site Managers/Supervisors, Foremen, Technicians, Scientists, Geologists, and Project Business Accountants. This does not include employees that are typically assigned to an office but are visiting a site for brief periods of time, such as to provide technical assistance, perform audits, and perform program reviews. |
| Site | Any location, facility, or project where APTIM is performing work. Sites may include, but are not limited to, laboratories, offices, shops, owned facilities, leased facilities, and/or project sites. |

## 6.0 REFERENCES

### 6.1 Required Forms/Checklists

| | |
|---|---|
| AMS-710-02-FM-02701 | Vehicle Inspection Form |
| AMS-710-02-FM-02702 | Motor Vehicle Procedure Acknowledgement Form |
| AMS-710-02-FM-02704 | Notice of Citation |
| AMS-710-02-FM-02705 | Request for Check of Driving Record |

### 6.2 Other Internal References

| | |
|---|---|
| AMS-710-05-PR-02300 | Incident Reporting |
| AMS-710-02-PR-05600 | Cellular Device Use |
| AMS-710-02-PR-03900 | Commercial Motor Vehicle Safety |
| AMS-710-01-PR-03600 | Substance Abuse Program |

### 6.3 Other External References

| |
|---|
| None |

## 7.0 ATTACHMENTS

| Attachment | Attachment Title |
|---|---|
| Attachment 7.1 | Vehicle Inspection Form |
| Attachment 7.2 | Motor Vehicle Procedure Acknowledgement Form |
| Attachment 7.3 | Notice of Citation |
| Attachment 7.4 | Request for Check of Driving Record |
| Attachment 7.5 | Driver Qualification Process Flow |
| Attachment 7.6 | Vehicle Inspection Process Flow |

# ATTACHMENT 7.1
# VEHICLE INSPECTION FORM

# NON-COMMERCIAL MOTOR VEHICLE SAFETY

| Make | | Model | | | |
|---|---|---|---|---|---|
| Unit # | | Inspection Date | | Odometer Reading | |

*The items below are to be inspected on a weekly basis. Report ALL items in need of repair to the mechanics at the time of inspection. Return the completed sheet to the Equipment Superintendent and Safety Department at the end of the week.*

| Inspection | | Notes |
|---|---|---|
| Lubrication | ☐ | |
| Starting System | ☐ | |
| Instruments (speedometer & temperature gauge) | ☐ | |
| Cooling System (Radiator) | ☐ | |
| Air System | ☐ | |
| Glass | ☐ | |
| Mirrors (Rear-view & left outside) | ☐ | |
| Defroster | ☐ | |
| Brakes | ☐ | |
| Steering System | ☐ | |
| Tires | ☐ | |
| Headlights | ☐ | |
| Tail lights | ☐ | |
| Brake lights | ☐ | |
| Horn | ☐ | |
| Windshield Wipers | ☐ | |
| Fire Extinguisher | ☐ | |
| Seat belts | ☐ | |
| Back-up alarm | ☐ | |
| Condition of vehicle body | ☐ | |
| Initials & badge # of inspector | ☐ | |
| Driver Notification Sticker present and legible | ☐ | |
| Other | ☐ | |

To be completed by Mechanic / Equipment Services Group:

| Date Reported | Repairs Made | Date Repaired |
|---|---|---|
| | | |
| | | |

This form must be sent to ESGdocs@aptim.com

| Signature of Mechanic / ESG Representative | |
|---|---|

# ATTACHMENT 7.2
# MOTOR VEHICLE PROCEDURE ACKNOWLEDGEMENT FORM

# NON-COMMERCIAL MOTOR VEHICLE SAFETY

I, the undersigned, acknowledge that I have been provided with the Company's Non-Commercial Motor Vehicle Safety Procedure and/or the Commercial Motor Vehicle Safety Procedure (if a CDL driver). I was afforded an opportunity to ask questions about these procedures, acknowledge that they apply to me, and understand that I may speak with my supervisor about any parts of the policy or procedures that I may not understand. Key elements of APTIM's Motor Safety Policy and Procedures include:

As an APTIM employee, or a Non-APTIM employee operating an APTIM vehicle or personal vehicle on company business, I understand that these driving activities are privileges and not rights of employment. My driving status and possibly my employment are conditioned upon the policy, procedures, and my adherence to them.

I further understand and acknowledge that I am required to follow federal, state, and local laws, including laws relating to licensing and the operation of motor vehicles, as well as the applicable procedures, rules, and regulations of APTIM clients relating to my operation of a motor vehicle. When such procedures, rules, or regulations conflict, I will follow the most conservative and safest practice and promptly speak with my supervisor for clarification.

Printed Name: _____ Date: _____

Employee ID Number (if applicable): _____

Signature: _____

Supervisor Printed Name: _____ Date: _____

Project / Location: _____

Signature: _____

Please send a copy of this form to the designated HR Representative to be kept in the personnel file.

# ATTACHMENT 7.3
# NOTICE OF CITATION FORM

# NON-COMMERCIAL MOTOR VEHICLE SAFETY

This form is to be completed each time an APTIM approved driver is issued a citation while driving a company vehicle or a personal vehicle for business purposes. Once complete, it is to be signed by the driver's supervisor and forwarded to the appropriate Human Resources Representative and the Corporate HSE Fleet Safety Department.

Driver Name _____ Employee No. (If applicable) _____

Nature of Citation _____

Date Citation Received: _____ Time Citation Received: _____

Location of Citation (City, State) _____

Law Enforcement or entity Issuing Citation: _____

Is Citation Being Contested? No Yes Details _____

_____

Court Location and Court Date from Citation: _____

Driver Signature _____ Date _____

Corrective Action Being Taken _____

_____

_____

Supervisor Signature _____ Date _____

**PLEASE PROVIDE A COPY OF THIS FORM TO SBU HSE LEAD AND YOUR HUMAN RESOURCES REPRESENTATIVE.**

CORPORATE HSE USE ONLY

MVR Check ran on Employee ___Y ___N Date: _____

Total Point Count: _____

New Driving Status: _____ Change in Driving Status: ___ Y ___ N

# ATTACHMENT 7.4
# REQUEST FOR CHECK OF DRIVING RECORD

**Fair Credit Reporting Act Disclosure Statement**

In accordance with the provisions of Section 604 (b) (2) (A) of the Fair Credit Reporting Act, 15 U.S.C. 1681 et seq, as amended by the Consumer Credit Reporting Reform Act of 1996 (title II, Subtitle D, Chapter I, of Public Law 104-208, 110 Stat. 3009-426) and other applicable consumer credit legislation, you are being informed that reports verifying your driving record may be obtained for employment purposes. These reports are required by Sections 382.413, 391.23 and 391.25 of Federal Motor Carrier Safety Administration Regulations. You have the right to receive a copy of the reports and have the prescribed allotment of time by law to have any errors corrected and the reports obtained after corrections have been posted.

| Violation | Assigned Point Value |
|---|---|
| Overweight, loss of load, vehicular equipment infraction, etc. | 1 |
| Moving violation: speeding, failure to stop, failure to signal turn, etc. | 2 |
| At-fault accident | 3 |
| Major citation: reckless driving (including speeding 15 or more miles per hour over the limit), tailgating, suspended license, speed contest, improper lane usage, open container, etc. | 6 |
| Driving under the influence or Hit and Run (Leaving the Scene) | 8 |

In the space provided below, please list all violations and accidents (regardless of fault) currently listed on your driving record by the state issuing your driver's license (include all states for which you have held a driver's license during the last two [2] years). Determine the number of points assigned from the table above, and write in column labelled Points. Finally, write the sum total of all points where indicated. If you are unsure if a violation is on your record, write it down.

| Violations | Driver's License Number | State of Issue | Date of Violation (M/Y) | Points as Determined from Above |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| Attach a blank sheet of paper if additional space is needed. *DO NOT WRITE ON THE BACK OF THIS FORM.* | | | | |
| | | | **Total Points** | |

I hereby certify that the information provided is a complete and accurate statement of my driving record for the previous twenty-four (24) months. I authorize the company to obtain a copy of my driving record from the state of issuance of my license(s) prior to my hire, post-accident, annually, and/or as determined necessary to ensure compliance with Federal, state, and local law, and with APTIM policies and/or procedures. Any driving record check that is conducted on me will fall under the Fair Credit Reporting Act as explained above. **I also understand that falsification of data may disqualify me from being hired or result in revocation of my company driving privileges or other disciplinary action as provided by company policies and procedures.**

Signature _____ Date _____ Position/Applied For _____

Driver License No. State of Issue Expiration Date

Do You Have a CDL? ☐ Y ☐ N List all Endorsements on CDL: _____

Printed Name_____ SSN _____ DOB _____ Employee # _____

Current Address _____ City _____ State ____ Zip _____

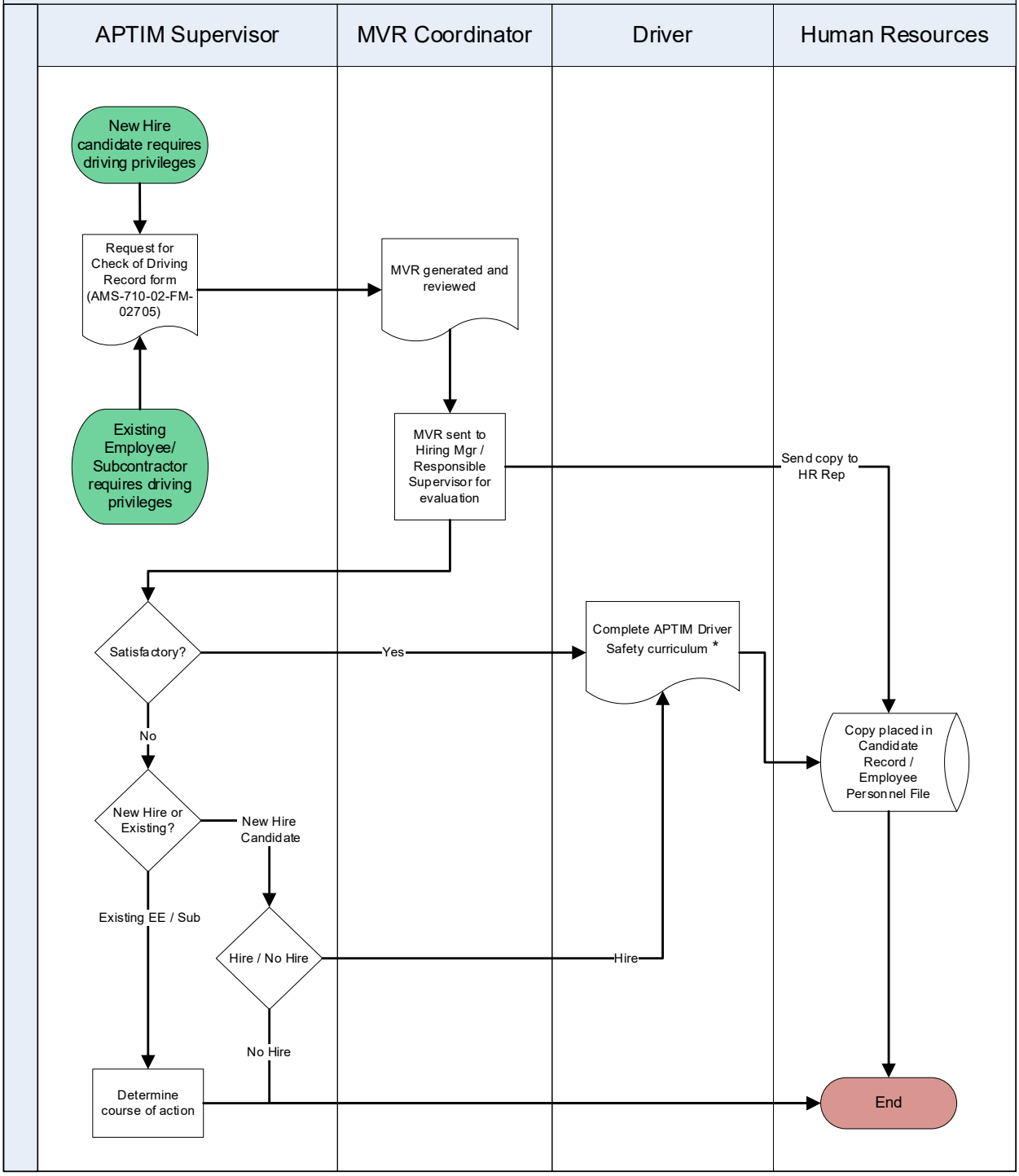
Requesting Authority (printed name) _____ Site / Location _____

*--- Send completed form to your respective MVR Coordinator ---*

# ATTACHMENT 7.5
# DRIVER QUALIFICATION PROCESS FLOW

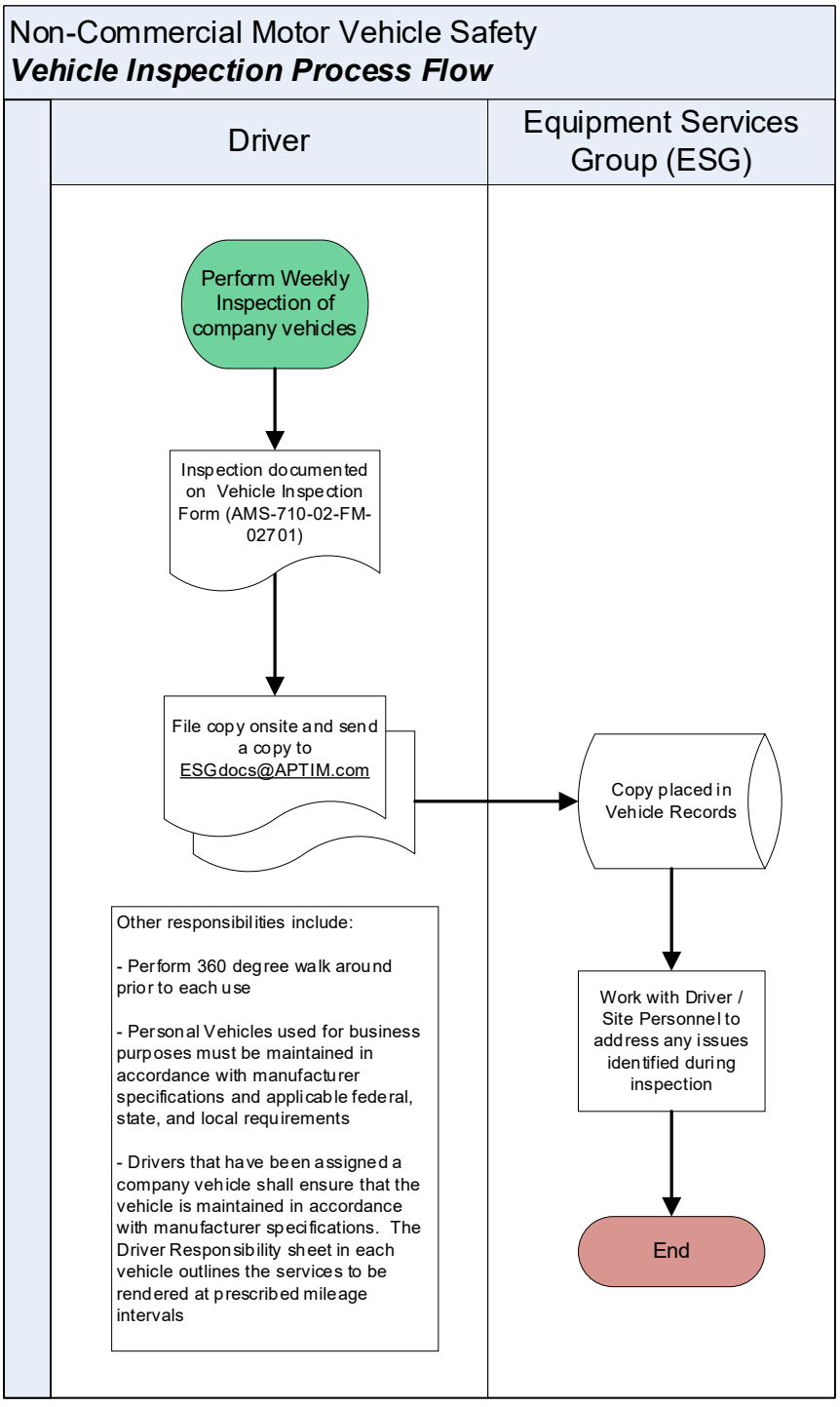
# NON-COMMERCIAL MOTOR VEHICLE SAFETY

Non-Commercial Motor Vehicle Safety
***Driver Qualification Process Flow***



# ATTACHMENT 7.6
# VEHICLE INSPECTION PROCESS FLOW

# NON-COMMERCIAL MOTOR VEHICLE SAFETY



# PROCEDURE

| | | | |
|---|---|---|---|
| **Procedure Title:** | **Mechanized and Marine Equipment** | **AMS Number:** | **AMS-710-02-PR-05700** |
| **Procedure Owner:** | **HSE** | **Issuing Authority:** | **APTIM Quality Management** |

# MECHANIZED AND MARINE EQUIPMENT

| | | | |
|---|---|---|---|
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| | | | |
| | | | |
| INT | Issued for Interim Use | M. Hadacek & S. Lachney | 7/30/2017 |
| **Rev** | **Changes** | **Approved** | **Date** |

## 1.0 PURPOSE

The purpose of this Procedure is to establish the minimum requirements for Mechanized and Marine Equipment used on APTIM sites.

## 2.0 SCOPE

This procedure applies to all APTIM employees, contractors, subcontractors, and visitors associated with a APTIM site.

## 3.0 RESPONSIBILITIES

- APTIM Managers
- APTIM Supervisors
- APTIM Employees
- APTIM Contractors
- APTIM Subcontractors
- APTIM Visitors

## 4.0 PROCEDURE

Each site shall make every attempt to prevent the possibility of incidents to employees or damage to the equipment or facilities when performing work activities with Mechanized and Marine Equipment through compliance with safety regulations, training of employees to properly perform their job activities and through employee involvement in safe work activities.

4.1 Mechanized and Marine Equipment

4.1.1 Mechanized and marine equipment covered by this procedure are those that operate within an off-highway project/facility, not open to public traffic.

4.1.2 These rules apply to the following types of mechanized and marine equipment: scrapers, loaders, crawler or wheel tractors, bulldozers, off-highway trucks, graders, compactors, backhoes, excavators, pile driving, agricultural and industrial tractors, and similar equipment.

4.1.3 The safety requirements, ratios, or limitations applicable to machines or attachment usage covered in Construction Manual 300, shall be complied with, and shall apply to cranes, machines, and attachments.

4.1.4 All mechanized and marine equipment covered by this procedure shall comply with the requirements of AMS-710-02-PR-06600 Working Around Overhead Power Lines when working or being moved in the vicinity of power lines or energized transmitters.

4.2 General Requirements

4.2.1 Do not use equipment that is not in proper operating condition. Attach a “Danger – Do Not Use” tag to inoperable equipment, remove key from equipment, and give key to the supervisor when notifying him/her of the inoperable equipment.

4.2.2 No modifications or additions which affect the capacity or safe operation of the equipment shall be made without the manufacturer's written approval.

4.2.2.1 If such modifications or changes are made, the capacity, operation, and maintenance instruction plates, tags, or decals shall be changed accordingly.

4.2.2.2 In no case shall the original safety factor of the equipment be reduced.

4.2.3 All equipment left unattended at night, adjacent to a highway in normal use, or adjacent to construction areas where work is in progress, shall have appropriate lights or

reflectors, or barricades equipped with appropriate lights or reflectors, to identify the location of the equipment.

4.2.4 A safety tire rack, cage, or equivalent protection shall be provided and used when inflating, mounting, or dismounting tires installed on split rims, or rims equipped with locking rings or similar devices.

4.2.5 Heavy machinery, equipment, or parts thereof, which are suspended or held aloft by use of slings, hoists, or jacks shall be substantially blocked or cribbed to prevent falling or shifting before employees are permitted to work under or between them. Bulldozer and scraper blades, skid steer loader buckets, dump bodies, and similar equipment, shall be either fully lowered or blocked when being repaired or when not in use. All controls shall be in a neutral position, with the motors stopped and brakes set, unless work being performed requires otherwise.

4.2.6 All equipment shall have a service brake system, an emergency brake system, and a parking brake system. These systems may use common components, and shall be maintained in operable condition.

4.2.7 Whenever the equipment is parked, the parking brake shall be set. Equipment parked on inclines shall have the wheels chocked and the parking brake set.

4.2.8 The use, care and charging of all batteries shall conform to the applicable requirements which include the following;

4.2.8.1 Face shields, aprons, and rubber gloves shall be provided for workers handling acids or batteries.

4.2.8.2 Facilities for quick drenching of the eyes and body shall be provided within 25 ft. (7.62 m) of battery handling areas.

4.2.8.3 When batteries are being charged, the vent caps shall be kept in place to avoid electrolyte spray. Vent caps shall be maintained in functioning condition.

4.2.9 Whenever visibility conditions warrant additional light, all equipment/vehicles, or combinations of equipment/vehicles, in use shall be equipped with at least two headlights and two taillights in operable condition.

4.2.10 All equipment/vehicles, or combination of equipment/vehicles, shall have brake lights in operable condition regardless of light conditions.

4.2.11 All equipment with cabs shall be equipped with windshields and powered wipers. Cracked and broken glass shall be replaced.

- All cab glass shall be safety glass, or equivalent, that introduces no visible distortion affecting the safe operation of the equipment.

4.2.12 Equipment operating in areas or under conditions that cause fogging or frosting of the windshields shall be equipped with operable defogging or defrosting devices.

4.2.13 All equipment with enclosed cabs operated in hot weather environments should be outfitted with cooling units, and personnel should be monitored for heat stress.

4.2.14 Equipment/vehicles used to transport employees shall have seats firmly secured and adequate for the number of employees to be transported.

4.2.15 Tools and material shall be secured to prevent movement when transported in the same compartment with employees.

4.2.16 Equipment shall not be loaded beyond its established load limit and the load shall be secured for safe transport

4.2.17 Passengers shall not be allowed on equipment unless seated in a manufacturer's installed seat and with the seat belt fastened.

4.2.18 All equipment/vehicles, whose pay load is loaded by means of cranes, power shovels, skid steer loaders, or similar equipment, shall have a cab shield and/or canopy adequate to protect the operator from shifting or falling materials.

4.2.19 All equipment/vehicles with dump bodies shall be equipped with positive means of support, permanently attached, and capable of being locked in position to prevent accidental lowering of the body while maintenance or inspection work is being done.

4.2.20 Operating levers controlling hoisting or dumping devices on haulage bodies shall be equipped with a latch or other device which will prevent accidental starting or tripping of the mechanism.

4.2.21 Trip handles for tailgates of dump trucks shall be so arranged that, in dumping, the operator will be in the clear.

4.2.22 Pneumatic-tired earth-moving equipment (trucks, scrapers, tractors, and trailing units) whose maximum speed exceeds 15 mph (24 kph), shall be equipped with fenders on all wheels.

- Mud flaps may be used in lieu of fenders whenever motor equipment/vehicle is not designed for fenders.

4.2.23 Scissor points on skid steer loaders and similar equipment, which constitute a hazard to the operator during normal operation, shall be guarded.

4.2.24 Mobile equipment shall be equipped with a fire extinguisher with a minimum rating of 10BC.

4.2.25 Never use buckets, forks, or attachments as a work platform or personnel carrier.

4.2.26 All rubber-tired, self-propelled scrapers, rubber-tired skid steer loaders, rubber-tired dozers, wheel-type agricultural and industrial tractors, crawler tractors, crawler-type skid steer loaders, and motor graders, with or without attachments that are used in construction work shall be equipped with rollover protective structures (ROPS) and seat belts. This requirement does not apply to side boom pipe laying tractors.

4.2.27 When a signal person is used, the equipment shall not be moved unless the designated signal person giving signals is in full view of the operator.

4.2.28 For movement of mobile equipment in congested areas, a designated signal person shall be in full view of the operator and shall direct the movement. In some cases, multiple signal persons may be required.

4.2.29 No one shall be allowed within the boom, bucket, or counterweight swing radius, when it is in operation. Barricades shall be erected to keep workers from entering, as appropriate.

4.2.30 Walk behind compactors (or similar) shall be equipped with a continuous pressure (dead man type) control to stop the equipment if released.

4.2.31 Personnel such as surveyors, who are required to work around heavy earthworking equipment, shall wear a high visibility vest or clothing.

4.2.32 The operator must place marker guides, lighting or other effective signs to indicate to the driver the limit of safe approach to the tipping area when dumping operations are being carried out (whether by day or night).

4.2.33 Drivers of trucks delivering materials to site in multi-stage tippers or side un-loaders must take into account the gradient of the ground on which they are tipping, the nature of the material being discharged and to watch out for "hang up" of material during discharge. If necessary, a spotter must be used to direct discharge via radio communication or hand signals.

4.2.34 When it is necessary (e.g., maintenance/refueling) to approach closer than 20 meters (65 feet) to a heavy vehicle, this shall only be done with the verbal permission of the driver/operator of the heavy vehicle. The following rules shall apply to parking of heavy equipment:

- Only park in designated areas;
- Lower all attachments on equipment fitted with moveable attachments (i.e., forks, buckets, blades, ripper's) when parking;
- If on an incline chock the wheels;
- Turn wheels into the side of the bank or road; and
- Apply the park brake and slew brake where applicable.

4.2.35 Vehicles used for the primary purpose of transporting fuel, explosives, oils etc. shall not haul passengers.

4.2.36 Smoking is not allowed in or within 50' of vehicles transporting fuel, explosives, oils, etc.

4.3 General Requirements for Operators

4.3.1 It is the responsibility of the operator to read and understand the operator's manual and the manufacturers' recommendations for each type and model of equipment to be operated and the requirements of this procedure.

4.3.2 The equipment must be inspected by the operator (designated person) prior to each use. Do not use equipment that is not in proper operating condition or is not within the last monthly inspection period. Attach a "Danger — Do Not Use" tag to inoperable equipment and notify the supervisor. Remove key from the equipment.

4.3.3 When so equipped, check the "operator presence/seat interlock" prior to starting equipment. Do not operate the equipment if the system is not functioning properly.

4.3.4 Operators must know the capacity and operating characteristics of the equipment to be operated.

4.3.5 The equipment must be attended at all times or attachments must be placed in the "transport lock position" or lowered to the ground.

4.3.6 The operator must check the work area for slopes, obstructions, potholes, etc. prior to beginning work. Check for overhead obstructions such as power lines, pipe racks, etc. and ensure proper clearances. See AMS-710-02-PR-06600 Working Around Overhead Power Lines.

4.3.7 When mounting or dismounting equipment, clean shoes and hands before climbing. Always use handrails, grab rails, and steps. Maintain a three-point contact with steps and handholds. Never jump on or off equipment. Never attempt to mount or dismount a moving machine. Do not use steering wheel or control levers as a handhold.

4.3.8 Loads must be carried as low as possible to maintain stability of the equipment and operator visibility.

4.3.9 Operations are to be performed only from the operators control station.

4.3.10 When equipped with "roll over protective structures" (ROPS), the operator must wear seat belt at all times and keep their body (hands, arms, legs, head) inside the protected area.

4.3.11 Never lift loads over people, occupied buildings, or operating equipment.

4.3.12 Use caution when handling objects such as round bales, poles, stumps, cylinders, sheets of plywood, etc. with skid steer loaders. Lifting too high or rolling the bucket too far back could result in objects sliding down the loader arms and falling onto the operator's control station.

4.3.13 Obey posted speed limits. When operating on the project/facility, take it slow and easy. Give right of way to loaded machines and maintain a safe distance from other machines.

4.3.14 Avoid steep slopes or unstable surfaces. When operating on a slope, keep the load low and use extreme caution. Avoid sudden starts, stops, and turns when operating on inclines.

4.3.15 When moving mobile equipment, plan the move by evaluating road or ground conditions, overhead obstacles, traffic and congestion, and work adjacent to the travel path.

4.3.16 When driving on a sloped area, always drive up or down the slope and not across the slope. . Avoid making turns on inclines. If it is necessary, make turns wide and slowly with load carried low. When traveling up or down inclines, do so with loaded buckets facing uphill and empty buckets facing downhill.

4.3.17 When parking, select a place out of the traffic areas. Select a level area whenever possible. When it is necessary to park on an incline, position the machine at right angles to the incline. Secure or lower buckets, blades, and attachments and set the parking brake. Shut down the machine and chock wheels. Cycle the controls to ensure all attachments are secure.

4.3.18 The driver of a haul or dump truck shall not enter or leave the cab while the truck is being loaded.

4.3.19 The driver of a shovel or loader shall not cause the bucket of the shovel or loader to be traversed over the driver's cab of a truck or other motor vehicle during loading operations.

4.4 Transporting or Driving Equipment on Public Highways

4.4.1 When traveling on public roads, lock dual brake pedals together. Make sure all clearance flags, lights, and warning signs are in place and visible. Make sure the “Slow Moving Vehicle” emblem is visible to traffic approaching from the rear. Use escort vehicles, as required.

4.4.2 When loading or unloading equipment, select a level surface. Chock the transport vehicle to prevent movement. Keep trailer bed and ramps free of oils, mud, snow, ice, and debris. On articulated machines, attach the steering frame lock after loading and remove it before unloading. Chain and block the machine securely. Secure all attachments in the transport mode and lower buckets or blades. Cover or remove “Slow Moving Vehicle” emblems before transporting.

4.4.3 Only the equipment operator and personnel trained and qualified to load equipment shall be allowed in the area during equipment loading or unloading.

4.4.4 Unless qualified as an operator of the specific type of equipment to be transported, the truck driver shall not be allowed to drive the equipment onto or off of the trailer.

4.5 General Requirements for Excavations

4.5.1 The location of underground utilities, i.e., electric, gas lines, water lines shall be identified prior to beginning excavation.

4.5.2 Check with the supervisor or the facility owner for permit requirements. If unidentified encumbrances or utilities are struck, stop all work and notify the supervisor.

4.5.3 Precautions must be implemented to keep personnel out of excavations and at least 10 ft. (3 m) away from the equipment and its maximum boom and/or counterweight swing radius when operating. Accessible areas within the swing radius of the equipment are to be barricaded to prevent personnel from being struck or crushed.

4.5.4 Vehicles/equipment shall not approach an excavation while employees are in the excavation.

4.5.5 When excavating, extreme caution should be utilized to avoid hazards caused by cave in, i.e., roll over, tipping, or objects falling from overhead. If equipped with such, use the machine stabilizers. Avoid dangers such as rock or earth slides, when working at the base of excavations, overhangs, or stockpiles. See AMS-710-02-PR-01600 Excavation and Trenching for additional requirements.

4.5.6 The supervisor must confirm that the design, layout, construction and maintenance of any dumping or stockpiling operations take the following into account:

- The nature of the material being dumped;
- The size and weight of the equipment being used;
- The site conditions, including stability of the area on which the dump is built; and
- The weather conditions.

4.5.7 The operator must not dump rock or other material from a haul or dump truck over a bank or into a bin unless there is an effective backstop provided or a person (spotter) suitably stationed to guide and direct the driver to a safe dumping position, via radio communications or hand signals.

4.6 Equipment Specific Precautions

4.6.1 Trencher

4.6.1.1 Prior to operating this equipment, the operator shall receive proper training and study the operator's manual to ensure a comprehensive understanding of the machine operation and controls.

4.6.1.2 When operating a trencher, ensure the equipment is ready for the job it must do.

- Use a digging boom of the right length with a tooth pattern appropriate to soil conditions.
- Keep guards, personnel restraints and trench cleaner in proper adjustment in relation to the digging chain.

4.6.1.3 If the trencher is a riding model, operate the machine only from the operator's seat. The digging chain, auger, or wheel of the trencher can throw rock or debris a considerable distance. Use proper face and eye protection.

4.6.1.4 Never allow anyone in the trench while digging.

4.6.1.5 When beginning a new trench, set the digging boom down carefully with the chain moving slowly. The chain will tend to pull the machine. Be prepared to counteract the pull. Dropping a rapidly moving digging chain to the ground can cause the trencher to move quickly and unexpectedly.

4.6.1.6 Use caution when trenching on hillsides. Avoid the potential for roll over or tipping. Always try to dig with the trencher in a level position. Vibration will tend to make the trencher slip sideways down a slope. Thoroughly evaluate the potential hazards and design the job such that equipment will remain stable throughout the course of the job.

4.6.1.7 Avoid fences, walls, or other obstructions. If the tip of the digging boom makes contact with an obstacle, the machine can climb up and tip backwards onto the operator.

4.6.1.8 During digging, if the machine strikes an unforeseen encumbrance and begins to labor, or jams, shut down the machine and inspect the worksite

and the chain. Never attempt to free a stuck chain while the trencher is running.

4.6.1.9 Stop the engine before attempting to service the chain.

4.6.2 Backhoes and Excavators (Trackhoes)

4.6.2.1 Prior to operating this equipment, the operator shall receive proper training and study the operator's manual to ensure a comprehensive understanding of the machine operation and controls.

4.6.2.2 Never operate the controls from the ground. Always operate from the operators control station.

4.6.2.3 Use stabilizers if equipped. Apply enough pressure to the stabilizers to support and level the machine. Do not elevate the tires off the ground higher that required.

4.6.2.4 Never enter, or allow anyone to enter the backhoe's pivot-point area or the swing radius of the boom. Maintain a clear zone of at least 10 ft. (9 m) beyond the maximum reach of the boom or counterweight.

4.6.2.5 Do not dig under the equipment or stabilizers.

4.6.2.6 When operating on a slope, swing to the uphill side to dump the load, if possible. If downhill dumping is necessary, swing only as far as required to dump the load. Use extreme caution. It equipped, use stabilizers to support the machine.

4.6.2.7 When using the backhoe/excavator bucket for hoisting:

- Consult the manufacturer's manual for lifting capacity.
- Position the machine so that load lowering is done over the front or back of the machine, not the side.
- For backhoes, always use stabilizers, and in soft soil place pads under each stabilizer.
- Ensure that the load is balanced and move slowly to maintain control of the load. Use tag lines when needed.
- Never lift the load higher than necessary to clear obstacles.
- Lower the load as soon as the obstacle is cleared and never hoist loads over people.

4.6.3 Skid Steer Loaders

4.6.3.1 Prior to operating this equipment, the operator shall receive proper training and study the operator's manual to ensure a comprehensive understanding of the machine operation and controls.

4.6.3.2 All skid-steer style loaders with cabs shall be fitted with a manufacturer-approved safety glass front door, front cage cover of equivalent effectiveness.

4.6.3.3 Skid steer loaders can tip quickly due to their short wheelbase and operating characteristics if the operator does not stay within the manufacturer operational limits.

4.6.3.4 Operators must maintain complete control at all times and operate at a speed suitable to site conditions.

4.6.3.5 Operate the skid steer loader from the operator's compartment—never from the outside.

4.6.3.6 Stay seated when operating the skid steer loader controls.

4.6.3.7 The operator must keep hands, arms, legs, and head inside the cab while operating the skid steer loader.

4.6.3.8 Travel and turn with the bucket in the lowest position possible. Come to a complete stop before raising the bucket to dump.

4.6.3.9 When changing direction, look both ways to ensure adequate clearance from personnel and equipment.

4.6.3.10 Use extreme caution when operating in and around excavations to avoid tipping.

4.6.3.11 Always travel up and down slopes with the loaded bucket facing up the hill or the empty bucket facing down the hill.

4.6.3.12 Avoid sudden starts, stops, and turns to prevent tipping or striking other equipment or people.

4.6.3.13 Attachments used with skid steer loaders must be approved by the manufacturer and used in accordance with manufacturer instructions. Equipment capacities must be adjusted to accommodate such attachments.

4.6.3.14 On skid steer loaders where the operator's seat and controls are between the lift arms and in front of the lift arm pivot points, and where the operators must enter and exit from the loader through the front of the machine and over the bucket, operators must use great care to avoid contact of foot or hand controls that may be activated and cause movement of the lift arms, bucket, or other attachment.

4.6.4 Compactors

4.6.4.1 Prior to using compaction equipment, the operator shall receive proper training and study the operator's manual to ensure a comprehensive understanding of the machine operation and controls.

4.6.4.2 Operators are required to wear safety toe shoes and metatarsal guards while operating hand held compaction equipment. Other types of personal protective equipment may be required, e.g., hearing protection, respiratory protection.

4.6.4.3 Caution must be exercised when working in or around excavations to avoid tipping or cave in. When in excavations 4 ft. (1.2 m) deep and greater, sides must be sloped or shored to prevent cave in. Shoring evaluation must consider the additional load, which may be imposed due to the compaction activity.

4.6.4.4 To minimize personnel exposure on steep slopes and exposures to excavation hazards in areas such as washouts or in excavations that are not shored or sloped, a remotely-controlled compactor should be used. Personnel shall stay clear of the equipment when in operation.

4.6.5 Burial Plow Attachment

4.6.5.1 When transporting a burial plow attachment, raise the plow to its fully elevated position and engage the transport lock. For parking, the plow should be either locked in the transport position or lowered to the ground.

4.6.5.2 Know the location of underground utilities and clear the area of all obstructions or bystanders before operating the machine.

4.6.5.3 When plowing on slopes, the machine's stability is increased due to the blade in the ground. Always enter or exit the ground slowly. Rapid entry or exit may cause the machine to tip.

4.6.6 Horizontal Boring Attachment

4.6.6.1 Prior to operating this equipment, the operator shall receive proper training and study the operator's manual to ensure a comprehensive understanding of the machine operation and controls.

4.6.6.2 Do not guide drill rod or pipe with hands, arms, feet, or other bodily contact. Use only guide tools as recommended by the manufacturer.

4.6.6.3 Keep bystanders and unauthorized personnel out of the work area and away from exposed drill rod or pipe.

4.6.6.4 Do not use excessive crowd (pushing) force on drill rod or pipe. Whipping action may result increasing the potential for incidents or injury.

4.6.6.5 Never use fasteners or hardware other than that supplied by the manufacturer to retain drill rod or pipe connectors

4.6.6.6 Do not service drill rod or pipe while engine is running.

4.6.7 Rock Cutting Attachment

4.6.7.1 Prior to operating this equipment, the operator shall receive proper training and study the operator's manual to ensure a comprehensive understanding of the machine operation and controls.

4.6.7.2 Read and understand the danger, caution, and warning signs on the equipment prior to beginning work.

4.6.7.3 Rock cutting may require hearing and/or respiratory protection. Check with your supervisor to determine the proper personal protective equipment.

4.6.7.4 Keep all unauthorized personnel away from the work area.

4.6.8 Industrial/Agricultural Mower

4.6.8.1 Prior to operating this equipment, the operator shall receive proper training and study the operator's manual to ensure a comprehensive understanding of the machine operation and controls.

4.6.8.2 Ensure that chain, flexible, or solid deflector shields are in place on the front and rear of the mower deck and are in good repair. Do not operate with damaged or missing shields.

4.6.8.3 Check for broken, missing, bent, or severely worn blades.

4.6.8.4 Check work area for debris and foreign objects to avoid them being picked up and thrown out by the mower. Inspect for rough terrain, drop-offs, ditches, potholes, steep slopes, stumps, standing water, mud, soft soil, or slippery conditions.

4.6.8.5 Keep unauthorized personnel out of the work area. The mower may throw objects up to 300 ft. (91 m).

4.6.8.6 Do not operate mower in transport position.

4.6.8.7 Avoid excessive ground speed for terrain conditions and sudden starts, stops, or turns.

4.6.8.8 Plan to mow downhill on steep slopes. Avoid over-speed of the power take off.

4.6.8.9 Ensure all required guards are in place.

4.6.8.10 Keep clear of rotating blades, parts, and drivelines.

4.7 Seat Belts

4.7.1 Seat belts shall be provided on all equipment covered by this procedure.

4.7.1.1 Seat belts need not be provided for equipment that is designed only for stand-up operation.

4.7.1.2 Seat belts need not be provided for equipment that does not have rollover protective structure (ROPS) or adequate canopy protection

4.7.2 Tractors shall have seat belts as required for the operators when seated in the normal seating arrangement for tractor operation, even though backhoes, breakers, or other similar attachments are used on these machines for excavating or other work.

4.8 Audible Alarms

4.8.1 All bi-directional equipment shall be equipped with a horn, distinguishable from the surrounding noise level, which shall be operated as needed when the machine is moving in either direction. The horn shall be maintained in an operative condition.

4.8.2 All bi-directional equipment that has an obstructed view to the rear to be used in reverse gear shall be equipped an operational reverse signal alarm distinguishable from the surrounding noise level.

4.9 Access Roads and Grades

4.9.1 No earthmoving and hauling equipment shall move upon any access roadway or grade unless the access roadway or grade is constructed and maintained to accommodate safely the movement of the equipment.

4.9.2 Every emergency access ramp and berm shall be constructed to restrain and control runaway equipment.

4.10 Pile Driving Equipment General Requirements

4.10.1 Boilers and piping systems which are a part of, or used with, pile driving equipment shall meet the applicable requirements of the ASME, Power Boilers (Section I).

4.10.2 All pressure vessels which are a part of, or used with, pile driving equipment shall meet the applicable requirements of the ASME, Pressure Vessels (Section VIII).

4.10.3 Overhead protection, which will not obscure the vision of the operator, shall be provided. Protection shall be the equivalent of 2-inch (50 mm) planking or other solid material of equivalent strength.

4.10.4 Stop blocks shall be provided for the leads to prevent the hammer from being raised against the head block.

4.10.5 Boom stops will be provided to prevent the leads from being pulled past “Top Dead Center” towards the operators cab.

4.10.6 Any work that would require an employee to work down line from an energy source, will fall into the lockout, tagout and try safety procedure.

4.10.7 A blocking device, capable of safely supporting the weight of the hammer, shall be provided for placement in the leads under the hammer at all times while employees are working under the hammer.

4.10.8 Guards shall be provided across the top of the head block to prevent the cable from jumping out of the sheaves.

4.10.9 When the leads must be inclined in the driving of batter piles, provisions shall be made to stabilize the leads.

4.10.10 Fixed leads shall be provided with ladder, and adequate rings, or similar attachment points, so that the loft worker (pile buck) may engage his safety lanyard to the leads. If the leads are provided with loft platforms(s), such platform(s) shall be protected by standard guardrails.

4.10.11 Air and steam hose leading to the hammer or jet pipe shall be securely attached to the hammer with an adequate length of at least 1/4-inch (9 mm) diameter chain or cable to prevent whipping in the event the joint at the hammer is broken. Safety chains, or equivalent means, shall be provided for each hose connection to prevent the line from thrashing around in case the coupling becomes disconnected.

4.10.12 Steam line controls shall consist of two shutoff valves, one of which shall be a quick-acting lever type within easy reach of the hammer operator.

4.10.13 The use of steam as a testing medium for equipment is prohibited without prior approval of the Senior Site Manager / Supervisor and the Site EHS Manager / Supervisor / Representative (or the Construction Business Line Management representative in the absence of the Site EHS Manager / Supervisor / Representative).

4.10.14 Guys, outriggers, thrust-outs, or counterbalances shall be provided as necessary to maintain stability of pile driver rigs.

4.10.15 Vibrations of pile driving rigs may cause loosening of bolts and other connections. Daily inspections at the beginning of the shift, and as necessary thereafter, shall be made to control these hazards.

4.10.16 Piles are usually delivered to the jobsite in railroad flatcars or trailer trucks. Upon arrival at the jobsite, an inspection shall be made of each load. Spacers, binders or dunnage may shift while in transit causing problems such that piles could fall, roll, or slip during unloading. Stanchions shall remain in place until all piles have been removed from the trailer or flatcar. Tag lines will provide proper control during movement of the pile by crane to the storage area. Workers shall not be allowed on top of the load if all stakes and reinforcing wire have been removed. Piling tongs shall not be permitted.

4.11 Pile Driving

4.11.1 Setting up the Pile Driving Rig

4.11.1.1 A coordinated effort is needed by each worker in setting up the pile driving rig. All equipment shall be inspected prior to assembly. The rig shall be assembled on solid ground, firmly supported by heavy timber sills or substantial cribbing. In some cases, heavy mats may be needed due to soil conditions. Steel blocks and wire rope shall be used for hoisting and pulling. All pile driving leads should be assembled separately and erected with power equipment. The crane shall be set level to enable the swing brake to hold and to maintain the boom angle consistent with the boom angle indicator. The jib shall be removed from boom for pile driving operations.

4.11.2 Operation

4.11.2.1 All employees shall be kept clear when piling is being hoisted into the leads.

4.11.2.2 Piles shall be properly placed for handling by the driving rig as close to the hoisting center as possible. Proper spacing with dunnage is necessary for the rig to safely hook onto the next desired pile. Tag lines are essential for the proper placement of the pile by the rig. Workers shall not guide the pile directly by hand until the pile is close to the driving lead.

4.11.2.3 When lifting a pile into the driving leads, all personnel not actually engaged in this operation shall be kept at least 2 pile lengths distance from the area.

4.11.2.4 Dogs on pile-driven hoist drums that automatically disengage either by relieving the load or rotating the drum shall be prohibited.

4.11.2.5 Pulling piles with hammer or pile line rigged through the head block is prohibited, unless driver and rigging are designed to safely withstand the imposed strain.

4.11.2.6 Stirrups shall be provided for worker's use on sheet piles or a mechanical device shall be used to guide the pile into place. If it is required to go aloft on sheet piling, the worker shall use a ladder or aerial lift.

4.11.2.7 There shall be head room at least twice the length of the individual sheet when interlocking sheet piling from the top of a driven sheet pile.

4.11.2.8 When piles are being driven in an excavated pit, the walls of the pit shall be sloped to the angle of repose or sheet-piled and braced. See AMS-710-02-PR-01600 Excavation and Trenching.

4.11.2.9 When steel tube piles are being "blown out", employees shall be kept well beyond the range of falling materials.

4.11.2.10 When it is necessary to cut off the tops of driven piles, pile driving operations shall be suspended except where the cutting operations are located at least twice the length of the longest pile from the driver.

4.11.2.11 When driving jacked piles, all access pits shall be provided with ladders and bulkheaded curbs to prevent material from falling into the pit.

4.11.3 Barges or floats supporting pile driving operations shall meet the applicable requirements for marine operation as outlined in 4.14 of this procedure.

4.11.3.1 All hose connections supplying power or that has material passing through them shall be secured at the connections with 1/4” diameter chain or cable to prevent whipping.

4.11.3.2 Lines supplying power to the hammer or other high pressure equipment shall be equipped with quick-acting, single action shut-off values.

4.11.3.3 Work areas shall be kept clear of obstructions such as extra hose footage, piling cutoffs or materials spoils.

4.11.3.4 A safe work area of 1 1/2 times the height of the leads shall be “Red” barricaded and maintained free of all personnel not directly involved in the pile driving operations.

4.11.4 Inspection and Maintenance

4.11.4.1 All equipment shall be maintained in accordance with established guidelines and/or the manufacture’s guidelines, which ever depicts the most stringent application for achieving optimum safety results.

4.11.4.2 Monthly inspection records shall be maintained. Crane inspection documents will be supplied before any crane operation begins.

4.11.4.3 Provisions shall be installed to allow for a general maintenance of the leads top sheaves to be accomplished from ground level.

4.11.4.4 Equipment will only be operated in a manner as it was designed to do. Alterations shall require site management approval at minimum.

4.11.4.5 Any piece of equipment that will not or does not operate in the manner designed by the manufacture shall be tagged “Defective” and taken out of service until properly repaired.

4.11.5 Pile Driving Equipment Operators

4.11.5.1 Only qualified and designated employees shall operate any piece of equipment.

4.11.5.2 Operators shall operate their assigned equipment only and shall only operate it in a safe and responsible manner.

4.11.6 Pile Driving Equipment Signaling

4.11.6.1 Equipment and winch operators shall accept signals only from the designated signal person. See AMS-710-02-PR-05900 General Crane and Derrick Safety

4.11.6.2 One person shall be the designated signal person.

4.11.6.3 When assigned to signal a piece of equipment, this employee accepts the shared responsibility for the safe operation of that piece of equipment.

4.11.7 Pile Driving Operations on, Over, or Adjacent to Water

4.11.7.1 The width of hulls for floating pile drivers shall not be less than 45% of the height of lead above the water.

4.11.7.2 Pile driver and dredge fairlead sheaves and spudline sheaves shall be guarded to prevent workers or tools from being drawn into them.

4.11.7.3 All walkways over water shall be a minimum of 20-inch wide with standard handrails along both sides on structures and gang planks.

4.11.8 Pile Extraction

4.11.8.1 Extreme stress on equipment can develop during pile extraction especially in water where the current is strong. Normal extraction is done with an extracting hammer designed for this purpose. The vibratory and sonic hammers designed for extraction have proved to be very satisfactory. For pile extraction, the following shall be executed:

4.11.8.2 If piling cannot be pulled without exceeding the load rating of equipment, a pile extractor shall be used.

4.11.8.3 When pulling piling, crane booms shall not be raised in excess of the crane manufacturer's written specifications for such operations and the crane shall not be allowed to tip. Remove jib from boom for extraction operations.

4.11.8.4 Extractor hooks shall be carefully inspected daily for signs of failure.

4.11.8.5 The screwbolt should be locked in the extractor pin with a spring clip or the vibration may loosen the bolt.

4.11.9 Personnel Protective Equipment

4.11.9.1 Guidelines shall be followed per the project Dress code which identifies the personnel protective equipment required.

4.11.9.2 Appropriate gloves shall be worn at all times.

4.11.9.3 Hearing protection areas shall be established and maintained.

4.11.9.4 Employees working where a fall exposure exist, shall be protected by Fall Protection Procedure.

4.11.10 Material Handling

4.11.10.1 The loading, unloading or moving of material shall be done in a safe manner that will not expose personnel to inherent dangers and *as* being under loads or pinch points.

4.11.10.2 All load hooks will have operable safety latches.

4.11.10.3 When possible, loads shall be lifted in a flat and controlled manner.

4.11.10.4 Piling lifted by one end shall be attached in a positive manner to prevent slippage. Examples not all inclusive would be: Place a full wrap on round material and pre-cut a hole in I-beam material to secure the shackle.

4.12 Site Clearing General Requirements

4.12.1 Employees engaged in site clearing shall be protected from hazards of irritant and toxic plants and suitably instructed in the first aid treatment available.

4.12.2 All equipment used in site clearing operations shall be equipped with rollover guards (ROPS). In addition, rider-operated equipment shall be equipped with an overhead and rear canopy guard meeting the following requirements:

4.12.2.1 The overhead covering on this canopy structure shall be of not less than 1/8-inch (3 mm) steel plate or 1/4-inch (9 mm) woven wire mesh with openings no greater than 1 inch (25 mm), or equivalent.

4.12.2.2 The opening in the rear of the canopy structure shall be covered with not less than 1/4-inch woven wire mesh with openings no greater than 1 inch (25 mm).

4.13 Industrial Trucks

4.13.1 Industrial trucks shall meet the requirements of AMS-710-02-PR-00800 Forklifts and Powered Industrial Trucks.

4.14 Marine Material Handling Operations

4.14.1 Access to Barges

4.14.1.1 Ramps for access of equipment/vehicles to or between barges shall be of adequate strength, provided with side boards, well maintained, and properly secured.

4.14.1.2 Unless employees can step safely to or from the wharf, float, barge, or river towboat, either a ramp, meeting the requirements of paragraph 4.15.1.1 of this procedure, or a safe walkway, shall be provided.

4.14.1.3 Jacob's ladders shall be of the double rung or flat tread type. They shall be well maintained and properly secured.

4.14.1.4 A Jacob's ladder shall either hang without slack from its lashings or be pulled up entirely.

4.14.1.5 When the upper end of the means of access rests on or is flush with the top of the bulwark, substantial steps properly secured and equipped with at least one substantial hand rail approximately 33 inches (838 mm) in height, shall be provided between the top of the bulwark and the deck.

4.14.1.6 Obstructions shall not be laid on or across the gangway.

4.14.1.7 The means of access shall be adequately illuminated for its full length.

4.14.1.8 Unless the structure makes it impossible, the means of access shall be so located that the load will not pass over employees.

4.14.2 Working Surfaces of Barges

4.14.2.1 Employees shall not be permitted to walk along the sides of covered lighters or barges with coamings more than 5 ft. (1.5 m) high, unless there is a 3 ft. (1 m) clear walkway, or a grab rail, or a taut handline is provided.

4.14.2.2 Decks and other working surfaces shall be maintained in a safe condition.

4.14.2.3 Employees shall not be permitted to pass fore and aft, over, or around deckloads, unless there is a safe passage.

4.14.2.4 Employees shall not be permitted to walk over deckloads from rail to coaming unless there is a safe passage. If it is necessary to stand at the outboard or inboard edge of the deckload where less than 24 inches (610 mm) of bulwark, rail, coaming, or other protection exists, all employees shall be provided with a suitable means of protection against falling from the deckload.

4.14.3 First-Aid and Lifesaving Equipment.

4.14.3.1 Provisions for rendering first aid and medical assistance shall be provided.

4.14.3.2 The employer shall ensure that there is in the vicinity of each barge in use at least one U.S. Coast Guard-approved 30-inch (762 mm) lifering with not less than 90 feet (28 m) of line attached, and at least one portable or permanent ladder which will reach the top of the apron to the surface of the water. If the above equipment is not available at the pier, the employer shall furnish it during the time that he is working the barge.

4.14.3.3 Employees walking or working on the unguarded decks of barges shall be protected with U.S. Coast Guard-approved work vests or buoyant vests.

4.15 Inspection and Maintenance

4.15.1 Frequent Inspection

4.15.1.1 All equipment shall have as a minimum a Frequent Inspection conducted by a designated person(s) upon its arrival on the project/facility and monthly intervals thereafter.

4.15.1.2 The initial and monthly frequent inspections shall be documented using the Mechanized and Marine Equipment Inspection Form AMS-710-02-FM-05701.

4.15.1.3 A designated person(s) shall inspect each piece of equipment covered by this procedure for defects. All equipment in use shall be visually checked at the beginning of each shift to assure the equipment, and accessories are in safe operating condition and free of apparent damage that could cause failure while in use.

4.15.1.4 All defects shall be corrected before the equipment is placed in service.

4.15.1.5 For rental equipment, it is recommended that

- The rental company be required to conduct the initial inspection, along with a APTIM designated person, upon initial delivery to the site and
- Conduct the monthly inspection of their equipment along with a APTIM designated person.

4.15.2 Preventive Maintenance

4.15.2.1 A preventive maintenance schedule shall be established per manufacturer's requirements.

4.15.2.2 Do not service or repair moving parts on equipment while it is running.

4.15.2.3 Bleed pressure, hot liquid, etc. before performing maintenance or repairs. Lotto (Lock Out, Tag Out, Try Out). See AMS-710-02-PR-01500 Control of Hazardous Energy.

4.15.2.4 Properly block equipment or loads before repairing or maintaining equipment.

4.15.2.5 Preventive maintenance records. See 4.17 of this procedure.

4.15.3 General Requirements for Fueling and Maintenance

4.15.3.1 Refueling and/or battery charging shall be done in well-ventilated and designated areas.

4.15.3.2 Shut down equipment before refueling. Sufficient time should be allowed for the engine to cool before refueling.

4.15.3.3 Use approved fuel hose with embedded grounding and approved connections. If not available, attach a static ground from equipment to fuel transfer equipment to avoid fuel ignition due to static discharge.

4.15.3.4 Always ensure the availability of safety shower or eyewash facilities near fueling areas. Fire protection equipment must be readily available.

4.15.3.5 Starting aids, such as jumper cables or ether, may only be used with extreme caution and according to manufacturer's instructions. Always connect the ground cable last. The ground cable should be attached to the engine at a point away from the battery.

4.15.3.6 Only trained and authorized personnel are permitted to perform equipment maintenance. This includes inflating or changing tires and "jump starting." Control of the sudden release of hazardous energy must be implemented during service or maintenance.

4.15.3.7 Equipment towing should be avoided. If it is necessary, use a rigid tow bar and consult the manufacturer's requirements.

4.16 Document Retention

4.16.1 Inspection documents shall be kept in the Project/Facility HSE Mgr. file.

4.16.2 The qualification and training records shall be kept in the Project/Facility HSE Mgr. file readily available for review.

4.16.3 Preventive maintenance records shall be completed and retained in the project/facility maintenance files.

4.17 Equipment Operator Qualification Procedure

4.17.1 The project/facility manager or his designated Competent Person shall:

- Prior to skills testing, train the operators using the manufacturer's manual for the equipment on which they are to be qualified.
- Evaluate the skills of each prospective operator to ensure that they have the physical abilities and knowledge to safely operate the equipment they are being qualified on.
- After fulfilling these requirements, complete the Mechanized and Marine Operators Qualification Form AMS-710-02-FM-05702.
- Issue each operator a AMS-710-02-FM-02803 Type C Wallet Card.

4.17.2 Operators of dump trucks, tractor/trailer trucks, buses, and any equipment that can be driven on a public roadway must also be licensed by the government/state to operate the vehicles on public roads or property.

4.17.3 Operators of mobile equipment covered in this procedure with the exception of crane operators and drivers of equipment driven on public roadways shall complete a Medical Questionnaire AMS-710-02-FM-05202 prior to being assigned work requiring the use of such equipment.

- The completed form shall be reviewed by the project/facility manager and the project/facility HSE manager.
- Occupational Health Services or a medical doctor shall resolve any concerns that might affect the ability of the prospective operator to safely operate the equipment.

## 5.0 REFERENCES

| | |
|---|---|
| AMS-710-02-PR-00800 | Forklifts and Powered Industrial Trucks |
| AMS-710-02-PR-01400 | Electrical Safety |
| AMS-710-02-PR-01500 | Control of Hazardous Energy |
| AMS-710-02-PR-01600 | Excavation and Trenching |
| AMS-710-02-FM-02803 | Type C Wallet Card |
| AMS-710-02-FM-05202 | Medical Questionnaire |
| AMS-710-02-PR-05900 | General Crane and Derrick Safety |
| AMS-720-01-FM-00020 | Business Glossary |
| AMS-720-01-FM-00021 | Technical Glossary |
| Construction Manual 300 | Mobile Crane Safety |

## 6.0 TERMINOLOGY

| ***Term*** | ***Definition*** |
|---|---|
| ASME | American Society of Mechanical Engineers |
| Backhoe | A tractor mounted attachment for digging trenches and excavations. |
| Bulldozer | A track mounted machine with a front mounted blade designed for moving materials by pushing it from one place to another. |
| Coaming | A raised edge around a hatch or opening in a deck of a ship or roof to prevent water from running down below. |
| Designated Person | A person selected or assigned by the employer or employer's representative as being competent to perform specific duties. |
| Dump Trucks | A vehicle with a tilting body to facilitate unloading itself. |
| Frequent Inspection | Daily or monthly intervals, by a designated person. |
| Loft Worker | A craft employee sometime referred to as a "pile buck" that assists with the placement and alignment of piles. |
| Skid Steer Loader | A machine with a bucket attachment designed for loading loose materials for transport. |
| ROPS | Roll Over Protective Structures mounted on equipment to protect the operator. |
| Scraper | Vehicles designed for removing soil by simultaneously scraping, loading, and transporting excavated materials. |
| Site | Any location, facility or project where APTIM is performing work. Sites may include, but are not limited to, laboratories, offices, shops, owned facilities, leased facilities and/or project sites. |
| Excavator | A track-mounted backhoe with a revolving superstructure. |
| Tractor/Trailer Dump Bed | A trailer type vehicle, which has a tilting body to facilitate unloading itself and which is moved by an independent tractor or truck. |

## 7.0 EXHIBITS

| | |
|---|---|
| Exhibit 7.1 | AMS-710-02-FM-05701 – Mechanized and Marine Equipment Inspection Form |
| Exhibit 7.2 | AMS-710-02-FM-05702 – Mechanized and Marine Equipment Operators Qualification Form |
| Exhibit 7.3 | AMS-720-01-FM-00020 – Business Glossary |
| Exhibit 7.4 | AMS-720-01-FM-00021 – Technical Glossary |

## 8.0 ATTACHMENTS

None

# PROCEDURE

| | | | |
|---|---|---|---|
| **Procedure Title:** | **Commercial Motor Vehicle Safety** | **AMS Number:** | **AMS-710-02-PR-03900** |
| **Procedure Owner:** | **HSE** | **Issuing Authority:** | **APTIM Quality Management** |

# COMMERCIAL MOTOR VEHICLE SAFETY

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| INT | Issued for Interim Use | M. Hadacek & S. Lachney | 7/30/2017 |
| **Rev** | **Changes** | **Approved** | **Date** |

## 1.0 PURPOSE

This procedure covers the minimum requirements for operation and maintenance of commercial motor vehicles. This procedure establishes the minimum standards for compliance of regulated carriers within APTIM..

## 2.0 SCOPE

This procedure applies to all APTIM operators of Commercial Motor Vehicles (CMV). This procedure does not supersede any Federal, State, or Local laws.

## 3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure:

- APTIM Human Resources
- APTIM Risk Management
- APTIM Managers
- APTIM Supervisors
- APTIM Employees

## 4.0 PROCEDURE

4.1 Sites wishing to establish one or more commercial drivers shall contact the applicable Transportation Administrator within their Operating Group for enrollment in the random drug testing pool and validation of compliance procedures.

4.2 All questions related to Drug and Alcohol testing will be referred to the Corporate HSE and the Substance Abuse Program procedure (AMS-710-01-PR-03600).

4.3 All Commercial Motor Vehicle Operators shall adhere to requirements listed in Non-Commercial Motor Vehicle Safety procedure (AMS-710-02-PR-02700).

4.4 Required Manuals (only applies to U.S.A. locations)

4.4.1 All U.S. sites operating CMVs shall maintain a current copy of the Federal Motor Carrier Safety Regulations (FMCSR) and the Hazardous Materials Regulations (HMR).

4.4.2 All U.S. regulated drivers will receive the latest version of the FMCSR pocketbook at time of hire. The driver will sign and return an acknowledgement statement showing receipt. This receipt is maintained in the Driver Qualification (DQ) file.

4.5 Training Requirements

4.5.1 Training requirements for all drivers include the following minimum courses:

4.5.1.1 Defensive Driver Training (DDT)

4.5.1.2 Entry Level Driver Training (when applicable)

4.5.1.3 Hazardous Materials Training (when applicable) at least every three years which may include:

- Cargo Tank Training
- Asbestos Training
- Materials of Trade Training
- Basic Hazmat Shipper Training (includes General Awareness, Function-Specific, Safety, Security Awareness, Emergency Response, and HazMat Incident Reporting Training)
- Compressed Gas Cylinder Training
- Written Security Plan Training

4.5.1.4 Corporate HSE Designated Training (conducted by either Operating Group, Business Line, or Corporate) required of all CMV drivers at hire and annually will include:

- Log Books/Pre and Post Trip Inspections (U.S.A. only)
- Load Securement
- Hours of Service (U.S.A. only)
- Drug and alcohol awareness
- CSA 2010 training (U.S.A. only)
- Other training directed by the Operating Group, Business Unit, or Training Department

4.5.1.5 Supervisors of regulated vehicles and drivers will also receive:

- Reasonable Suspicion Training
- Required Maintenance Awareness
- Dispatcher Training
- Required Documentation for Drivers

4.5.1.6 Drivers with less than 1 year experience will undergo Corporate HSE Designated Entry Level Driver Training.

4.5.1.7 Refresher training is required for all CMV drivers at least once per year.

4.6 Compliance

Each site shall monitor overall compliance as required by this procedure.

4.7 Auditing

One targeted in-house transportation compliance audit will be conducted on each Business Unit per year by the Fleet Safety Manager or designee.

4.8 Minimum Requirements

A person is qualified to operate a CMV if he or she is:

4.8.1 At least 21 years old;

4.8.2 Can read and speak the English language sufficiently to converse with the general public, to understand highway traffic signs and signals in the English language, to respond to official inquiries, and make entries on reports and records;

4.8.3 Can by reason of experience, training, or both, safely operate the type of motor vehicle he or she drives;

4.8.4 Is physically qualified to drive a CMV in accordance with applicable federal regulations.

4.8.5 Can by reason of experience, training, or both, determine whether the cargo to be transported has been properly located, distributed, and secured in or on the motor vehicle;

4.8.6 Is familiar with methods and procedures for securing cargo in or on the motor vehicle; and

4.8.7 Has a complete and current Driver Qualification File in the possession of the appropriate Transportation Administrator.

4.9 Financial Responsibility for Motor Carriers

CMV drivers shall meet financial responsibility requirements dictated in AMS-710-02-WI-03092 (Financial Responsibility for Motor Carriers). .

4.10 Notification and reporting of accidents

Motor Vehicle Accident notifications and reporting shall be conducted in accordance with AMS-710-02-WI-03903 (Notification and Reporting Motor Vehicle Accidents).

4.11 Qualifications of Drivers

CMV drivers shall meet the qualification requirements detailed in AMS-710-02-WI-03904 (Qualification of Commercial Motor Vehicle Drivers).

4.12 Driving of Commercial Motor Vehicles

Authorized passengers are limited to employees of APTIM and those subcontractor, client, or regulatory personnel who are integral to a task being performed.

4.13 Driving Practices

4.13.1 The operator of the vehicle will wear a seat belt and is responsible for ensuring that all passengers in the vehicle wear applicable restraints.

4.13.2 Cell phone use shall be in accordance with AMS-710-02-PR-05600 (Cellular Device Use).

4.13.3 In accordance with Federal, State, Local, and company regulations, a radar detector shall not be used in a CMV.

4.13.4 All applicable rules and regulations outlined in the Non-Commercial Motor Vehicle Safety procedure (AMS-710-02-PR-02700) will also apply.

4.13.5 Negative Transportation Reports/Roadside Inspections/CMV Driver Violations

4.13.5.1 Transportation reports that are generated as a result of a scale-side, road-side, or other inspection will be handled in a manner consistent with the negative public (Driver Check) report, as defined in AMS-710-02-PR-02700 (Non-Commercial Motor Vehicle Safety).

4.13.5.2 All roadside inspections and citations will be reported to the driver's manager and the appropriate Transportation Administrator within 72 hours of the inspection. This includes any inspection regardless if no violations were found or if said inspection included violations.

4.13.5.3 Any violation during a roadside inspection or accident will stay on the driver's CMV record for a period of 24 months. Any driver receiving points will be subject to the following:

- Can drive without restriction. Past 24 months point total 0-20 points. Verbal counselling and violation training reviewed.
- Can drive with understanding of probationary status. Past 24 months point total 21-39 points. Driver receives Written Warning and will operate under Probationary Status.
- Company driving privileges revoked for 12 months. Past 24 months point total 40 or more. Driver revocation for 12 months.
- Points incurred by a driver that is reasonably beyond their control (i.e., mismatched brake chambers) will be reviewed by a committee and if found to be reasonably beyond the driver's control, may be removed from the driver's score.

4.13.5.4 Repeat offenses within 12 months will be reviewed by committee and subject to receive written warning, placed on probationary status, and subject to disciplinary action.

4.13.5.5 A driver's manager or site manager will also be held responsible and subject to disciplinary actions for any violation or citation resulting from improper or unauthorized operations of a CMV if said driver was directed to operate the CMV by their manager without proper qualifications and / or

training. Disciplinary actions up to and including termination shall be based on severity of violation for the manager.

4.14 Inspection, Repair, and Maintenance

4.14.1 Applicability

All CMVs shall be included in a scheduled preventive maintenance program. Service intervals shall be in terms of miles or hours of operation. Service intervals and service requirements shall be, at a minimum, per the manufacturer's recommendations with manufacturer recommendations documented in the Vehicle Maintenance File with the appropriate maintenance department.

4.14.2 Manufacturer Recommended Service

Whenever manufacturer service recommendations either fail to cover company's utilization of the equipment or are unavailable, preventative maintenance shall be done in accordance with AMS-855-01-WI-00400 (Repair and Maintenance for Equipment Services Fleet).

4.14.3 Pre Trip

4.14.3.1 All drivers shall conduct a pre-trip inspection (including tow bars, aerial devices, and saddle mounts as applicable) before operating a CMV and a documented post-trip inspection at the end of each shift. No CMV shall be operated unless the following parts and accessories are in good working order:

- Service brakes (including trailer brake connections)
- Parking brake
- Steering mechanism
- Lighting devices and reflectors
- Tires
- Horn
- Windshield wiper(s)
- Rear-vision mirror(s)
- Coupling devices
- Wheels & Rims
- Emergency Equipment

4.14.3.2 The Driver's Inspection Report Form (AMS-710-02-FM-02701) shall be used. A copy is to be submitted to the Maintenance Supervisor and the original is to remain with the CMV. When repairs are complete, the mechanic is to make the appropriate entry in the Vehicle Maintenance File and sign the original Driver's Inspection Report in the CMV. The on-coming driver shall verify that repairs have been made, sign the Driver's Inspection Report and turn in the final copy. Final (original) copy shall be forwarded to the local Transportation Representative for comparison with Driver's Daily Logs and retention.

4.14.4 Drivers' Vehicle Inspection Report

All Drivers' Vehicle Inspection Report forms shall be forwarded to the local Transportation Representative or other assigned representative and remain on file for three months.

4.14.5 Annual Inspection

All CMVs shall be subject to an annual safety inspection. A copy of this inspection shall be forwarded to the Maintenance Supervisor for inclusion into the CMVs maintenance file. Note that the vehicle shall either carry a copy of the inspection or be marked with a sticker/decal displaying the information.

4.14.6 Limited Inspection

A limited safety inspection is required to be performed in accordance with scheduled preventative maintenance guidelines for the specific CMV and is to be noted in the home terminal Vehicle Maintenance File.

4.14.7 Inspectors

4.14.7.1 Inspectors shall meet the qualification requirements.

4.14.7.2 Have a combination of training or experience totalling at least 1 year

4.14.7.3 Are knowledgeable of and have mastered the methods, procedures, tools, and equipment used when performing vehicle inspections.

4.14.8 Brake Inspectors

Brake inspectors shall meet the qualification which generally includes completion of an approved training program or one year of documented experience. (Use forms provided in DOT Manual.) Any driver making brake adjustments shall also have certification of qualifications on file with the Transportation Administrator and the local shop or maintenance facility performing the maintenance.

4.14.9 Driver Inspections

Where APTIM employees perform inspections and repairs, documentation of qualifications shall be on file with the local Transportation Representative and the local shop or maintenance facility

4.14.10 Outside Vendor Repair

Where an outside vendor is used for inspection and repair, APTIM management shall verify that the vendor understands and will comply with inspector qualification requirements.

4.14.11 Maintenance File

The Maintenance/Inspection Check list (see FMCSR) shall be used to check completeness of Vehicle Maintenance Files.

4.14.12 Out of Service

The current version of the North American Uniform Out-of-Service criteria shall be followed in determining the service status of all CMVs.

4.14.13 Cargo Tankers

All cargo tanks shall have a copy of the manufacturer's data report and required recertification in the maintenance file. Qualifications for recertification vendors shall be on file with the local Transportation Representative

4.14.14 Exemption Vehicles

All exemption vehicles or trailers are required to carry a copy of the exemption on the vehicle.

4.15 Hours of Service of Drivers (only applies to U.S.A. locations)

4.15.1 Hours of Service Applicability

No motor carrier shall permit or require any driver used by it to drive a property-carrying CMV, nor shall any such driver drive a property-carrying CMV:

- More than 11 cumulative hours following 10 consecutive hours off duty; or
- For any period after the end of the 14th hour after coming on duty following 10 consecutive hours off duty, No motor carrier shall permit or require a driver of a property-carrying CMV to drive, nor shall any driver drive a

property-carrying commercial motor vehicle, regardless of the number of motor carriers using the driver's services for any period after-

- Having been on duty 60 hours in any period of 7 consecutive days if the employing motor carrier does not operate CMVs every day of the week; or
- Having been on duty 70 hours in any period of 8 consecutive days if the employing motor carrier operates commercial motor vehicles every day of the week.
- Any period of 7 consecutive days may end with the beginning of any off-duty period of 34 or more consecutive hours; or
- Any period of 8 consecutive days may end with the beginning of any off-duty period of 34 or more consecutive hours.

4.15.2 Utility Service Vehicles

As noted above, Utility Service Vehicles are exempt from the Hours-of-Service, but not any other portion of the regulation outlined by the FMCSR including but not limited to the proper maintenance of the record of duty status.

4.15.3 Log Submissions (only applies to U.S.A. locations)

All required drivers shall record their duty status on the Driver's Daily Log (see DOT Manual), including recap. Logs shall be completely filled out and submitted to home terminal management daily, or no less often than every 13 days for extended trips. Note that a driver's daily log cannot be used as a time card only.

4.15.4 Log Violations (only applies to U.S.A. locations)

Local management shall carefully review all Drivers' Daily Logs. They shall require the driver to correct any errors and take follow-up action (training or progressive discipline) where regulations or company procedures have been violated.

4.15.5 Log Auditing (only applies to U.S.A. locations)

The Driver Management Online Log Checker System or manual verification shall be used by management to review Driver's Daily Logs.

4.15.6 Log Books

All original Drivers' Daily Logs shall be forwarded to the Transportation Administrator or locally appointed representative or supervisor by the thirteenth day following completion of the log and remain there for six months. Copies shall also be retained at the local office for six months.

4.16 Load Securement

4.16.1 Drivers shall not operate a CMV unless the vehicle's cargo is properly distributed and adequately secured

4.16.2 Driver shall ensure the CMV's cargo or any other objects does not obscure the driver's view ahead or to the right or left sides.

4.17 Transportation of Hazardous Materials

4.17.1 Driving and Parking Rules

4.17.1.1 APTIM shall maintain a Certificate of Hazardous Materials Registration for elements registered to transport Hazmat so that certain hazardous materials defined in that section can be transported. APTIM's current U.S. Registration can be obtained by contacting the Corporate HSE Fleet Department. A copy of this Registration or other country equivalent that shows the Certificate number shall be kept in trucks.

4.17.1.2 APTIM shall have a written Security Plan that shall be implemented whenever the hazardous materials defined in that section are being

shipped from a jobsite. Implementation shall include training those hazmat employees to the elements of the security plan.

4.17.1.3 APTIM shall obtain a Hazardous Materials Safety Permit if any of the materials listed in that section are to be transported.

4.17.1.4 If APTIM determines that the fleet will function as a transporter of hazardous waste, APTIM shall comply with requirements for hazardous waste transporters as well as all applicable transportation regulations. These requirements will include obtaining a federal and/or state environmental agency identification number and potentially additional training for drivers.

4.17.2 Additional Driver Requirements

4.17.2.1 A driver of a commercial motor vehicle that will haul a quantity of hazardous materials that requires placarding shall obtain a hazardous materials endorsement.

4.17.2.2 A driver of a commercial motor vehicle that will haul a quantity of hazardous materials that requires placarding shall have a means of contact, such as a cellular telephone, radio, or an electronic tracking or monitoring system.

4.17.3 Pre-, En route, and Post-Shipment Vehicle Requirements

4.17.3.1 Pre-Shipment Requirements: When loading hazardous materials onto a truck, loading personnel shall strictly adhere to the separation/segregation requirements.

4.17.3.2 The driver shall complete a Daily Vehicle Inspection Report (AMS-710-02-FM-02701).

4.17.3.3 The driver shall ensure the following documents are in the truck: Emergency Response Guidebook, Certificate of Hazardous Materials Registration copy or the Registration number, a current vehicle inspection (annual), hazardous materials shipping papers if applicable, current license tags, current liability insurance certificate, Hazardous Materials Safety Permit copy or the Permit number.

4.17.3.4 En route Shipping Requirements: All movement of hazardous materials in commerce will be performed per regulatory requirements.

4.17.3.5 Post-Shipping Requirements: transporters shall keep a copy or electronic image of hazardous materials shipping papers for 375 days.

4.17.4 Carriage by public highway

4.17.4.1 All loads of hazardous materials or hazardous wastes shall be accompanied by shipping papers or hazardous waste manifest, respectively. All documents shall be retained for at least 3 years by site. Shipping documents using any generic descriptions shall also contain the technical name of the hazardous substance in parentheses following the basic description.

4.17.4.2 Shipping documents shall be within the drivers reach and readily visible. When the driver is out of the cab, they shall be in the driver's door pocket or on the driver's seat.

4.17.4.3 All hazardous materials/waste loads shall be marked, labeled, and placarded.

4.17.4.4 All hazardous materials/waste loads shall be reported and segregated.

4.17.4.5 In the event of a spill of reportable quantity, the jurisdictional chemical response hotline should be contacted. In the United States, CHEMTREC should be notified.

4.18 Drug and Alcohol Policy

Employees shall adhere to the requirements detailed in AMS-710-01-PR-03600 (Substance Abuse Program).

4.19 Transportation of Explosives

Transportation of explosives shall be conducted in accordance with AMS-710-02-PR-03900 and AMS-710-02-WI-07012 (Transportation of Explosives).

## 5.0 REFERENCES

| | |
|---|---|
| AMS-710-01-PR-03600 | Substance Abuse Program |
| AMS-710-02-PR-02700 | Non-Commercial Motor Vehicle Safety |
| AMS-855-01-WI-00500 | Commercial Motor Vehicle (CMV) Driver Vehicle Inspection Reports (DVIR) |
| AMS-710-02-PR-05600 | Cellular Device Use |
| AMS-710-02-WI-07012 (Transportation of Explosives). | Transportation of Explosives |
| AMS-710-02-WI-03902 | Financial Responsibility for Motor Carriers |
| AMS-710-02-WI-03903 | Notification and Reporting Motor Vehicle Accidents |
| AMS-710-02-WI-03904 | Qualification of Commercial Motor Vehicle Drivers |
| AMS-855-01-WI-00400 | Repair and Maintenance for Equipment Services Fleet |

## 6.0 TERMINOLOGY

| ***Term*** | **Definition** |
|---|---|
| Commercial Motor Vehicle (CMV) Requiring CDL Drivers | In accordance with Federal Motor Carrier Safety Regulations (FMCSR) 383.91, there are three vehicle groups which require a fully qualified, documented DOT driver holding a Commercial Driver's License. These classes are as follows: Group A, Group B and Group C. |
| Company | APTIM and its majority owned entities, subsidiaries, and affiliates. |
| DOT | United States Department of Transportation |
| Transportation Administrator | The Transportation Administrator for Capital Services is located in Findley, OH. The Transportation Administrator for other DOT sites is the Fleet Safety Manager in The Woodlands, TX. |
| FMCSA | Federal Motor Carrier Safety Administration |
| FMCSR | Federal Motor Carrier Safety Regulations |
| MCS-150 | Document to register and file with the DOT/FMSCA for operations that will perform Interstate/Intrastate commerce in the U.S.A. |
| Commercial Motor Vehicles NOT Requiring CDL Drivers | "Commercial Motor Vehicle means any self-propelled or towed vehicle used on public highways in interstate commerce to transport passengers or property when...the vehicle has a gross weight rating or gross combination weight rating of 10,001 or more pounds." |

## 7.0 EXHIBITS

| | |
|---|---|
| Exhibit 7.1 | AMS-720-01-FM-00020 – Business Glossary |
| Exhibit 7.2 | AMS-720-01-FM-00021 – Technical Glossary |

## 8.0 ATTACHMENTS

None

# PROCEDURE

**Procedure Number:**

**AMS-710-02-PR-01610**

**Revision:**

**0**

**Procedure Owner:**

**HSE**

**Issuing Authority:**

**VP HSE**

**Approval Date:**

**9/3/2019**


# UTILITY CONTACT PREVENTION

| Rev | Changes | Approved | Date |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| 0 | Initial Issue | M, Karr | 9/3/2019 |

**Parent Document:** N/A

# UTILITY CONTACT PREVENTION

## 1.0 PURPOSE

The purpose of this document is to provide the minimum requirements to ensure that all utilities are properly identified, to prevent personal injury, property damage and/or causing negative impact to the surrounding community and environment.

The following deliverables are defined within this procedure:

| Deliverable | Producer | Customer |
|---|---|---|
| Authorization to Drill Permit Form (AMS-710-02-FM-01611) | Competent Person – Utility Contact Prevention | Project Manager<br>HSE<br>Employees<br>External Client |
| Utility Mark-Out Documentation Form (AMS-710-02-FM-01612) | Competent Person – Utility Contact Prevention | Project Manager<br>HSE<br>Employees<br>External Client |
| Intrusive Activities Checklist (AMS-710-02-CK-01613) | Competent Person – Utility Contact Prevention | Project Manager<br>HSE<br>Employees<br>External Client |

## 2.0 SCOPE

This procedure applies to all APTIM sites planning above ground or intrusive activities, where the utility locations and clearances are not positively identified.

Work conducted around overhead power lines with mobile equipment is addressed in AMS-710-02-PR-06600, Equipment Operation Around Overhead Power Lines.

This procedure authorizes implementation of local, or client required procedures, when those procedures are more protective. Applicable local and/or client specific procedures shall be documented in the project-specific Health and Safety Plan (HASP), Work Plan, or Accident Prevention Plan.

### 2.1 Exceptions

Exceptions must be approved per the requirements of AMS-710-05-PR-01300, HSE Request for Variances.

## 3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure:

- APTIM Managers
- APTIM Project Managers

- APTIM Utility Contact Prevention – Competent Person
- APTIM Supervisors
- APTIM Employees
- APTIM Contractors
- APTIM Subcontractors

### 3.1 APTIM Managers

APTIM Managers are to ensure their Project Managers are adhering to these expectations.

### 3.2 APTIM Project Managers

Project Managers have to designate their Competent Persons and ensure they're implementing these expectations.

### 3.3 APTIM Utility Contact Prevention – Competent Person

See detailed responsibilities in section 4.1.1.

### 3.4 APTIM Supervisors, Employees, Contractors and Subcontractors

Supervisors, employees, contractors and subcontractors are required to not proceed or act outside of the expectation.

## 4.0 PROCEDURE

### 4.1 Underground Utility Contact Avoidance during Intrusive Activities

#### 4.1.1 Preliminary Requirements

4.1.1.1 The Project Manager - Designates a Competent Person – Utility Contact Prevention (UCP), to manage the aspects of work associated with the intrusive activities, supervise the employees who have the potential to contact any utilities, and fulfill the requirements of this procedure.

4.1.1.2 The Competent Person - UCP is responsible for the following:

- Determining location-specific regulations and client requirements for the notification, identification, locating, marking, contact prevention, and protection of utilities.
- Ensuring boundaries of intrusive activities have been clearly marked, prior to contacting utility locating services.
- Ensuring National One-call center and/or other utility locating services have been contacted, and formal notification of the pending intrusive activities has been completed.

- Ensuring that utility owners are contacted to mark the location of their facilities in the area of the intrusive activities. They shall obtain and document the utility mark-out confirmation number or ticket number provided by the One Call Center. Generally, this notification for a mark-out request must be made from at least two (2) business days (48 hours) to three (3) business days (72 hours) before beginning intrusive activities.
- Ensuring private utility locating services have been contacted and have completed mark-outs, in areas not covered by a One-call center.
- Ascertaining the requirements for maintaining the open ticket with the One Call Center (or local equivalent), client, and/or property owner after the initial formal notification and taking action required to maintain the open ticket, until intrusive activities are completed.
- Ensure time requirements for allowing utility owners to mark locations are met, and authorizing intrusive activities, after satisfaction that all utilities have been located and marked.
- Ensuring all above ground utilities are marked, flagged, or otherwise protected, in areas where equipment could come into contact with them.
- Photograph all utility markings.
- Ensure markings are protected and preserved as feasible.

4.1.1.3 Due to the sensitivity and costs associated with damage to fiber optic cables, the Competent Person - UCP must ensure and document verbal contact and an agreement with the fiber optic cable owner, for all work within 50 feet of fiber optic cables. Additional protective measures for intrusive activities near fiber optic cables shall be specified in site specific HASP, Site Safety Plan, etc.

4.1.1.4 The Competent Person - UCP must verify that the necessary emergency procedures to be taken if underground utilities become damaged are provided in the HASP, work plan, Job Safety Analysis, or Activity Hazard Analysis. These emergency procedures must be conveyed to employees as specified in Section 4.2.3, Field Crew Training (below).

### 4.1.2 General Requirements

4.1.2.1 A designated Competent Person - UCP shall be onsite at all times when intrusive activities are conducted.

4.1.2.2 Overhead utility locations must be marked where heavy equipment or other equipment has the potential for contacting overhead or adjacent utilities. Where required by law, advanced notification to the utility company may be required for any work where potential exists for incidental contact with utility lines. Daily site inspections are required to determine where activities will take place and to ensure all adjacent above ground utilities are identified, marked, and/or protected, to prevent contact. Provide updated information to employees in daily tailgate meetings.

4.1.2.3 Maintain a minimum of 10 feet from overhead power lines, up to 50 kV. Adjust distances based on voltages over 50 kV by adding 0.4 inches per kV to the minimum 10 foot clearance. 20 feet of separation from lines, is required if voltage is unknown. Spotters are required to ensure safe clearance is maintained.

4.1.2.4 Prior to conducting any intrusive activities, the Competent Person - UCP must verify the Intrusive Activities Checklist (AMS-710-02-CK-01613) and the Utility Mark-out Documentation form (AMS-710-02-FM-01612) have been completed. No intrusive activities work is to be performed until all utility mark-outs are verified and until the facility owner-members have all provided the appropriate positive response.

4.1.2.5 Location specific procedures may not always be conveyed to contractors. The property owner, client, and/or facility operator must be consulted on the issue of underground utilities. All knowledge of past and present utilities must be evaluated prior to conducting work.

4.1.2.6 Only hand digging is permitted within 3 feet of underground high voltage lines, product lines, gas lines, or fiber optic cables. Once the line or cable is exposed, heavy equipment can be used but must remain at least 3 feet from the exposed line or cable.

4.1.2.7 If possible, shoveling/digging should be conducted parallel to the expected utility run.

**4.1.3 Operating Requirements Specific to Excavation Activities**

4.1.3.1 Refer to Section 5.0, Terminology to determine the applicable activities considered to be included as excavation.

4.1.3.2 The requirements of AMS-710-02-PR-01600, Excavation and Trenching must be followed.

4.1.3.3 After all mark outs have been completed, and the excavation locations have been accepted by the Competent Person - UCP prior to mechanical excavation, each utility identified inside the excavation location must be hand dug or vacuum excavated to a verify the utility location. The utility locations must be exposed in enough locations to verify its path of travel. If possible, the excavation location should be moved away from any utilities.

4.1.3.4 All utilities exposed during an excavation will be protected from accidental damage.

4.1.3.5 Utilities which are found to change elevation (shallower or deeper) or direction of run (curve) require UCP approval prior to soil removal/excavation operations.

4.1.3.6 When excavating close to a utility, outside the required 3 foot radius, the excavator should have a spotter to assist and guide the excavation equipment operator.

4.1.3.7 While the excavation is open, underground installations shall be protected, supported, or removed as necessary to safeguard employees.

4.1.3.8 The utility owner should be contacted for guidance on protecting the utility from damage when backfilling excavations. When excavation is complete, as practical, 6 inches of soil may be placed over the utility to shield/protect during backfilling operations

4.1.3.9 Areas of refusal (tree roots, large rocks, concrete structures) which prevent either digging to depth or exposing utilities require UCP approval prior to beginning soil removal operations.

### 4.1.4 Operating Requirements Specific to Drilling Activities

4.1.4.1 Refer to Section 5.0, Terminology to determine the applicable activities considered to be drilling activities.

4.1.4.2 Follow all requirements in Section 4.1.1. & 4.1.2

4.1.4.3 After all mark outs have been completed, prior to drilling, each individual location must be hand dug or vacuum excavated to a minimum of 5 feet below ground surface (bgs).

4.1.4.4 Should the local geology be prone to refusal or should there be any other reason the drilling location cannot be cleared to a minimum of 5 feet bgs by hand digging or vacuum extraction, then the appropriate geophysical techniques should be utilized to verify the drilling location is clear of utilities to 5 feet bgs.

4.1.4.5 At any drilling location that cannot be cleared by hand digging or vacuum extraction, then an Authorization to Drill Permit (AMS-710-02-FM-01611) must be approved by the Director of Operations (or designee, which may be delegated to the business line manager for each area) in addition to the project/program manager/director. The SBU HSE lead may be consulted, but signature is not required.

### 4.1.5 Operating Requirements for Boring & Trenching Activities at Retail Fuel Dispensing Stations

4.1.5.1 Work in and around known retail fuel systems (lines and tanks) may be best performed by a licensed, APTIM approved tank subcontractor.

4.1.5.2 Gauge tank pit observation wells prior to beginning drilling activities.

4.1.5.3 Locate emergency shut off system prior to drilling activities.

4.1.5.4 Look for any visual indications that product lines or utilities have been installed in boring location (cracked concrete, sagging concrete, patched concrete, trench cuts, etc.)

4.1.5.5 Establish “No Drill Zones” if possible. No Drill Zones are areas around UST’s, gas dispensers, lines or the canopy of retail fuel dispensing stations.

4.1.5.6 Boring and trenching activities at retail fuel dispensing systems should be moved to a pea gravel free area of the site when possible.

4.1.5.7 If relocation is not possible, an air knife or vacuum extraction approach will be used for pre-clearance of underground utilities.

4.1.5.8 If pea gravel is encountered, stop work and either move the bore hole location or install with vacuum extraction techniques to a depth of 5 feet, if possible.

4.1.5.9 Standard pre-clearance tools (i.e. hand augurs, post hole diggers, spud bars, etc.) are prohibited when working in and around pea-gravel due to the possibility of damage to fiberglass tanks and lines from tool strikes.

### 4.1.6 Operating Requirements Specific to Sheet Piling Activities

4.1.6.1 Follow Section 4.1.4, Operating Requirements Specific to Drilling Activities.

4.1.6.2 After all mark outs have been completed, prior to installation of piling, each utility identified inside the sheet piling location must be hand dug or vacuum excavated to a verify the utility location. Additional planning may be necessary to change the location of the sheet piling location or the location of the utilities.

## 4.2 Training Requirements

### 4.2.1 Competent Person – Utility Contact Prevention

The Competent Person UCP must have successfully completed APTIM's internal Underground and Overhead Utility Contact Prevention training. It is the Project Manager's responsibility to verify that the Competent Person –UCP has completed training prior to overseeing activities.

### 4.2.2 Competent Person - Excavation Training

The Competent Person - Excavation shall have documented training or documented experience in excavation activities.

### 4.2.3 Field Crew Training

4.2.3.1 Prior to assignment of work, the Competent Person - UCP will provide the above and underground utilities information obtained to affected field crew personnel via the job safety analysis (JSA). Information will include:

- The utilities identified in work areas that may be affected by operations.
- The location and depth of the utilities associated with the affected essential services
- Any conditions on the proposed intrusive activities work and clearance requirements.

4.2.3.2 Prior to assignment of work, the Competent Person - UCP will also provide the following information to affected field crew personnel:

- The requirements of this procedure.

- The required work practices and controls to prevent contacting utilities.
- The emergency procedures necessary if utilities are damaged.
- The roles and responsibilities of each worker within the work crew.

### 4.3 Incident Reporting Requirements

4.3.1 Employees are required to immediately report to their direct supervisor any utility contact incident or near miss incident.

4.3.2 All incidents involving utility contact shall be reported by the Competent Person – UCP and site supervisor as required by AMS-710-05-PR-02200, Incident Reporting.

4.3.3 Any damage caused or discovered to natural gas, liquid petroleum, or any hazardous liquid utilities, underground utilities must be immediately reported by the Competent Person – UCP, to emergency services, to the facility owner, and utility owner.

4.3.4 All other utilities contact, and damages are to be reported to the facility operator and the One Call Center (or local equivalent) by the Competent Person - UCP.

4.3.5 The Competent Person - UCP shall verify that all other local reporting requirements are met, e.g., reporting underground pipeline damages involving excavation in Texas to the Railroad Commission of Texas.

## 5.0 TERMINOLOGY

Key terms within the context of the procedure. Terminology is to be listed in a table as shown below:

| Term | Definition |
|---|---|
| As-Built Drawings | As-built drawings are blueprints that are usually obtained from the facility owner or client. They show original buried utilities and any modifications that have been made. |
| Company | APTIM |
| Competent Person – Utility Contact Prevention | Assigned by the Project Manager: An APTIM employee who is capable of identifying existing and predictable hazards presented by utilities located at an APTIM site that may be, hazardous, or dangerous to employees, could result in property damage, or negatively impact the community or environment. The Competent Person Utility Contact Prevention has successfully completed APTIM's in-house 'Underground/Overhead Utility Contact Prevention' training course, possesses an appropriate educational background, field experience, and has the authority to correct deficiencies or take prompt corrective measures to eliminate them. The required identification and documentation procedure for competent persons is specified in AMS-710-02-PR-04200, Competent/Qualified Person Procedure. |

# UTILITY CONTACT PREVENTION

| | |
|---|---|
| Drilling Activities | Any mechanical or manual penetration of the earth's surface using drilling, boring, auguring, or similar type of equipment. For the purposes of this procedure, drilling activities include the use of direct-push equipment and driving equipment such as hammers, impact hammers, vibratory drivers, or similar types of equipment. |
| Driving Activities | Any mechanical or manual penetration of the earth's surface using driving equipment. Driving activities include the installation of piles, sheet piles, poles, stakes, and fence posts. |
| | |
| Excavation | Any operation in which earth, rock, or other material in or on the ground is moved, removed, or otherwise displaced by means of any tools, power equipment or explosives, and includes, without limitation, grading, trenching, digging, ditching, drilling, augering, boring, tunneling, scraping, cable or pipe plowing, piling, and driving. Any manmade cut, cavity, trench, or depression in an earth surface formed by earth removal. |
| Excavation Activities | Any mechanical or manual penetration of the earth's surface using heavy equipment such as excavators, backhoes, dozers, etc. Excavation activities also include manual use of hand shovels, pick-axes, etc. The use of 3-foot or larger diameter augers is also considered excavation activity. |
| Fiber Optic Cables | Optical communication cables that are buried underground. |
| Intrusive Activities | Any mechanical or manual penetration of the earth's surface, including drilling activities, driving activities, and/or excavation activities using drilling equipment, driving equipment, or excavating equipment. |
| No Drill Zones | No Drill Zones are areas located on retail petroleum sites where drilling is not permitted due to the presence of Underground Storage Tanks's (UST's), gas dispensers, lines or the canopy of retail fuel dispensing stations. |
| One Call Center | 811-One Call, Dig Safe, Miss Dig, etc. dial-in telephone number for requesting the location and mark-out of buried utilities, such as gas lines, electrical lines, telephone/cable lines, sewer lines, and water lines |
| Private Utility Locating Service | A private utility locating service is a firm established to locate underground utilities using specialized locating equipment, such as ground penetrating radar location devices or radio transmitter type utility locating equipment. |
| Site | Any location, facility or project where APTIM is performing work. Sites may include, but are not limited to, laboratories, offices, shops, owned facilities, leased facilities, and/or project sites. |
| Site Survey | Inspection of the site to look for signs of buried utilities that may not be indicated through as-built drawings or through utility locating services. The survey typically involves inspection of overhead electrical services, basements, utility rooms, garages, |

| | |
|---|---|
| | etc., for signs of old electrical conduits or fuel/water/septic lines. |
| Utility | Any active or inactive above ground or subsurface structure that is or was designed to service a public or private facility. These may include, but are not limited, to the following:<br>• Electric power lines<br>• Propane lines<br>• Natural gas lines<br>• Telephone lines<br>• Telephone cables<br>• Fiber optic lines<br>• Fiber optic cables<br>• Water lines<br>• Steam and pneumatic lines<br>• Sewer/sewage lines<br>• Drain lines<br>• Underground storage tanks<br>• Septic tanks<br>• Process or product lines<br>• Reclaimed water lines |
| Vacuum Excavator | Equipment that excavates underground utilities with a combination of alternating water-and-air or air-and air pulsations (e.g., air knife, water knife, etc.) |

## 6.0 REFERENCES

Forms/checklists and other supporting policies, work processes, and procedures, included in the body of the procedure.

### 6.1 Required Forms/Checklists

Forms and checklists that are required for use by the procedure should be listed in Section 6.1.

| | |
|---|---|
| AMS-710-02-FM-01611 | Authorization to Drill Permit Form |
| AMS-710-02-FM-01612 | Utility Mark-Out Documentation Form |
| AMS-710-02-CK-01613 | Intrusive Activities Checklist |

### 6.2 Other Internal References

| | |
|---|---|
| AMS-710-02-PR-04200 | Competent/Qualified Person Procedure |
| AMS-710-02-PR-06600 | Working Around Overhead Power Lines with Mobile Equipment |
| AMS-710-02-PR-01600 | Excavation and Trenching |
| AMS-710-05-PR-01300 | HSE Request for Variances |

| | |
|---|---|
| AMS-710-05-PR-02200 | Incident Reporting |

### 6.3 Other External References

None

## 7.0 ATTACHMENTS

| Attachment | Attachment Title |
|---|---|
| None | |

# PROCEDURE

| | | | |
|---|---|---|---|
| **Procedure Title:** | **Control of Hazardous Energy** | **AMS Number:** | **AMS-710-02-PR-01500** |
| **Procedure Owner:** | **HSE** | **Issuing Authority:** | **APTIM Quality Management** |

# CONTROL OF HAZARDOUS ENERGY

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| INT | Issued for Interim Use | M. Hadacek & S. Lachney | 7/30/2017 |
| **Rev** | **Changes** | **Approved** | **Date** |

## 1.0 PURPOSE

The purpose of this Procedure is to establish the minimum requirements for Control of Hazardous Energy on APTIM sites.

The following deliverables are defined within this procedure:

- Written site specific control of hazardous energy sources (lock-out/tag-out) plan
- Annual inspections of control of hazardous energy procedures and controls
- Control of Hazardous Energy training for affected and authorized employees

## 2.0 SCOPE

This procedure is to be utilized when creating a site specific plan for control of hazardous energy, inspections of procedures and controls, and training of authorized employees.

## 3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure:

- APTIM Managers
- APTIM Supervisors
- APTIM Employees
- APTIM Electrical Superintendent
- APTIM Contractors
- APTIM Subcontractors
- APTIM Visitors

## 4.0 PROCEDURE

Upon commencement of site activities, the Site Manager and Site HSE Manager shall develop a written plan for the control of hazardous energy sources (Lock-out/Tag-out) to prevent the possibility of incidents to employees when performing work activities on or around hazardous energy sources. The plan shall be maintained in the site electronic data management system. This procedure applies to all equipment, vehicles, processes or systems that are powered by Electrical, Mechanical, Hydrostatic, or Pneumatic energy. When APTIM shares a site with client personnel, the APTIM Plan shall compliment the Client program. If APTIM is required to work to the client program, the plan must address the program interfaces and verify the minimum requirements set forth in this Procedure shall be met. Employees shall not be allowed to work on energized systems or equipment without written authorization from the Site Manager and consultation of the HSE Manager.

### 4.1 General

4.1.1 This Procedure specifies methods of controlling hazardous energy sources during construction and maintenance activities involving work on electrical services, facilities, shop equipment, engine-driven equipment, pressurized pipelines, and systems used as service lines for construction. This Procedure also covers activities to be used during start-up phases.

4.1.2 APTIM employees, contractors, subcontractors, and visitors shall adhere to requirements listed in this procedure.

4.1.3 If an energy isolating device is not capable of being locked out, the Tag-out procedure will be used.

4.1.4 If an energy isolation device is capable of being locked out, then the Lock-out procedures shall be used.

4.1.5 Whenever replacement or major repair, renovation or modification of a machine or equipment is performed, and whenever new machines or equipment are installed,

energy isolating devices for such a machine shall be designed to accept a lock-out device.

4.1.6 Affected workers, where Lock-out/Tag-out and/or Blinding/Blanking are performed, shall be made aware of systems that are being worked on in their areas.

4.2 Energy Control Procedures

4.2.1 Procedures shall be developed, documented and utilized for the control of potentially hazardous energy when employees are engaged in activities where Lock-out is required.

4.2.2 The procedures shall clearly outline the scope, purpose, authorization, rules, and techniques to be utilized for the control of hazardous energy, and the means to enforce compliance including but not limited to the following:

- A specific statement of the intended purpose of the procedure.
- Specific procedural steps for the shutting down, isolating, blocking and securing machines or equipment to control hazardous energy.
- Specific procedural steps for the placement, removal and transfer of lockout and tagout devices and the responsibility for them and;
- Specific requirements for testing a machine or equipment to determine and verify the effectiveness of lockout/tagout devices and other energy control measures.

4.3 Protective Materials and Hardware

4.3.1 A standard “DANGER - DO NOT OPERATE” tag (AMS-710-05-FM-01503) and individually keyed locks shall be used by each site.

4.3.2 Tags used shall be dated, signed, a description of the work being performed shown on the tag, and securely attached to the equipment/lock.

4.3.3 Tags shall not be reused, but destroyed immediately upon removal. No alterations to a tag are permitted.

4.3.4 No device shall be operated with a tag or lock attached regardless of circumstances.

4.3.5 No person shall remove another person’s tag or lock unless it is deemed an emergency situation and the requirements of 4.9 are adhered to.

4.3.6 It is the discipline Supervisor’s responsibility to ensure that no work is performed beyond the protection of blinds, blanks, locks, and tags.

4.3.7 Tags required beyond one shift shall be replaced by the oncoming shift. In no case will locks and tags be permitted to remain for more than 30 days without another inspection and redating with signatures.

4.3.8 Each authorized worker performing work on a system is required to affix a lock and tag on the system even though the equipment or system is already locked out. In these situations, a multiple locking device shall be used.

4.3.9 Lockout devices and tagout devices shall be singularly identifiable; shall be only devices used for controlling energy; shall not be used for other purposes; and shall meet the following requirements:

4.3.9.1 Lockout and tagout devices shall be capable of withstanding the environment to which they are exposed for the maximum amount of time the exposure is expected.

4.3.9.2 Tagout devices shall be constructed and printed so that exposure to weather conditions or wet and damp locations will not cause the tag to deteriorate or the message on the tag to become illegible.

4.3.9.3 Lockout and tagout devices shall be standardized within the facility in at least one of the following criteria: color, shape, or size; and additionally, in the case of tagout devices, print and format shall be standardized.

4.3.10 Lockout and tagout devices shall be substantial enough to prevent removal without the use of excessive force or unusual techniques, such as with the use of bolt cutters.

4.3.11 Tagout devices, including their means of attachment, shall be substantial enough to prevent inadvertent or accidental removal. Tagout device attachment means shall be

- non-reusable.
- attachable by hand.
- self-locking.
- non-releasable with a minimum unlocking strength of 50 lbs.

4.3.12 At least equivalent to a one-piece, all-environment nylon cable tie. Lockout devices and tagout devices shall indicate the identity of the employee applying the device.

4.4 Types of Systems Requiring Lock-out/Tag-out and/or Blinding/Blanking

4.4.1 Examples of types of energy sources requiring lock-out/tag-out and/or blinding/blanking are as follows:

4.4.1.1 Electrical systems prior to being connected to a power source and energized will be locked out until they are released for service. Any time repairs or modifications are made to electrical systems, either temporary or permanent, they shall be locked out. Locks/Tags shall be applied to the main disconnect whenever possible.

4.4.1.2 Lines, valves, and similar systems that are being tested pneumatically with gases shall be tagged and/or locked out in accordance with 4.3, to prevent accidental discharge of the pressure within the line. In addition, areas affected by the pneumatic test shall be barricaded against entry and the Site HSE Manager notified before commencement of the test. For safe test distance requirements for personnel see 4.8.2.

4.4.1.3 Sources of energy such as pipelines, valves, and pumps shall be locked, blanked off, and otherwise secured to prevent charging, energizing, or creating any type of hazard to persons working on systems or inside a confined space.

4.4.2 Electrical Operated Systems

4.4.2.1 Whenever work on electrical equipment or services are scheduled, the power source (disconnects, circuit breakers, switches) controlling electrical equipment or systems shall be de-energized.

4.4.2.2 The Electrical Superintendent or their designee shall assure that any power panel(s), distribution panel(s), or equipment controller(s) have been de-energized. Control circuit devices, such as push buttons, selector switches, and interlocks, may not be used as the sole means of de-energizing circuits or equipment.

4.4.2.3 Stored electrical energy which might endanger personnel shall be released. Capacitors shall be discharged and high capacitance elements shall be short-circuited and grounded, if the stored electrical energy might endanger personnel.

4.4.2.4 Completed Danger – Do Not Operate Tag(s) and locks shall be attached to the controlling device by:

- The person responsible for de-energizing the system, and
- The craft supervisor responsible for this operation.

4.4.2.5 Each authorized worker required to work on the de-energized equipment or systems shall ascertain that the craft supervisor's and/or their foreman's completed Danger Tag and lock is attached to the controlling device or devices and place their lock and tag on the device before they begin work.

4.4.2.6 The de-energized equipment or system shall be tested using a voltmeter on the downstream side of the tagged-out controlling device. If the equipment is wired directly to a power panel box and is energized by turning on a push button or butterfly switch on the equipment, the power panel box on the downstream side shall be tested using a voltmeter.

4.4.2.7 The Electrical Superintendent or their designee will establish and maintain a lockout log. (See AMS-710-02-FM-01501).

4.4.2.8 The lockout log shall list craft workers or personnel applying a lock and tag on any power panel, distribution panel, or equipment-controlling device.

4.4.2.9 Each employee shall detail in the lockout log the time of day the lock was applied, the necessity for the lockout, the area or machine where the work is being performed and the approximate length of time that the power panel, distribution panel, or equipment controller will be de-energized.

4.4.2.10 When the work is completed, the employees shall report this information to the Electrical Superintendent before removing their lock. The employees shall log the time the work was completed in the lockout log and the time the lock was removed.

4.4.2.11 The last lock on the lockout device shall not be removed until the Electrical Superintendent inspects the power panel, distribution panel, or the equipment controller that was de-energized.

4.4.2.12 Faceplates, doors, and covers shall be installed and in place before the panels are re-energized.

4.4.2.13 The Electrical Superintendent shall notify craft workers in the area that the power panel, distribution panel, or controller is about to be re-energized. The Electrical Superintendent or his designee may then remove that last lock.

4.4.2.14 The Electrical Superintendent or their designee shall check the re-energized power panel, distribution panel or equipment controller for proper operation.

4.4.2.15 The date and time of day when these panels or equipment controllers were restored to service shall be entered in the lockout log.

4.4.2.16 To lock out electrically powered shop equipment to ensure maximum employee safety, a power disconnect switch shall be installed between the main power supply panel and each piece of electrically driven equipment which is directly connected to the power panel box. (This does not apply to equipment, which is equipped with a plug connection, including welding equipment.) This disconnect switch shall be located close to the equipment and properly identified. Pushbuttons or butterfly controls of equipment shall not be locked out. A short circuit can occur between a locked out pushbutton and relay causing the equipment to be energized with full power. Since some equipment is wired with dual controls and locking out one pushbutton does not render that equipment inoperable, after tag and lockout try start buttons to be certain disconnect is complete.

4.4.3 Construction Equipment or Facilities

4.4.3.1 The Electrical Superintendent, or their designee, shall open the switch, pull fuses and place his lock and tag on the equipment and then shall try the system.

4.4.3.2 Other employees shall place their locks and tags on the lockout device.

4.4.3.3 Employees shall complete lockout log information.

4.4.3.4 Upon completion of the work the employees shall remove their locks and tags. The Electrical Superintendent shall be that last person to remove their locks.

4.4.4 Operating Facilities and Equipment

4.4.4.1 Operating unit electrician shall de-energize the system or equipment and demonstrate accuracy to the Electrical Superintendent or their designee.

4.4.4.2 Electrical Superintendent or their designee shall ascertain that the system is de-energized and place their lock and tag on the lockout device.

4.4.4.3 Other employees working on the system shall place their locks and tags on the device and complete the lockout log.

4.4.4.4 Upon completion of the work, the Electrical Superintendent or their designee is the last construction personnel to remove their lock and tag in the presence of the Operating Unit Electrician.

4.4.4.5 The Operating Unit Electrician then assumes control of the system.

4.4.5 Mechanical Work

4.4.5.1 Whenever work is scheduled on mechanical equipment or pressurized systems, controlling devices such as circuit breakers, switches, valve handles, and other operating mechanisms shall be locked and tagged out to prevent their manipulation or operation.

4.4.5.2 Affected workers required to work on mechanical equipment or pressurized systems shall determine that the craft supervisor's and their foreman's completed Lock/Danger Tag is attached to the controlling device or devices before they begin work.

4.4.5.3 Where controlling devices permit, a lock shall be placed on the device by each employee to ensure that the controlling device is not inadvertently energized.

4.4.5.4 De-energized equipment or systems shall be checked or tested to verify that the equipment is inoperable or that the pressurized system has been drained of its contents on the downstream side. To prevent harmful exposures, pressurized systems shall then be flushed out with water if liquids are involved or with inert gas if compressed gases are involved.

4.4.5.5 Appropriate air tests shall be conducted whenever pressurized systems have previously contained hazardous gases or liquids, especially if welding and burning operations are involved when the system has been shut down. When isolating a pressurized system, slip-blind or blanks are required.

4.4.5.6 All work that may involve pressurized vessels, pipes, or systems shall be done in accordance with 4.3.

4.5 Isolation of Structures and Pipelines

4.5.1 Safety Rule

4.5.1.1 All structures and pipelines, on which hot work is to be performed, shall be physically isolated from sources of contamination, be clean, and gas free.

The only exception to this rule is USA municipal potable water tanks and hot taps approved by Corporate HSE.

- Flange class designation is not the design pressure of the flange.
- Sample for lower flammable limit (LFL) and oxygen on all municipal potable water tanks before entry or any hot or cold work.

4.5.1.2 The isolation, emptying, cleaning, and gas freeing are to be performed by the customer unless special arrangements have been agreed upon beforehand with Business Unit/Operating Group HSE Director. Blanks can be sized for the design pressure of the pipeline when known or the flange class when the design pressure is unknown. All blinds shall be per the current edition of ASME B16.5 or B16.47, matching the mating flange Class (150, 300) and diameter.

4.5.2 Isolation Method

4.5.2.1 The preferred methods of isolation for structures and pipelines are illustrated in AMS-710-02-FM-05302 Isolation of Structures and Pipelines New/Repair Work/Maintenance, Figure 1.0. These methods use a “free air space” between the source of contamination and the structure or pipeline. These methods are applicable for new construction, repairs and maintenance work, but if the pipeline contains an expansion joint, Engineering-Assigned shall approve the method of isolation before the disconnect is made.

4.5.2.2 The isolation methods in AMS-710-02-FM-05302 Figure 2 shall only be used when the methods in Figure 1.0 are not physically possible. To use Figure 2 isolation methods requires:

- Authorization by the local Operation or Construction Manager after site inspection to assure this method of isolation is necessary.

4.5.2.3 Prior to installation of the isolation blank, the blank is examined by a qualified APTIM employee for correctness; identified (steel stencil) such that after installation, it can be confirmed to be installed at the correct location.

- A qualified APTIM employee confirms the blank is installed at the correct location with gaskets on either side and a tag is attached.

4.5.3 Isolation Exception

4.5.3.1 Exceptions to isolation illustrated in AMS-710-02-FM-05302 Figure 1.0 and Figure 2.0 can only be approved by Corporate Risk Analysis. Exceptions will only be considered after a written safety plan is submitted to Corporate HSE.

4.5.3.2 The safety plan must provide adequate HSE Supervision to control potential hazards. A minimum of one full time HSE Supervisor is required. Additional supervisors may be required to insure complete control of safety on large turn arounds, special projects or process facilities. This HSE supervision shall be furnished by APTIM.

4.5.4 Remote Blank/Blind With Vapor Barrier

4.5.4.1 When it is impractical to isolate at the structures, it is permissible through the Isolation Exception 4.5.3 to install an appropriately sized blank/blind at a remote location (i.e., battery limit). A vapor barrier is required at the structure so no product residue or liquid from low-areas in the piping can enter the structure. The vapor barrier can be 3/16 to 1/4 inch (4.76 to 6.35 mm) thick, skillet blind with a 1 inch wide X 6 inches long (25 to 152 mm)

handle. The skillet blind shall have a ¼ inch (6.35 mm) hole in the handle to attach a tag.

4.5.5 Company Policy on cleaning and gas-freeing vessels

4.5.5.1 APTIM personnel are not to assume responsibility for the cleaning and gas-freeing of any structure or pipeline. Exceptions to this rule shall be approved by Corporate HSE.

4.5.6 Blank Thickness

4.5.6.1 Carbon steel blank thickness can be determined based on pipeline design pressure when available, or flange class as follows:

- DESIGN PRESSURE KNOWN – Using Table 1.0, Exhibit 7.1, follow the pipe size vertically down to a pressure equal to or greater than the required design pressure, then horizontally across to the left to determine the required blank thickness i.e., 320 psi design pressure, 18" pipe - blank thickness required is 1-1/8 inches (minimum allowable temperature is 15° F - See Table 3.0, Exhibit 7.1
- FLANGE CLASS KNOWN – Using Table 1.0, Exhibit 7.1, flange class is stamped on the flange i.e., Class 600 flange, 18 inch pipe - blank thickness required is 2-3/8 inches (minimum allowable temperature is 40° F - See Table 3.0, Exhibit 7.1.

4.5.6.2 Test pressure maximum 1-1/2 times design pressure of pipeline

4.5.6.3 Blank thickness/pressure calculated per ASME B31.3 paragraph 304.5.3

4.5.6.4 Allowances, such as corrosion, assumed to be zero

4.5.6.5 Gasket required on both sides of installed blank

4.5.6.6 Sizes larger than 24 inches based on ASME B16.47 Series A

- Maximum temperature A283-C is 200° F
- Maximum temperature A36 is 700° F
- Minimum temperature - See Table 3.0, Exhibit 7.1

4.5.6.7 Stainless steel blank thickness can be determined based on pipeline design pressure when available or flange class as follows:

- DESIGN PRESSURE KNOWN - Using Table 2.0, Exhibit 7.1, follow the pipe size vertically down to a pressure equal to or greater than the required design pressure, then horizontally across to the left to determine the required blank thickness. i.e., 540 psi design pressure, 10 inch pipe - blank thickness required is 7/8 inches
- FLANGE CLASS KNOWN - Using Table 2.0, Exhibit 7.1, flange class is stamped on the flange i.e., Class 600 flange, 10 inch pipe - blank thickness required is 1-1/4 inches

4.5.6.8 Test pressure maximum 1-1/2 times design pressure of pipeline

4.5.6.9 Blank thickness/pressure calculated per ASME B31.3 paragraph 304.5.3

4.5.6.10 Allowances, such as corrosion, assumed to be zero

4.5.6.11 Temperature range is -325° F to 300 F for solution heat treated material

4.5.6.12 Gasket required on both sides of installed blank

4.6 Unauthorized Use of a Danger – Do Not Operate Tag

4.6.1 The standard Danger – Do Not Operate Tag shall be used only for the purpose of identifying a de-energized piece of equipment or system. It is not to be used as a substitute for a defective tag or a Caution Tag.

4.6.2 A Caution Tag is to be used to inform personnel of special precautions or instructions for safe and proper operation of equipment.

4.6.3 Do not use a Caution Tag to warn against operating a system or piece of equipment. Only a Danger – Do Not Operate Tag (AMS-710-02-FM-01503) may be used to prevent the operation of a system or piece of equipment.

4.7 Unauthorized Actions

4.7.1 The unauthorized removal of a Danger Tag from the controlling device of de-energized systems or pieces of equipment shall be grounds for immediate termination of the employee(s) involved.

4.7.2 The unauthorized operation of a controlling device of a de-energized system or piece of equipment that has been tagged out with a Danger Tag shall be grounds for immediate termination of the employee(s) involved.

4.7.3 The unauthorized removal of a blind or blank from a de-energized system or piece of equipment shall be grounds for immediate termination of the employee(s) involved.

4.8 Testing

4.8.1 Functional Testing

4.8.1.1 When the performance of a work activity requires the functional testing of a machine, component, or system, the locks and tags may be temporarily removed in accordance with this procedure, to perform the test. As a result of the testing, if it is determined that the equipment needs further work, the locks and tags shall be positioned back on to the device. If it is not necessary to replace all the locks and tags, then the unnecessary locks and tags shall be returned to the Lockout/Tagout Coordinator. The Site HSE Manager shall initial the Lockout/Tagout Request in the removal block to indicate that these locks and tags have been removed.

- Make sure all danger areas are clear of personnel.
- Verify that the main disconnect switch or circuit breaker cannot be moved to the on position.
- Use a voltmeter or other equipment to check the switch on electrical devices.
- Press all start buttons and other activating controls on the equipment itself.
- Shut off all machine controls when the testing is finished.

4.8.1.2 When multi-worker or multi-craft situations exist, a multi-lockout tag is to be used. These devices allow for multiple locks for protection of all craft involved. Each lock shall be properly tagged.

4.8.2 Safe Test Distances for Personal

4.8.2.1 The following AMS Procedures shall be reviewed for establishing safe personal test distances:

- Hydro-Pneumatic Testing of Field Erected Pressure Vessels - AMS–830-05-PR-46002
- Hydrostatic Testing of Field Erected Pressure Vessels – AMS-830-05-PR-46003
- Pneumatic Testing of Field Erected Pressure Vessels – AMS–830-05-PR-46004
- Safe Working Distance for Hearing Protection during Hydrotest of Piping – AMS–830-06-FM-40003
- Safe Working Distance for Hearing Protection During Pneumatic Testing of Piping – AMS–830-06-FM-40004

4.9 Emergency Removal of Employee's Lockout Lock

4.9.1 Lockout/tagout device removal

4.9.1.1 Each lockout/tagout device shall be removed from each energy-isolating device by the employee who applied the device. When the employee who applied the lockout/tagout device is not available to remove it, the device may be removed only after the following steps have been completed.

- The craft supervisor and general foreman/foreman shall verify that the employee who applied the lockout/tagout device is not at the facility or available to return.
- The craft supervisor and general foreman/foreman shall make a reasonable effort to contact the employee to inform him or her that the lockout/tag-out device shall be removed. The employee shall return to the site, to remove the lock if possible.
- The craft supervisor and the general foreman/foreman shall "walk-down" the entire system to verify it is safe to start the system.
- The craft supervisor and general foreman/foreman shall complete an "Emergency Lockout Device Removal" form (AMS-710-02-FM-01502) and present it to the site superintendent and the Site HSE Manager for approval to remove the lock.

Note: If the Site Superintendent or the Site HSE Manager is absent, the Site Manager assumes their signature authority. If the Site Manager is also absent then the designees that have received signature authority by designation may sign the "Emergency Lock-out Device Removal" form only after contacting the person they are receiving this signature authority from and that person has granted verbal permission to do so.

- The craft supervisor and/or general foreman/foreman shall ensure that the employee whose lock was removed has been notified prior to returning to work on the system.

4.10 Training

4.10.1 Personnel shall receive Lock-Out/Tag-Out Training as required by the OSHA Standard for Control of Hazardous Energy Sources.

4.10.2 Authorized employees shall also be trained to recognize hazardous energy sources, the type and magnitude of the energy available in the workplace, and the methods and means necessary for energy isolation and control.

4.10.3 Each affected employee shall be instructed in the purpose and use of the energy control procedure. workers shall receive Lock-Out/Tag-Out Training to include the following minimum requirements:

4.10.3.1 Retraining of all affected employees shall be conducted and documented when there is a change in:

- Assignments
- Machines
- Equipment
- Processes
- When lock out/tag out inspections reveal a need, or supervision sees a need
- New hazards or changes in the energy control procedure

4.10.4 When tagout systems are used, employees shall also be trained in the following limitations of tags:

4.10.4.1 Tags are essentially warning devices affixed to energy isolating devices, and do not provide the physical restraint on those devices that is provided by a lock.

4.10.4.2 When a tag is attached to an energy isolating means, it is not to be removed without authorization of the authorized person responsible for it, and it is never to be bypassed, ignored, or otherwise defeated.

4.10.4.3 Tags must be legible and understandable by all authorized employees, affected employees, and all other employees whose work operations are or may be in the area, in order to be effective.

4.10.4.4 Tags and their means of attachment must be made of materials which will withstand the environmental conditions encountered in the workplace.

4.10.4.5 Tags may evoke a false sense of security, and their meaning needs to be understood as part of the overall energy control program.

4.10.4.6 Tags must be securely attached to energy isolating devices so that they cannot be inadvertently or accidentally detached during use.

4.10.5 Sites shall maintain a list of the names and job titles of all employees who are authorized to lock out/tag out the specified machine, system or equipment.

4.10.6 A written record shall be maintained of all employees who have been trained in the company or site's lock out/tag out program.

4.11 Periodic Inspections

4.11.1 Periodic inspections of the energy control procedures shall be conducted at least annually.

4.11.1.1 The periodic inspection shall be performed by an authorized employee other than the one utilizing the energy control procedure.

4.11.1.2 The periodic inspection shall be conducted to correct deviations or inadequacies identified.

4.11.1.3 Where lockout is used for energy control, the periodic inspection shall include a review between each authorized and affected employee, of that employee's responsibilities under the energy control procedure.

4.11.1.4 The site shall certify that periodic inspections have been performed. The certification shall identify the machine or equipment on which the energy control procedure was being utilized, the date of the inspection, and the person performing the inspection.

## 5.0 `REFERENCES

| | |
|---|---|
| 29 CFR 1910.147 | Control of Hazardous Energy |
| ASME B16.5 | Pipe Flanges and Flanged Fittings |
| ASME B16.47 | Series A Flanges |

## 6.0 TERMINOLOGY

| ***Term*** | ***Definition*** |
|---|---|
| Affected employee | An employee whose job requires him/her to operate or use a machine or equipment on which servicing or maintenance is being performed under lockout or tagout, or who's job requires him/her |

| | |
|---|---|
| | to work in an area which such servicing or maintenance is being performed. |
| Authorized employee | A person who locks out tags out machines, systems or equipment in order to perform servicing or maintenance on that machine, system or equipment. An affected employee becomes and authorized employee when the employees' duties include performing servicing. |
| Blanking or Blinding | The absolute closure of a pipe, line or duct by the fastening of a solid plate (such as a spectacle blind or skillet blind) that completely covers the bore, that is capable of withstanding the maximum pressure of the pip, line or duct with no leakage beyond the plate. |
| Capable of being locked out | An energy isolating device is capable of being locked out if it has a hasp or other means of attachment to which, or through which, a lock can be affixed, or it has a locking mechanism built into it. Other energy isolating devices are capable of being locked out, if lockout can be achieved without the need to dismantle, rebuild, or replace the energy isolating device or permanently alter its energy control capability. |
| Caution Tag | This tag is used to inform personnel of special precautions or instructions about safe and proper operation of equipment. This tag is not to be used to prevent the machines, systems, or equipment from being operated. |
| Danger – Do Not Operate Tag | This tag is attached to warn others that the machines, systems, and/or equipment has been isolated from its power source (de-energized) and that employees are working on the machines, systems, or equipment. |
| Double Valve and Vent | A valve arrangement in a piping system in which three valves are arranged in conjunction with a vent line. One valve is upstream of the vent, another downstream, on one is on the vent itself. To isolate the downstream system, the vent valve is opened, the other two are closed and all three valves are locked into position. |
| Energy Sources | Any source of energy, i.e., electrical, spring, gravity, hydraulic, pneumatic, and chemical. |
| Qualified Person | A person who by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training, and experience, has successfully demonstrated his/her ability to solve or resolve problems related to the subject matter, the work, or the project. |
| Site | Any location, facility or project where APTIM is performing work. Sites may include, but are not limited to, laboratories, offices, shops, owned facilities, leased facilities and/or project sites. |

## 7.0 EXHIBITS

| | |
|---|---|
| Exhibit 7.1 | Tables |
| Exhibit 7.2 | AMS-710-02-FM-01501 – Lock Out Log |
| Exhibit 7.3 | AMS-710-02-FM-01502 – Emergency Lock Out Device Removal |
| Exhibit 7.4 | AMS-710-02-FM-01503 – Do Not Operate Tag |
| Exhibit 7.5 | AMS-710-02-FM-05302 – Isolation of Structures and Pipelines |

| | |
|---|---|
| | New/Repair Work/Maintenance |
| Exhibit 7.6 | AMS-720-01-FM-00020 – Business Glossary |
| Exhibit 7.7 | AMS-720-01-FM-00021 – Technical Glossary |

## 8.0 ATTACHMENT

None

## TABLE 1.0
## CARBON STEEL BLANKS
## (16.1 ksi stress - ASTM A283-C/A36)

| | | PIPE SIZE | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 1 1/2 | 2 | 3 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 24 | 30 | 36 |
| | | DESIGN PRESSURE (psi) | | | | | | | | | | | | | | | |
| THICKNESS (in) | 1/4 | 3120 | 1480 | 950 | 440 | 270 | 120 | 70 | 50 | 30 | 30 | 20 | 20 | 10 | 10 | 10 | 0 |
| | 3/8 | 7010 | 3320 | 2140 | 990 | 600 | 280 | 160 | 100 | 70 | 60 | 50 | 40 | 30 | 20 | 10 | 10 |
| | 1/2 | 12460 | 5910 | 3810 | 1750 | 1060 | 490 | 290 | 190 | 130 | 110 | 80 | 70 | 50 | 40 | 20 | 20 |
| | 5/8 | | 9230 | 5950 | 2740 | 1660 | 760 | 450 | 290 | 210 | 170 | 130 | 100 | 80 | 60 | 40 | 30 |
| | 3/4 | | | 8560 | 3940 | 2390 | 1100 | 650 | 420 | 300 | 250 | 190 | 150 | 120 | 80 | 50 | 40 |
| | 7/8 | | | | 5370 | 3250 | 1500 | 880 | 570 | 400 | 340 | 260 | 200 | 160 | 110 | 70 | 50 |
| | 1 | | | | 7010 | 4240 | 1960 | 1150 | 740 | 530 | 440 | 340 | 270 | 210 | 150 | 100 | 70 |
| | 1 1/8 | | | | 8870 | 5370 | 2480 | 1460 | 940 | 670 | 550 | 420 | 340 | 270 | 190 | 120 | 80 |
| | 1 1/4 | | | | | 6630 | 3060 | 1800 | 1160 | 830 | 680 | 520 | 410 | 340 | 230 | 150 | 100 |
| | 1 3/8 | | | | | 8020 | 3700 | 2180 | 1400 | 1000 | 830 | 630 | 500 | 410 | 280 | 180 | 130 |
| | 1 1/2 | | | | | 9540 | 4400 | 2600 | 1670 | 1190 | 990 | 750 | 600 | 480 | 340 | 210 | 150 |
| | 1 3/4 | | | | | | 5990 | 3530 | 2280 | 1620 | 1340 | 1030 | 810 | 660 | 460 | 290 | 200 |
| | 2 | | | | | | 7830 | 4620 | 2970 | 2110 | 1750 | 1340 | 1060 | 860 | 600 | 380 | 270 |
| | | BLANK THICKNESS (in) | | | | | | | | | | | | | | | |
| Class 150 | | 1/4 | 1/4 | 1/4 | 1/4 | 3/8 | 3/8 | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 1 1/2 | 1 3/4 | 2 1/8 |
| Class 300 | | 1/4 | 1/4 | 1/4 | 3/8 | 1/2 | 5/8 | 7/8 | 1 | 1 1/4 | 1 3/8 | 1 1/2 | 1 3/4 | 1 7/8 | 2 1/4 | 2 7/8 | 3 3/8 |
| Class 600 | | 1/4 | 1/4 | 3/8 | 1/2 | 5/8 | 7/8 | 1 1/4 | 1 1/2 | 1 5/8 | 1 7/8 | 2 1/8 | 2 3/8 | 2 3/4 | 3 1/4 | 4 | 5 |

## TABLE 2.0
## STAINLESS STEEL BLANKS
## (20 ksi stress - ASTM A240 type 304/316)

| | | PIPE SIZE | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 1 1/2 | 2 | 3 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 24 | 30 | 36 |
| | | DESIGN PRESSURE (psi) | | | | | | | | | | | | | | | |
| THICKNESS (in) | 1/4 | 3870 | 1830 | 1180 | 540 | 330 | 150 | 90 | 60 | 40 | 30 | 30 | 20 | 20 | 10 | 10 | 0 |
| | 3/8 | 8710 | 4130 | 2660 | 1220 | 740 | 340 | 200 | 130 | 90 | 80 | 60 | 50 | 40 | 30 | 20 | 10 |
| | 1/2 | 15480 | 7340 | 4730 | 2180 | 1320 | 610 | 360 | 230 | 160 | 140 | 100 | 80 | 70 | 50 | 30 | 20 |
| | 5/8 | | 11470 | 7390 | 3400 | 2060 | 950 | 560 | 360 | 260 | 210 | 160 | 130 | 100 | 70 | 50 | 30 |
| | 3/4 | | | 10640 | 4900 | 2960 | 1370 | 810 | 520 | 370 | 310 | 230 | 190 | 150 | 100 | 70 | 50 |
| | 7/8 | | | | 6670 | 4030 | 1860 | 1100 | 710 | 500 | 420 | 320 | 250 | 200 | 140 | 90 | 60 |
| | 1 | | | | 8710 | 5270 | 2430 | 1430 | 920 | 660 | 540 | 420 | 330 | 270 | 190 | 120 | 80 |
| | 1 1/8 | | | | 11020 | 6670 | 3080 | 1810 | 1170 | 830 | 690 | 530 | 420 | 340 | 230 | 150 | 100 |
| | 1 1/4 | | | | | 8230 | 3800 | 2240 | 1440 | 1030 | 850 | 650 | 510 | 420 | 290 | 190 | 130 |
| | 1 3/8 | | | | | 9960 | 4590 | 2710 | 1750 | 1240 | 1030 | 790 | 620 | 500 | 350 | 220 | 160 |
| | 1 1/2 | | | | | 11850 | 5470 | 3230 | 2080 | 1480 | 1220 | 940 | 740 | 600 | 420 | 270 | 190 |
| | 1 3/4 | | | | | | 7440 | 4390 | 2830 | 2010 | 1670 | 1280 | 1010 | 820 | 570 | 360 | 250 |
| | 2 | | | | | | 9720 | 5740 | 3690 | 2620 | 2180 | 1670 | 1320 | 1070 | 740 | 470 | 330 |
| | | BLANK THICKNESS (in) | | | | | | | | | | | | | | | |
| Class 150 | | 1/4 | 1/4 | 1/4 | 1/4 | 1/4 | 3/8 | 1/2 | 5/8 | 3/4 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 1 5/8 | 1 7/8 |
| Class 300 | | 1/4 | 1/4 | 1/4 | 3/8 | 3/8 | 5/8 | 3/4 | 7/8 | 1 1/8 | 1 1/4 | 1 3/8 | 1 1/2 | 1 3/4 | 2 | 2 1/2 | 3 |
| Class 600 | | 1/4 | 1/4 | 3/8 | 1/2 | 5/8 | 7/8 | 1 | 1 1/4 | 1 1/2 | 1 3/4 | 1 7/8 | 2 1/8 | 2 3/8 | 2 7/8 | 3 1/2 | 4 1/4 |

**TABLE 3.0**
**MINIMUM TEMPERATURE FOR BLANKS W/O IMPACT TESTING**
**(A283-C/A36)**

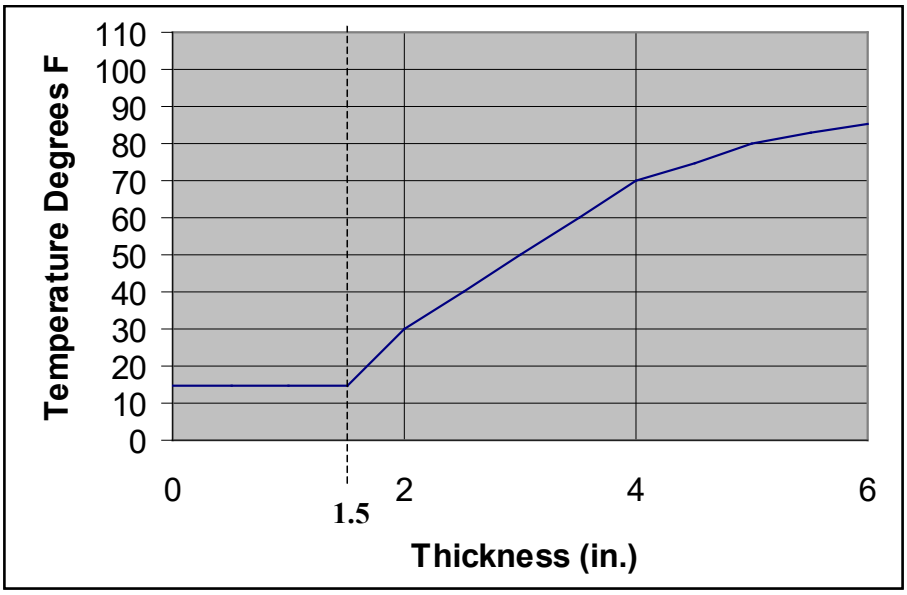


**TABLE 4.0**
**BLANK AND GASKET DIAMETERS**

| Pipe Size | Class 150 | | | Class 300 | | | Class 600 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Blank | Gasket | | Blank | Gasket | | Blank | Gasket | |
| | O.D. | O.D. | I.D. | O.D. | O.D. | I.D. | O.D. | O.D. | I.D. |
| 1 | 2 1/2 | 2 5/8 | 1.0625 | 2 3/4 | 2 7/8 | 1.0625 | 2 3/4 | 2 7/8 | 1.0625 |
| 1 1/2 | 3 1/4 | 3 3/8 | 1.91 | 3 5/8 | 3 3/4 | 1.91 | 3 5/8 | 3 3/4 | 1.91 |
| 2 | 4 | 4 1/8 | 2 3/8 | 4 1/4 | 4 3/8 | 2 3/8 | 4 1/4 | 4 3/8 | 2 3/8 |
| 3 | 5 1/4 | 5 3/8 | 3 1/2 | 5 3/4 | 5 7/8 | 3 1/2 | 5 3/4 | 5 7/8 | 3 1/2 |
| 4 | 3/4 | 6 7/8 | 4 1/2 | 7 | 7 1/8 | 4 1/2 | 7 1/2 | 7 5/8 | 4 1/2 |
| 6 | 8 5/8 | 8 3/4 | 6 5/8 | 9 3/4 | 9 7/8 | 6 5/8 | 10 3/8 | 10 1/2 | 6 5/8 |
| 8 | 10 7/8 | 11 | 8 5/8 | 12 | 12 1/8 | 8 5/8 | 12 1/2 | 12 5/8 | 8 5/8 |
| 10 | 13 1/4 | 13 3/8 | 10 3/4 | 14 1/8 | 14 1/4 | 10 3/4 | 15 3/8 | 15 3/4 | 10 3/4 |
| 12 | 16 | 16 1/8 | 12 3/4 | 16 1/2 | 16 5/8 | 12 3/4 | 17 7/8 | 18 | 12 3/4 |
| 14 | 17 3/8 | 17 3/4 | 14 | 18 3/4 | 19 1/8 | 14 | 19 1/4 | 19 3/8 | 14 |
| 16 | 19 7/8 | 20 1/4 | 16 | 20 7/8 | 21 1/4 | 16 | 22 1/8 | 22 1/4 | 16 |
| 18 | 21 1/4 | 21 5/8 | 18 | 23 1/8 | 23 1/2 | 18 | 24 | 24 1/8 | 18 |
| 20 | 23 1/2 | 23 7/8 | 20 | 25 3/8 | 25 3/4 | 20 | 26 3/4 | 26 7/8 | 20 |
| 24 | 27 7/8 | 28 1/4 | 24 | 30 1/8 | 30 1/2 | 24 | 31 | 31 1/8 | 24 |
| 30 | 34 1/4 | 34 3/4 | 30 | 37 | 37 1/2 | 30 | 37 3/4 | 38 1/4 | 30 |
| 36 | 40 3/4 | 41 1/4 | 36 | 43 1/2 | 44 | 36 | 44 | 44 1/2 | 36 |

| | | | |
|---|---|---|---|
| **Procedure Title:** | **Bloodborne Pathogens** | **AMS Number:** | **AMS-710-01-PR-00300** |
| **Procedure Owner:** | **HSE** | **Issuing Authority:** | **VP HSE** |

# BLOODBORNE PATHOGENS

| | | | |
|---|---|---|---|
| | | | |
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| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| 0 | Added 4.3.4.5 “Hand-washing Facilities” | M. Hetzler | 2/1/2018 |
| INT | Issued for Interim Use | M. Hadacek & S. Lachney | 7/30/2017 |
| **Rev** | **Changes** | **Approved** | **Date** |

## 1.0 PURPOSE

The purpose of this Procedure is to establish the minimum requirements for the control of Bloodborne Pathogens on APTIM sites.

## 2.0 SCOPE

This procedure applies to all APTIM employees, contractors, subcontractors and visitors associated with APTIM site.

## 3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure:

- APTIM Managers
- APTIM Supervisors
- APTIM Employees
- APTIM Contractors
- APTIM Subcontractors
- APTIM Visitors

## 4.0 PROCEDURE

APTIM sites shall use this procedure as the minimum requirements for their site specific Bloodborne Pathogens Standard.

4.1 Program Development

The Bloodborne Pathogens Program Coordinator/Site HSE Manager shall ensure that the exposure determination is conducted during the mobilization stages of the project and that the Exposure Control Plan (ECP) is completed.

4.2 Exposure Determination

4.2.1 Exposure Determination includes:

4.2.1.1 Exhibit 7.1 - List I - list of job classifications in which all employees have occupational exposure.

4.2.1.2 Exhibit 7.2 - List II - list of job classifications in which some employees have occupational exposure.

4.2.1.3 Exhibit 7.3 - List III - list all tasks and Practices in which occupational exposure occurs and that are performed by employees in job classifications included in the lists above.

4.3 Exposure Control Plan

4.3.1 The Site HSE Manager completes the APTIM ECP.

4.3.2 The ECP is a template which includes the information as listed in 4.3.4, 4.3.5, 4.3.6, and 4.4. This Plan provides the overall requirements for compliance with this Practice, and instructs each project to include site specific information for disposal of contaminated waste, care of Personal Protection Equipment (PPE), laundering materials, personal hygiene, decontamination etc.

4.3.3 The Site HSE Manager implements the elements of the APTIM ECP and uses the template to develop the specific procedures and practices.

4.3.4 The ECP shall address the following Methods of Compliance at a minimum:

4.3.4.1 Engineering and Work Practice Controls

4.3.4.2 Universal Precautions

4.3.4.3 Personal Protective Equipment (PPE)

4.3.4.4 Housekeeping:

- Decontamination
- Handling of Regulated Waste
- Laundry

4.3.4.5 Hand-washing Facilities - If provision of handwashing facilities are not feasible, then an appropriate antiseptic hand cleanser in conjunction with cloth/paper towels or antiseptic towelettes must be provided.

4.3.5 The ECP shall address the following Medical Management at a minimum:

4.3.5.1 Hepatitis B Vaccination

4.3.5.2 Post-Exposure Evaluation and Follow-up

4.3.6 The ECP shall address the following training elements at a minimum:

4.3.6.1 Bloodborne Pathogen Training for employees included in the plan

4.3.6.2 Awareness training for all employees

4.3.6.3 Employees covered under this plan due to reasonably anticipated exposure shall be provided training that includes at least:

- A copy of APTIM's reference standard and any additional country or regional specific standards.
- A general explanation of epidemiology and symptoms of bloodborne diseases
- An explanation of modes of transmission
- An explanation of the ECP
- Appropriate methods of identifying tasks that may involve exposure
- An explanation of use and limitations of methods to prevent or reduce exposure
- PPE information
- Selection basis for PPE
- Hepatitis B vaccination information
- Actions and notification in emergency situation
- Practices to follow in event of exposure
- Post-exposure evaluation and follow-up
- Signs and labels or color-coding system
- Opportunity for interactive questions and answers

4.3.6.4 Training shall be done at the time of initial assignment and at least annually thereafter, within one year of their previous training.

4.3.6.5 Employees who are not expected to contact blood or Other Potentially Infectious Materials (OPIM) shall be informed of the existence of the ECP and the responsible individuals on site.

4.3.7 The ECP shall address the communication of hazards to employees, recordkeeping and the procedure for the evaluation of circumstances surrounding exposure incidents.

4.3.8 The ECP shall be accessible to employees so they can have the opportunity to examine and copy the plan.

4.3.9 The ECP shall be reviewed and updated at least annually and whenever necessary to reflect new or modified task and procedures which affect occupational exposure and to reflect new or revised employee positions with occupational exposure. The revisions to the ECP will also reflect changes in technology that eliminate or reduce exposure to bloodborne pathogens.

4.3.10 The Site HSE Manager will solicit input from non-managerial employees responsible for direct patient care who are potentially exposed to injuries from contaminated sharps in the identification, evaluation, and selection of effective engineering and work practice controls and shall document the solicitation in the ECP, as applicable.

4.4 Medical Management

4.4.1 Hepatitis B Vaccination Series

4.4.1.1 All employees who, due to the nature of their assignment are at risk of occupational exposure (those are the employees included in List I and List II above) shall be offered the Hepatitis B vaccination series. The offer shall be made following training and within 10 days of initial assignment. The employee need not accept the offer of the vaccination; however, the declining employee must complete the Declination Form included in the AMS-710-01-FM-00301 Bloodborne Pathogens Plan Template prior to performing any assigned duties.

4.4.1.2 If an employee initially declines HBV vaccination but at a later date, while still covered under the program decides to accept the HBV vaccine, APTIM will provide the vaccine at that time. Should a booster dose be recommended at a future date, such booster dose(s) shall be provided.

4.4.2 Post-Exposure Evaluation and Follow-Up

4.4.2.1 Following an exposure incident, APTIM will make available to each potentially exposed employee, a confidential medical evaluation and follow-up. This follow-up will include documentation of the route(s) of exposure and the circumstances under which the exposure incident occurred, identification and documentation of the source individual (unless the identification cannot be established or it is prohibited by a local law), appropriate testing, prophylaxis for Hepatitis B virus, illness reporting, evaluation of reported illnesses, and counselling following a report of an occupational exposure incident to blood or other potentially infectious materials.

4.4.2.2 Employees covered in the ECP (those included in List I and List ii) who are exposed to blood or other potentially infectious materials shall be offered the post exposure evaluation and follow-up within 24 hours of the exposure.

4.4.2.3 If an employee, who was not included in the program, has an occupational exposure through a “Good Samaritan” act, the employee will be offered the post-exposure evaluation and follow-up in addition to the Hepatitis B vaccination at no charge and at a reasonable time and place (within 24 hours of the exposure).

4.4.2.4 The site HSE Manager shall ensure that the healthcare professional evaluating an employee after an exposure incident is provided the following information:

- A copy of any applicable regulation;
- A description of the exposed employee’s duties as they relate to the exposure incident;
- Documentation of the route(s) of exposure and circumstances under which exposure occurred;
- Results of the source individual’s blood testing, if available; and
- All medical records relevant to the appropriate treatment of the employee including vaccination status.

4.5 Regulated Waste Handling and Disposal

4.5.1 Each site shall make arrangements for the proper disposal of medical wastes (i.e., bandages, gauze, sharps, etc.) in accordance with AMS-710-04-PR-04123.

4.6 Record Retention

4.6.1 The following records shall be maintained in the site HSE files for the duration of the employee's employment plus thirty (30) years.

4.6.1.1 Medical Records. The medical records shall include:

- Name and social security number, as applicable, of the employee;
- A copy of the employee's hepatitis B vaccination status including dates of all the hepatitis B vaccinations and any medical records relative to the employee's ability to receive vaccination;
- A copy of all results of examinations, medical testing, and follow up procedures;
- Healthcare written opinion; and
- A copy of the information provided to the healthcare professional.

4.6.1.2 Training. Training records shall include the following:

- Dates of training sessions;
- Contents or a summary of the training sessions;
- Names and qualifications of persons conducting the training; and
- Names and job titles of all persons attending the training session.

4.6.1.3 Sharps Injury Log. The Sharp Injury Log shall contain:

- Type and brand of device involved in the incident;
- Department or work area where the exposure incident occurred; and
- Explanation of how the incident occurred.
- Data will be entered into APTIM's HSE Data Management System for use as the Sharps Injury Log.

## 5.0 REFERENCES

| | |
|---|---|
| AMS-720-01-FM-00020 | Business Glossary |
| AMS-720-01-FM-00021 | Technical Glossary |
| AMS-710-04-PR-04123 | Medical Waste Management |

## 6.0 TERMINOLOGY

| | |
|---|---|
| Bloodborne Pathogens | Pathogenic microorganisms that are present in human blood and can cause disease in humans. These pathogens include, but are not limited to, hepatitis B virus (HBV) and human immunodeficiency virus (HIV). |
| Engineering Controls | Controls (e.g., sharps disposal containers, self-sheathing needles, safer medical devices, such as sharps with engineered sharps injury protections and needleless systems) that isolate or remove the bloodborne pathogens hazard from the workplace. |
| Other Potentially Infectious Materials (OPIM) | (1) The following human body fluids: semen, vaginal secretions, cerebrospinal fluid, synovial fluid, pleural fluid, pericardial fluid, peritoneal fluid, amniotic fluid, saliva in dental procedures, any body fluid that is visibly contaminated with blood, and all body fluids in situations where it is difficult or impossible to differentiate between body fluids; |

| | |
|---|---|
| | (2) Any unfixed tissue or organ (other than intact skin) from a human (living or dead); and<br>(3) HIV-containing cell or tissue cultures, organ cultures, and HIV- or HBV-containing culture medium or other solutions; and blood, organs, or other tissues from experimental animals infected with HIV or HBV |
| Regulated Wastes | Liquid or semi-liquid blood or other potentially infectious materials; contaminated items that would release blood or other potentially infectious materials in a liquid or semi-liquid state if compressed; items that are caked with dried blood or other potentially infectious materials and are capable of releasing these materials during handling; contaminated sharps; and pathological and microbiological wastes containing blood or other potentially infectious materials. |
| Site | Any location, facility or project where APTIM is performing work. Sites may include, but are not limited to, laboratories, offices, shops, owned facilities, leased facilities and/or project sites. |
| Universal Precautions | An approach to infection control. According to the concept of Universal Precautions, all human blood and certain human body fluids are treated as if known to be infectious for HIV, HBV, and other bloodborne pathogens. |
| Work Practice Controls | Controls that reduce the likelihood of exposure by altering the manner in which a task is performed (e.g., prohibiting recapping of needles by a two-handed technique). |

## 7.0 EXHIBITS

| | |
|---|---|
| Exhibit 7.1 | List I – Job Classifications with Regular Exposure |
| Exhibit 7.2 | List II – Job Classifications with Some Exposure |
| Exhibit 7.3 | List III – Tasks and Practices With Exposure |
| Exhibit 7.4 | Bloodborne Pathogens Plan Template – AMS-710-01-FM-00301 |

## 8.0 ATTACHMENTS

None

## 9.0 EXHIBIT 7.1 – LIST I JOB CLASSIFICATIONS WITH REGULAR EXPOSURE PAGE 1 0F 1

| JOB CLASSIFICATION | REGULAR EXPOSURE | SOME EXPOSURE | NO EXPOSURE |
|---|---|---|---|
| Staff Physician | X | | |
| Registered Nurse | X | | |
| Licensed Practical Nurse | X | | |
| Emergency Medical Technician | X | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

| AMS Number: | Revision: | Approval Date: |
|---|---|---|
| AMS-710-01-PR-00300 | 0 | 2/1/2018 |

**EXHIBIT 7.2 – LIST II JOB CLASSIFICATIONS WITH SOME EXPOSURE PAGE 1 OF 1**

| JOB CLASSIFICATION | REGULAR EXPOSURE | SOME EXPOSURE | NO EXPOSURE |
|---|---|---|---|
| First Aid/CPR Certified Personnel | | X | |
| Safety Representative | | X | |
| Security Representative | | X | |
| Custodian | | X | |
| Non-Designated EMT and First Aid/CPR Certified Personnel (Good Samaritans) | | | X |
| All Other APTIM Personnel (Good Samaritans) | | | X |

**EXHIBIT 7.3 - LIST III TASKS AND PRACTICES WITH EXPOSURE** **PAGE 1 OF 1**

| TASKS AND PROCEDURES |
|---|
| Bleeding Control With Spurting Blood |
| Bleeding Control With Minimal Bleeding |
| Emergency Childbirth |
| Blood Drawing (Phlebotomy, Needle sticks, Etc.) |
| Starting An Intravenous (IV) Line |
| Endotracheal Intubation, Esophageal Obturator Use |
| Oral/Nasal Suctioning, Manually Cleaning Airway |
| Handling And Cleaning Instruments With Microbial Contamination |
| Giving Injections |
| Rendering First Aid |
| Rendering Cardiopulmonary Resuscitation (CPR) |
| Decontamination Following Accidents/Injuries |
| Vehicle/Equipment Accidents Where There Is Presence Of Blood |
| Rescue Of Bleeding Employee |
| Medical Procedures With Blood (Suturing And Suture Removal) |
| Handling Of Regulated Waste Containers |
| Laboratory Blood Processing |
| Wound Care |
| Epistaxis (Nosebleed) Control |
| Handling Of Contaminated Waste |
| Handling Of Contaminated Personal Protective Clothing & Equipment |
| Handling Of Contaminated Laundry And Personal Clothing |
| Housekeeping/Custodial Duties Where There Is Presence Of Blood |
| |

## 10.0 ATTACHMENTS

None

# PROCEDURE

| | | | |
|---|---|---|---|
| **Procedure Title:** | **Stop Work Authority** | **AMS Number:** | **AMS-710-05-PR-00400** |
| **Procedure Owner:** | **HSE** | **Issuing Authority:** | **VP HSE** |

# STOP WORK AUTHORITY

| | | | |
|---|---|---|---|
| | | | |
| 1 | Added sections 4.5.3.7 and 4.5.3.8 to give more clarity on existing requirements. | M. Hetzler | 5/31/2018 |
| 0 | Updated to incorporate the APTIM branded STOP WORK Authority Card | M. Hetzler | 2/9/2018 |
| INT | Issued for Interim Use | M. Hadacek & S. Lachney | 7/30/2017 |
| **Rev** | **Changes** | **Approved** | **Date** |

## 1.0 PURPOSE

The purpose of this procedure is to outline the requirement of all employees to stop an unsafe act or condition in the workplace.

## 2.0 SCOPE

This procedure applies to all APTIM employees, contractors, subcontractors, vendors, and site visitors associated with an APTIM site.

## 3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure.

- APTIM Managers
- APTIM Supervisors
- APTIM Employees
- APTIM Contractors
- APTIM Subcontractors
- APTIM Vendors
- APTIM Site Visitors

## 4.0 PROCEDURE

4.1 As an APTIM representative, employees have the responsibility and the authority, without fear of reprimand or retaliation, to immediately stop any work activity that presents a danger to themselves, co-workers, clients, the public, or the environment.

4.2 It is each employee's responsibility to get involved by questioning and rectifying any situation that is an at-risk behavior or condition. If the employee does not feel the issue is addressed adequately, the employee has the responsibility to raise it to a higher level.

4.3 No work will resume until all stop work issues and concerns have been adequately addressed.

4.4 Any form of retribution or intimidation directed at any individual or company for exercising their authority as outlined in this program will not be tolerated.

4.5 Follow the three steps identified on the Stop Work Authority (SWA) Card (Attachment 8.1)

4.5.1 Recognize the hazard that could bring harm to you, fellow employees or the environment.

When a person identifies a perceived unsafe condition, act, error, omission, or lack of understanding that could result in an undesirable event, a "stop work intervention shall be immediately initiated with the person(s) potentially at risk.

4.5.2 Stop the task before an incident happens. This may be the most difficult part, but it is a responsibility and an expectation. Remember, every employee has the authority to do so.

4.5.2.1 If the supervisor is readily available and the affected person(s) are not in immediate risk, the "stop work action" should be coordinated through the supervisor.

4.5.2.2 If the supervisor is not readily available or the affected person(s) are in immediate risk, the "stop work" intervention should be initiated directly with those at risk.

4.5.2.3 "Stop work" interventions should be initiated in a positive manner by briefly introducing yourself and clarifying the intent and set expectations of the Stop Work events.

4.5.2.4 Notify all affected personnel and supervision of the stop work issue. If necessary, stop associated work activities, remove person(s) from the area, stabilize the situation and make the area as safe as possible.

4.5.3 Discuss the hazardous condition or behavior and share the information with others to help avoid similar situations. Develop a plan to eliminate or mitigate the hazard.

4.5.3.1 All parties shall discuss and gain agreement on the stop work issue.

4.5.3.2 If determined and agreed that the task or operation is okay to proceed as is (i.e., the stop work initiator was unaware of certain facts or procedures), the affected persons should thank the initiator for their concern and proceed with the work.

4.5.3.3 If determined and agreed that the stop work issue is valid, then every attempt should be made to resolve the issue to all affected person's satisfaction prior to the commencement of work.

4.5.3.4 If the stop work issue cannot be resolved immediately, work shall be suspended until proper resolution is achieved. When opinions differ regarding the validity of the stop work issue or adequacy of the resolution actions, the location's "person in charge" shall make the final determination.

4.5.3.5 Positive feedback should be given to all affected employees regarding resolution of the stop work issue. Under no circumstances should retribution be directed at any person(s) who exercise in good faith their stop work authority as detailed in this program.

4.5.3.6 All stop work interventions and associated detail shall be documented and reported via the behavior-based safety observation processes.

4.5.3.7 Stop Work reports shall be reviewed by a supervisor or manager in order to measure participation, determine quality of interventions and follow-up, trend common issues, identify opportunities for improvement, and facilitate sharing of lessons learned.

4.5.3.8 It is the desired outcome of any Stop Work Intervention that the identified safety concern(s) have been addressed to the satisfaction of all involved persons prior to the resumption of work. Most issues can be adequately resolved in a timely manner at the job site, occasionally additional investigation and corrective actions may be required to identify and address root causes.

4.6 Training

4.6.1 All employees and contractors shall be trained in the use of Stop Work Authority during APTIM HSE Induction.

4.6.2 Upon completion of training, employees and contractors shall be issued a SWA card.

## 5.0 REFERENCES

None

## 6.0 TERMINOLOGY

| ***Term*** | ***Definition*** |
|---|---|
| Site | Any location, facility, or project where APTIM is performing work. Sites may include, but are not limited to, laboratories, offices, shops, owned or leased facilities, and/or project sites. |

| | |
|---|---|
| Supervisor | Person in control of the work and the personnel conducting the work (foreman, general foreman, superintendent) |

## 7.0 EXHIBITS

| | |
|---|---|
| Exhibit 7.1 | AMS-720-01-FM-00020 – Business Glossary |
| Exhibit 7.2 | AMS-720-01-FM-00021 – Technical Glossary |

## 8.0 ATTACHMENTS

| | |
|---|---|
| Attachment 8.1 | Stop Work Authority Card |

STOP WORK AUTHORITY

APTIM

I will **IDENTIFY** hazards that could cause harm to me, my fellow employees, others in the surrounding area, or to the environment.

I will **STOP** the task before a harmful event might occur. While this can be difficult or uncomfortable, I commit to using my authority to stop work in a respectful and timely manner.

I will **DISCUSS** the hazardous condition or behavior, share information with others to help avoid similar situations, and help develop a plan to eliminate or mitigate the hazard.

**APTIM Ethics Line 1-800-461-9330**

APTIM is dedicated to performing work in a quality manner and in compliance with applicable regulations, policies, and ethics. As an APTIM employee, you are responsible for reporting safety and quality issues that could cause harm to you, others around you, the public, or the environment.

Stopping work to discuss a hazard can be done without fear of retaliation or reprimand, and must be done as soon as work is put into safe condition. If you do not feel the safety/quality issue is being addressed, it is your responsibility to raise the issue to a higher level or use an alternate method to report your issue.

No other company policy may supersede, limit, or otherwise discourage your responsibility to raise a safety or quality concern.

Gary Baughman, CEO

# PROCEDURE

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|---|---|---|---|
| **Procedure Title:** | **Hazardous Waste Operations** | **AMS Number:** | **AMS-710-04-PR-00300** |
| **Procedure Owner:** | **HSE** | **Issuing Authority:** | **APTIM Quality Management** |

# HAZARDOUS WASTE OPERATIONS

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| INT | Issued for Interim Use | M. Hadacek & S. Lachney | 7/30/2017 |
| **Rev** | **Changes** | **Approved** | **Date** |

## 1.0 PURPOSE

The purpose of this procedure is to establish the minimum requirements for developing and implementing a written health and safety program for APTIM employees involved in hazardous waste operations conducted at treatment, storage, and disposal (TSD) facilities.

## 2.0 SCOPE

This procedure applies to personnel who develop and implement written HSE Programs for employees involved in hazardous waste operations.

## 3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure:

- APTIM Managers
- APTIM Supervisors
- APTIM Employees

## 4.0 PROCEDURE

### 4.1 General

The Site HSE Manager shall develop and implement a written safety and health program for employees involved in hazardous waste operations (AMS-710-04-WI-00301 Health and Safety Plans for Hazardous Waste Operations Sites). The program shall be designed to identify, evaluate, and control safety and health hazards in the facility for the purpose of employee protection. The program shall provide for emergency response and shall address, as appropriate, site analysis, engineering controls, maximum exposure limits, hazardous waste handling procedures, and the use of new technologies (AMS-710-04-WI-00302 Emergency Response at Hazardous Waste Sites).

### 4.2 Hazard Communication

The safety and health program shall contain a hazard communication program. Refer to AMS-710-01-PR-00400 Hazard Communication.

### 4.3 Emergency response

The safety and health program shall contain Emergency Response requirements or shall reference the Emergency Preparedness Plan (AMS-710-03-PR-00400).

### 4.4 Medical Surveillance

A medical surveillance program shall be developed and implemented. All employees who are or may be exposed to health hazards or hazardous substances at or above the permissible exposure limits or, if there is no permissible exposure limit, above the published exposure levels without regard to the use of respirators for thirty (30) days or more in a calendar year shall be included in the program at no cost to the employee.

### 4.5 Decontamination

4.5.1 A decontamination program shall be developed, communicated to employees, and implemented before any employees or equipment enters an area on site where potential exposure to hazardous substance(s) exists (AMS-710-04-WI-00305 Hazardous Waste Decontamination).

4.5.2 All employees leaving a contaminated area shall be appropriately decontaminated. All contaminated clothing and equipment leaving a contaminated area shall be appropriately disposed of or decontaminated (AMS-710-04-PR-04113 Waste Characterization).

4.5.3 Decontamination shall be performed in geographical areas that will minimize cross contamination or the exposure of uncontaminated employees or equipment.

4.5.4 The Site HSE Manager shall monitor all methods of decontamination and determine their effectiveness. If methods are found to be ineffective, appropriate steps will be taken to correct the deficiencies.

4.5.5 Regular showers and changing rooms shall be provided outside the contaminated area.

4.6 New Technology

A program shall be developed and implemented to introduce new and innovative equipment for employee protection into the work place.

4.7 Material Handling

Where employees handle drums or containers, AMS-710-02-PR-00300 Material Storage and Handling shall be implemented prior to starting such work.

4.8 Engineering Controls

Engineering controls work practices, personal protective equipment, or a combination of these shall be implemented in accordance with 29 CFR 1910.120 (g) to protect employees from exposure to hazardous substances and safety and health hazards.

4.9 Monitoring

4.9.1 General

Monitoring shall be performed in accordance with 29 CFR 1910.120 (h) to prevent employee exposure to hazardous concentrations of hazardous substances and to assure proper selection of engineering controls, work practices, and personal protective equipment (AMS-710-04-WI-00304 Hazardous Waste Site Control).

4.9.2 Air Monitoring

Air monitoring shall be used to identify and quantify airborne levels of hazardous substances and safety and health hazards in order to determine the appropriate level of employee protection.

4.9.3 Initial Entry

Upon initial entry, representative air monitoring shall be conducted to identify any immediately dangerous to life and health (IDLH) condition, exposure over Permissible Exposure Limits (PELs) or if other dangerous condition(s) exist (i.e., the presence of flammable atmosphere or oxygen deficient environments).

4.9.4 Periodic Monitoring

Periodic monitoring shall be conducted when the possibility of an IDLH condition or flammable atmosphere has developed, or when there is indication that exposure may have risen over PELs. Periodic monitoring shall be considered when the PELs have risen and one or more of the following scenarios occur:

- Beginning of new work on a different portion of the site
- Contaminates other than those previously identified are being handled
- When a different type of operation is initiated
- When obvious liquid contamination is present

4.10 Training

All employees working on sites or at treatment, storage, and disposal (TSD) operations where they may be exposed to health hazards or hazardous substances must receive training to enable the employees to perform their assigned duties and functions in a safe and healthful manner so as not to endanger themselves or other employees (AMS-710-04-WI-00303 Hazardous Waste Operations Training).

4.10.1 New Employees

Employees engaged in hazardous substance removal or other activities, which expose or potentially expose them to hazardous substances and health hazards shall receive initial training which consists of a minimum of 40 hours of instruction off-site and three days of field experience, under direct supervision of a trained, experienced supervisor as described in 29 CFR 1910.120.

4.10.2 Current Employees

Current employees whose previous work experience and/or training are equivalent to the initial training requirement shall be considered as having met the initial training requirements. The Training Manager or his/her designee shall make the determination of equivalency. Current employees shall receive 8 hours of refresher training annually as described in 29 CFR 1910.120.

4.10.3 Trainers

Trainers shall be qualified to instruct employees on the subject matter presented in training. Such trainers shall have satisfactorily completed a training program for teaching their subjects, or they shall have the academic credentials and instructional experience necessary to teach as described in 29 CFR 1910.120.

4.11 Project Manager shall:

4.11.1 Verify compliance with the appropriate regulatory standard(s)

4.11.2 Ensure project-specific Health and Safety Program (HASP) documents are applicable health and safety requirements

4.12 HSE Representative shall:

4.12.1 Verify compliance with the appropriate regulatory standard(s) (AMS-710-04-WP-00001 Implement Environmental Management System (EMS)).

4.12.2 Ensure project-specific Health and Safety Program (HASP) documents are applicable health and safety requirements

4.12.3 Ensure medical and exposure records are handled correctly (AMS-710-01-PR-03500)

## 5.0 REFERENCES

| | |
|---|---|
| 29 CFR 1910.1200 | Hazard Communication |
| 29 CFR 1910.141 | Sanitation |
| AMS-710-01-PR-00400 | Hazard Communication |
| AMS-710-03-PR-00400 | Emergency Preparedness Plan |
| AMS-710-01-PR-03500 | Medical and Exposure Records |
| AMS-710-02-PR-00300 | Material Storage and Handling |
| AMS-710-04-PR-04113 | Waste Characterization |
| AMS-710-04-WI-00301 | Health and Safety Plans for Hazardous Waste Operations Sites |
| AMS-710-04-WI-00302 | Emergency Response at Hazardous Waste Sites |
| AMS-710-04-WI-00303 | Hazardous Waste Operations Training |

| | |
|---|---|
| AMS-710-04-WI-00304 | Hazardous Waste Site Control |
| AMS-710-04-WI-00305 | Hazardous Waste Decontamination |
| AMS-710-04-WP-00001 | Implement Environmental Management System (EMS) |

## 6.0 TERMINOLOGY

| ***Term*** | ***Definition*** |
|---|---|
| Buddy System | A system of organizing employees into work groups in such a manner that each employee of the work group is designated to be observed by at least one other employee in the work group. The purpose of the buddy system is to provide rapid assistance to employees in case of an emergency. |
| Clean-up Operation | An operation where hazardous substances are removed, contained, incinerated, neutralized, cleared-up, or in any manner processed or handled with ultimate goal of making the site safer for people or the environment. |
| Decontamination | The removal of hazardous substances from employees and their equipment to the extent necessary to preclude the occurrence of foreseeable adverse health effects. |
| Emergency Response or Responding to Emergencies | A response effort by employees from outside the immediate release area or by designated responders to an occurrence which results, or is likely to result, in an uncontrolled release of a hazardous substance. Responses to incidental releases of hazardous substances where the substance can be absorbed, neutralized or otherwise controlled at the time of release by employees in the immediate release area, or by maintenance personnel are not considered emergency responses. Responses to releases of hazardous substances where there is no potential safety or health hazard are not considered to be emergency responses. |
| Facility | Any building, structure, installation, equipment, pipe or pipeline, well, pit, pond, lagoon, impoundment, ditch, storage container, motor vehicle, rolling stock, or aircraft, or any site or area where a hazardous substance has been deposited, stored, disposed of, or placed, or otherwise come to be located; but does not include any consumer product in consumer use or any water-borne vessel. |
| Hazardous Substance | A substance which results or may result in adverse effects on the health or safety of employees. |
| Health Hazard | A chemical, mixture of chemicals, or a pathogen for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. Health hazards include: chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic system and agents which damage the lungs, skin, eyes, or mucous membranes. |

## 7.0 EXHIBITS

| | |
|---|---|
| AMS-720-01-FM-00020 | Business Glossary |

AMS-720-01-FM-00021 Technical Glossary

## 8.0 ATTACHMENTS

None

# PROCEDURE

| | | | |
|---|---|---|---|
| **Procedure Title:** | **Work Area Hazard Assessment** | **AMS Number:** | **AMS-710-05-PR-01700** |
| **Procedure Owner:** | **HSE** | **Issuing Authority:** | **APTIM Quality Management** |

# WORK AREA HAZARD ASSESSMENT

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| INT | Issued for Interim Use | M. Hadacek & S. Lachney | 7/30/2017 |
| **Rev** | **Changes** | **Approved** | **Date** |

## 1.0 PURPOSE

The purpose of this Procedure is to establish the minimum requirements for Work Area Hazard Assessment on APTIM sites.

## 2.0 SCOPE

This procedure applies to all APTIM employees, contractors, subcontractors, and visitors associated with a APTIM site.

## 3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure:

- APTIM Managers
- APTIM Supervisors
- APTIM Employees
- APTIM Contractors
- APTIM Subcontractors

## 4.0 PROCEDURE

4.1 Work Area Hazard/Recognition Process Philosophy

4.1.1 It is The Work Area Hazard/Recognition Process Philosophy that a hazard's risk potential is the product of the Level of Focus and the Level of Distraction. The Level of Focus and the Level of Distraction have an inverse relationship. An increase in focus shall decrease the distraction resulting in less risk potential for an incident to occur at the actual work front. An increase in distraction shall have a decrease in focus resulting in a greater risk potential for an incident to occur at the actual work front. This philosophy is applicable at all levels, phases, and stages of work activity.

4.1.2 Varied types of work hazard analyses are to be conducted to mitigate hazard risk potential with the Level of Focus increasing and the Level of Distraction decreasing as the hazard analysis becomes nearer to the actual work activity.

4.1.3 The result from the completion of every hazard analysis/recognition process becomes the basis from which to begin the next level of hazard analysis/recognition study. This process is visually displayed in the Pyramid of Work Area Hazard Recognition/ Assessment (Figure 4-1).

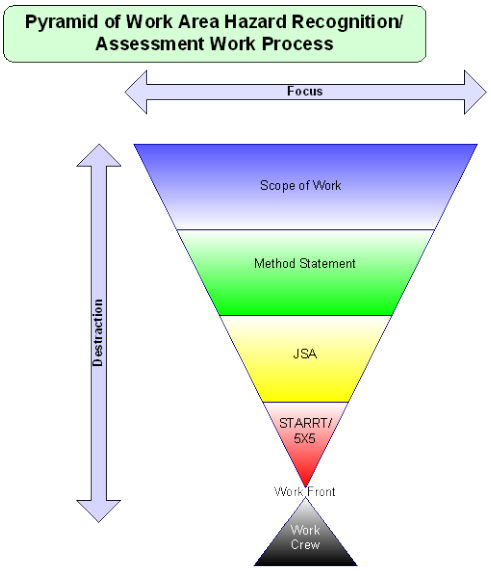



Figure 4-1

4.1.4 If during the Work Area Hazard/Recognition Process it is discovered that a previous step failed to identify a potential risk or hazard, then the previous step shall be repeated or revisited to incorporate the new findings.

4.1.5 Work shall not proceed to the next level or step of the Work Area Hazard Analysis Process prior to the completion of the previous step.

4.2 Work Area Hazard Assessment Flow

4.2.1 The basic work flow process is depicted in Attachment 8.1. Utilizing this methodology each site shall develop a Work Area Hazard Assessment Process specific to their needs. Performing a method statement is a best management practice to tie steps one (1) and three (3) together, but is not required

4.2.2 The location specific Work Area Hazard Assessment Process shall minimally include a means of engaging the supervision in developing an assessment prior to the start of work and a method of engaging their respective work crews in the assessment process. The location specific Work Area Hazard Assessment Process shall, minimally, have a means of ensuring each worker has the opportunity to conduct a 360° review of their specific work task, as well as documenting that review.

4.2.3 Scope of Work (Step One)

4.2.3.1 The first step in the Work Hazard Analysis/Recognition Process begins with the process of defining the Scope of Work. The Scope of Work is a definition of the work to be performed. The objective is to establish an understanding of the work to be performed.

4.2.3.2 The Scope of Work shall define the major elements of work to be executed (e.g., civil, structural, mechanical, or electrical).

4.2.3.3 Within the Scope of Work each of the major disciplines shall be defined to include elements such as:

- Painting and coating
- Instrumentation and electrical
- Structural
- Civil

4.2.3.4 The major disciplines identified in the Scope of Work review shall serve as the basis for development of the method statements

4.2.4 Method Statement (Step Two)

4.2.4.1 The second step in the Work Hazard Analysis/Recognition Process entails the development of a Work Method Statement or equivalent document (e.g., Job Hazard Assessment). A Work Method Statement shall provide specific instructions on the work to be performed, outline hazards involved, and identify key safety measures to be implemented during the work activity. The Method Statement shall also detail which control measures have been introduced to ensure the safety of anyone who is affected by the task or process.

4.2.4.2 For each discipline of work identified under the site scope of work the Site Manager shall prepare Method Statements, using AMS-710-05-FM-01702—Sample Method Statement 2.

4.2.4.3 The site HSE Manager/Supervisor shall maintain a copy of the site method statements and shall submit copies to Business Unit/Operating Group HSE Director or designee for business sector, area, district and/or global application.

4.2.4.4 Within the Method Statement the following minimum information shall be included:

- Sequence of key activities
- Identification of the craft required, including necessary skill/certification
- Identification of the tools and equipment required
- A clear statement of responsible persons, i.e., who is in charge of the work, who has specific responsibilities, e.g., flagmen, riggers.
- Identification of what materials are required for execution of the activity

- Identification of what services are required and how they shall be provided
- Reference to emergency procedures, including contact telephone numbers, reference to emergency provisions such as spill kits.
- Key activities identified in the Method Statement(s) (or equivalent document(s)) shall serve as the basis for the development of an activity specific Job Safety Analysis (JSA).

4.2.5 Job Safety Analysis (Step Three)

4.2.5.1 The third step in the Work Area Hazard Analysis/Recognition Process is to develop a JSA for each key activity to be performed, during the shift. A JSA shall document each step of the activities, identify potential hazards associated with each step, and list the control measure(s) to be used to mitigate the potential hazard(s).

4.2.5.1 A new JSA shall be completed at the work location every day, before commencement of any work activity and updated in the event of changing conditions. If conditions that a work crew encounters during a work period (inclement weather, another contractor began work in area change), the JSA shall be modified to address the new hazards. The JSA shall be changed to reflect new conditions in the task being performed or new hazards not identified previously.

4.2.5.2 Utilize the hierarchy of control measures to develop safe job procedures to eliminate or mitigate the hazards and prevent potential accidents:

1. Eliminate the hazard if possible
2. Use engineering controls to mitigate the hazard
3. Use administrative controls to minimize exposure
4. Use PPE

4.2.5.3 For each key activity identified under the site method statement supervision shall prepare a JSA. Supervision should use one of the following to prepare the JSA:

- AMS-710-05-FM-01704—Sample JSA 1
- AMS-710-05-FM-01705—Sample JSA 2
- AMS-710-05-FM-01708—Sample JSA 3

4.2.5.4 Supervision shall review the prepared JSA prior to work and ensure all appropriate elements are addressed in the JSA and that it is specific to their planned work activities.

4.2.5.5 The supervisor shall review the completed JSA with their respective work crews prior to starting the work activity.

4.2.5.6 Periodic reviews shall be conducted by the site HSE Manager and Senior Level Site Manager to ensure the integrity of the JSA process.

4.2.5.7 JSA's are to remain with the work crew(s) until the task(s) are completed at which time they shall be submitted to the site HSE Manager for inclusion in the site HSE files.

4.2.5.8 These steps identified in the JSA shall serve as the basis for development of job step specific worker completed assessments.

4.2.6 5 x 5 Analysis/STARRT (Step Four)

4.2.6.1 The fourth step in the Work Hazard Analysis/Recognition Process is to develop a 5 X 5 Analysis/Safety Task Analysis and Risk Reduction Talk (STARRT) Card or equivalent form) just prior to the performance of the work. The job or task specific analysis is performed by the individual who is to

perform the work. This is the individual's opportunity to confirm that he has everything needed to perform the work in a safe manner.

4.2.6.2 The individual shall prepare job step specific analysis, using one of the following

- AMS-710-05-FM-01706—Sample 5x5 Analysis
- AMS-710-05-FM-01707—Sample STARRT Card
- Or an equivalent form

4.2.6.3 The work crew shall be actively involved in conducting a 360° review of their specific work area, identifying hazards of their work and the hazards of work activities that surround them. The work crew lead and the work crew shall collectively review the means of mitigation and ensure proper controls and measures are in place.

4.2.6.4 The job or task specific analysis is a tool for the individual to identify any unaccounted hazards that one may encounter associated with the tasks they shall actually be performing.

## 5.0 REFERENCES

None

## 6.0 TERMINOLOGY

| ***Term*** | ***Definition*** |
|---|---|
| Hazard | A condition, practice, behavior or situation, or a combination of these, that can cause injury or illness in people, or damage to the environment or property. |
| JSA | Job Safety Analysis, technique that focuses on job tasks as a way to identify hazards before they occur |
| Site | Any location, facility or project where APTIM is performing work. Sites may include, but are not limited to, laboratories, offices, shops, owned facilities, leased facilities and/or project sites. |
| Work Area Hazard Assessment | Evaluation of a work place condition, practice, behavior or situation that an employee may encounter while performing a job/task that has the potential for risks/hazards. |

## 7.0 EXHIBITS

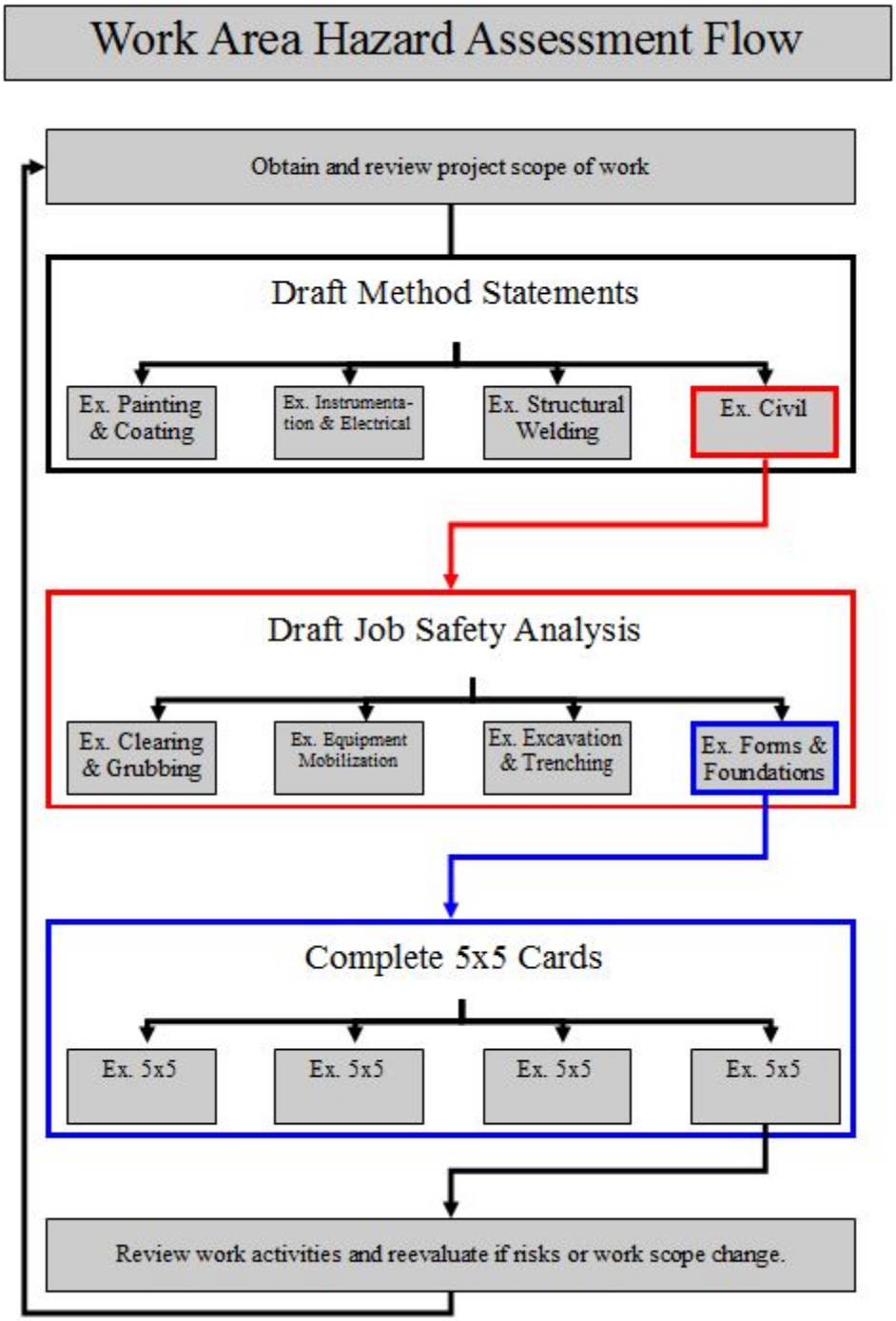
| | |
|---|---|
| Exhibit 7.2 | AMS-710-05-FM-01702—Sample Method Statement 2 |
| Exhibit 7.3 | AMS-710-05-FM-01704—Sample JSA 1 |
| Exhibit 7.4 | AMS-710-05-FM-01705—Sample JSA 2 |
| Exhibit 7.5 | AMS-710-05-FM-01706—Sample 5x5 Card |
| Exhibit 7.6 | AMS-710-05-FM-01707—Sample STARRT Card |
| Exhibit 7.7 | AMS-710-05-FM-01708---Sample JSA 3 |
| Exhibit 7.8 | AMS-720-01-FM-00020---Business Glossary |
| Exhibit 7.9 | AMS-720-01-FM-00021---Technical Glossary |

## 8.0 ATTCHMENTS

Attachment 8.1 Work Area Hazard Assessment Process Flow

| AMS Number: | Revision: | Approval Date: |
|---|---|---|
| AMS-710-05-PR-01700 | INT | 7/30/2017 |

Attachment 8.1 Work Area Hazard Assessment Process Flow



# PROCEDURE

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|---|---|---|---|
| **Procedure Title:** | **Personal Protective Equipment** | **AMS Number:** | **AMS-710-02-PR-03000** |
| **Procedure Owner:** | **HSE** | **Issuing Authority:** | **APTIM Quality Management** |

# PERSONAL PROTECTIVE EQUIPMENT

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| INT | Issued for Interim Use | M. Hadacek & S. Lachney | 7/30/2017 |
| **Rev** | **Changes** | **Approved** | **Date** |

| AMS Number: | Revision: | Approval Date: |
|---|---|---|
| AMS-710-02-PR-03000 | INT | 7/30/2017 |

## 1.0 PURPOSE

The purpose of this Procedure is to establish the minimum requirements for the use of Personal Protective Equipment (PPE) on APTIM sites.

## 2.0 SCOPE

This procedure applies to all employees of APTIM, contractors, subcontractors and visitors associated with a APTIM site.

## 3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure:

- APTIM Managers
- APTIM Supervisors
- APTIM Employees
- APTIM Contractors
- APTIM Subcontractors
- APTIM Visitors

## 4.0 PROCEDURE

4.1 Requirements

4.1.1 PPE is the last line of defense against hazards and shall not be used as a substitute for engineering, work practice, and/or administrative controls. PPE shall be used in conjunction with these controls to ensure employee safety and health. PPE includes all clothing or other work accessories designed to create a barrier against work place hazards. Employees must be made aware that PPE does not eliminate the hazard. If PPE fails, hazard exposure will occur.

4.1.2 Every attempt shall be made to prevent the possibility of incidents when employees perform work activities by providing them with the appropriate PPE, through compliance with safety regulations and training of employees to properly use, inspect and wear the required PPE and through employee involvement in safe work activities.

4.1.3 The Company reserves the right to select and/or approve all PPE to be issued and used by its employees, visitors, and/or subcontractors. Only such equipment issued or approved will be allowed on its jobsites. Failure to comply with this procedure will result in disciplinary action up to and including termination in accordance with AMS-710-05-PR-00200.

4.1.4 The Site Manager shall ensure that the Site HSE Manager has assessed the workplace to determine if hazards are present or likely to be present. This assessment shall be documented in writing. The documentation shall identify the work place, the person(s) evaluating the work place, the dates of the assessment, and the hazards if any. The Site Manager shall approve the hazard assessment as accurate and complete. If hazards are present, controls shall be implemented to eliminate or reduce the hazard. If controls are not available and/or the hazard is not eliminated, the requisite PPE shall be used. APTIM Management shall:

4.1.4.1 Select and have each affected employee use the types of PPE chosen.

4.1.4.2 Communicate appropriate selection of PPE to employees. (Training).

4.1.4.3 Ensure that employees have PPE that properly fits them.

4.1.4.4 Ensure that employees understand the proper usage of the required PPE.

4.1.5 Workers must report any damaged or defective PPE and the defective or damaged PPE shall be removed from service and shall not be reused.

4.1.6 APTIM shall ensure that each employee who is required to wear PPE is trained in the following:

4.1.6.1 When PPE is necessary.

4.1.6.2 What PPE is necessary.

4.1.6.3 How to put on, take off, adjust, and wear the PPE.

4.1.6.4 The limits of the PPE.

4.1.6.5 The proper care, maintenance, useful life, inspection and disposal of the PPE.

4.1.6.6 The proper practices for keeping the PPE clean and hygienic.

4.1.6.7 The proper use to ensure the PPE is not misused or damaged.

4.1.7 Each affected employee shall demonstrate an understanding of the training and the ability to use PPE properly, before being allowed to perform work requiring the use of PPE.

4.1.8 When there is reason to believe that any affected employee who has already been trained does not have the understanding and skill required, the employee shall be retrained. Circumstances where retraining is required include, but are not limited to, the following:

4.1.8.1 Changes in the workplace which renders previous training obsolete.

4.1.8.2 Changes in the type of PPE to be used which renders previous training obsolete.

4.1.8.3 Inadequacies in an affected employee's knowledge or use of assigned PPE.

4.2 The Site HSE Manager along with Site Management will authorize the purchase of appropriate types and models of PPE.

4.3 The company will provide all PPE to the employee at no cost to the employee with exception of items deemed to be personal in nature to include, but not limited to:

4.3.1 Prescription Safety Eyewear

4.3.2 Thermal undergarments

4.3.3 Safety Toed Protective Footwear

4.3.4 Sites may, at their discretion, accept the cost of these personal in nature items as well.

4.4 The site shall document each affected employee has been trained using the Personal Protective Equipment Training Record form, AMS-710-01-FM-03001. The written documentation shall include the name of each employee trained, the dates of the training, and the subject of the training.

4.5 Employee-owned Equipment

4.5.1 Each employee shall be issued a hard hat (AMS-710-02-PR-03100), protective eyewear (AMS-710-02-PR-03200), hearing protection (AMS-710-01-PR-00900), hand protection (AMS-710-02-PR-03400) and/or respiratory protection (AMS-710-02-PR-03500), fall protection (AMS-710-02-PR-00900), personal flotation devices (AMS-710-02-PR-03700) and flagmen and traffic vests (AMS-710-02-PR-03600) if required. An employee wishing to utilize their own PPE must be able to demonstrate it meets APTIM requirements and must pass inspection by the Site HSE Manager.

4.5.2 Employees are responsible to provide their own work clothes (AMS-710-02-PR-03800) and sturdy safety-toed work boots (AMS-710-02-PR-03300) that meet APTIM's PPE requirements. Should an employee report for work with unsatisfactory PPE, the employee will not be permitted to work until APTIM's requirements are met.

4.6 Miscellaneous

4.6.1 Sweat Pads

4.6.1.1 When weather or working conditions cause perspiration, sponge pads can be worn on the forehead to prevent perspiration from seeping into eyes or fogging safety goggles.

4.6.2 Sunscreen

4.6.2.1 Clothing, hats and shade are the best method for protecting skin from ultraviolet (UV) rays. Any remaining exposed skin may be protected by applying sunscreen with approval from the Site HSE Manager. In active facilities approval for use of sunscreen must be obtained from the client.

## 5.0 REFERENCES

| | |
|---|---|
| AMS-710-02-PR-03100 | Head Protection |
| AMS-710-02-PR-03200 | Eye Protection |
| AMS-710-02-PR-03300 | Foot Protection |
| AMS-710-02-PR-03400 | Hand Protection |
| AMS-710-02-PR-03500 | Respiratory Protection |
| AMS-710-02-PR-03600 | Flagmen and Traffic Vests |
| AMS-710-02-PR-03700 | Personal Floatation Devices |
| AMS-710-02-PR-03800 | Basic Work Clothing |
| AMS-710-02-PR-00900 | Fall Protection |
| AMS-710-01-PR-00900 | Noise Control and Hearing Conservation |

## 6.0 TERMINOLOGY

| ***Term*** | ***Definition*** |
|---|---|
| PPE | Personal Protective Equipment |
| Site | Any location, facility or project where APTIM is performing work. Sites may include, but are not limited to, laboratories, offices, shops, owned facilities, leased facilities and/or project sites. |

## 7.0 EXHIBITS

| | |
|---|---|
| Exhibit 7.1 | AMS-710-02-FM-03001 – Personal Protective Equipment Training Record |
| Exhibit 7.2 | AMS-710-02-FM-03002 – Global Approved PPE Listing |
| Exhibit 7.3 | AMS-720-01-FM-00020 – Business Glossary |
| Exhibit 7.4 | AMS-720-01-FM-00021 – Technical Glossary |

## 8.0 ATTACHMENTS

None

# PROCEDURE

| | | | |
|---|---|---|---|
| **Procedure Title:** | **Respiratory Protection** | **AMS Number:** | **AMS-710-02-PR-03500** |
| **Procedure Owner:** | **HSE** | **Issuing Authority:** | **APTIM Quality Management** |

# RESPIRATORY PROTECTION

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| INT | Issued for Interim Use | M. Hadacek & S. Lachney | 7/30/2017 |
| **Rev** | **Changes** | **Approved** | **Date** |

## 1.0 PURPOSE

The purpose of this Procedure is to establish the minimum requirements for Respiratory Protection on APTIM projects and at office, warehouse, or shop locations.

## 2.0 SCOPE

This procedure applies to all APTIM employees, contractors, subcontractors and visitors associated with a APTIM project, office, warehouse, or shop locations.

## 3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure:

- APTIM Managers
- APTIM Supervisors
- APTIM Employees
- APTIM Contractors
- APTIM Subcontractors
- APTIM Visitors

## 4.0 PROCEDURE

Each project, shop, warehouse or facility shall follow this procedure and use it as the minimum guidelines to develop their site specific procedure for Respiratory Protection.

4.1 General

4.1.1 Every consideration will be given to the use of effective engineering controls to eliminate or reduce exposure to respiratory hazards to the point where respirators are not required. However, when feasible engineering controls are not effective in controlling toxic substances, the company, at no charge, will provide appropriate respiratory protective equipment to the employee.

4.1.2 Employees required to use respiratory protective devices because of exposure to toxic substances will do so as a condition of employment. Employees required to use respirators will be properly fitted, appropriately tested, medically screened, and thoroughly trained in their use.

4.2 Written Plan

4.2.1 A written Respiratory Protection Plan will be developed for the specific respiratory hazards of the location based upon a location/task risk assessment. The written Plan will also include information that is to be included in training, the provisions for controlling the distribution of respirators, the method to be used for cleaning and maintenance of respirators, and how the requirements of this Procedure will be met at the location level.

4.2.2 The Location HSE Manager is responsible for the development and implementation of the location-specific respiratory protection program.

4.2.3 The Location HSE Manager will develop a respiratory hazard assessment specific to their risks using AMS-710-02-FM-03507. This hazard assessment will be reviewed, minimally, on an annual basis or as changing conditions warrant.

4.3 Respirator Selection and Use

4.3.1 If a question exists concerning the type of respirator required Corporate HSE shall be consulted.

4.3.2 The Location HSE Manager will select respirators to be used on site, based on the hazards to which workers are exposed. The Location HSE Manager will conduct a hazard evaluation for each operation, process, or work area where airborne

contaminants may be present in routine operations or during an emergency. The hazard evaluation will include:

4.3.2.1 Identification and development of a list of hazardous substances used in the workplace, by department, or work process.

4.3.2.2 Review of work processes to determine where potential exposures to these hazardous substances may occur. This review shall be conducted by surveying the workplace, reviewing process records, and talking with employees and supervisors.

4.3.2.3 Exposure monitoring to quantify potential hazardous exposures.

4.3.3 Issuing Respirators

4.3.3.1 Respirators will not be fit tested or issued to individuals who have facial hair (including stubble) or any other condition, which interferes with the sealing surface of the respirator.

4.3.3.2 Respirators will not be fit tested nor issued to individuals who have not received appropriate respirator training in addition to fit testing and a medical clearance.

4.3.3.3 Employee owned respirators shall not be used.

4.3.4 General Use Procedures:

4.3.4.1 Employees will use their respirators under conditions specified by this program, and in accordance with the training they receive on the use of each particular model. In addition, the respirator shall not be used in a manner for which it is not certified by NIOSH or by its manufacturer.

4.3.4.2 All employees shall conduct user seal checks each time that they wear their respirator. Employees shall use either the positive or negative pressure check (depending on which test works best for them) specified in Appendix B-1 of the Respiratory Protection Standard.

4.3.4.3 All employees shall be permitted to leave the work area to go to the locker room to maintain their respirator for the following reasons: to clean their respirator if the respirator is impeding their ability to work, change filters or cartridges, replace parts, or to inspect respirator if it stops functioning as intended. Employees should notify their supervisor before leaving the area.

4.3.4.4 Employees are not permitted to wear tight-fitting respirators if they have any condition, such as facial scars, facial hair, or missing dentures, that prevents them from achieving a good seal. Employees are not permitted to wear headphones, jewelry, or other articles that may interfere with the face piece-to-face seal.

4.3.4.5 Once the type of respirator that is applicable and suitable for the purpose intended has been selected, the selection process should give consideration to the fit and comfort of the respirator.

4.3.5 Emergency Procedures:

4.3.5.1 When an alarm sounds, employees in the affected department must immediately don their emergency escape respirator, shut down their process equipment, and exit the work area. All other employees must immediately evacuate the building. The location specific Emergency Preparedness Plan describes these procedures (including proper evacuation routes and rally points) in greater detail.

4.3.6 Respirator Malfunction

4.3.6.1 For any malfunction of an APR (e.g., such as breakthrough, facepiece leakage, or improperly working valve), the respirator wearer should inform his or her supervisor that the respirator no longer functions as intended, and go to the designated safe area to maintain the respirator. The supervisor must ensure that the employee receives the needed parts to repair the respirator, or is provided with a new respirator.

4.3.6.2 All workers wearing atmosphere-supplying respirators will work with a "buddy".

4.3.6.3 If a worker experiences a malfunction of an SAR, he or she should signal to the "buddy" that he or she has had a respirator malfunction. The buddy shall don an emergency escape respirator and aid the worker in immediately exiting the spray booth.

4.4 Breathing Air Quality and Use

4.4.1 The Location HSE Manager shall ensure that compressed air, compressed oxygen, liquid air, and liquid oxygen used for respiration accords with the following specifications:

4.4.2 Compressed and liquid oxygen shall meet the United States Pharmacopoeia requirements for medical or breathing oxygen; and

4.4.3 Compressed breathing air shall meet at least the requirements for Grade D breathing air described in ANSI/Compressed Gas Association Commodity Specification for Air, G-7.1-1989, to include:

4.4.3.1 Oxygen content (v/v) of 19.5-23.5%;

4.4.3.2 Hydrocarbon (condensed) content of 5 milligrams per cubic meter of air or less;

4.4.3.3 Carbon monoxide (CO) content of 10 ppm or less;

4.4.3.4 Carbon dioxide content of 1,000 ppm or less; and

4.4.3.5 Lack of noticeable odor.

4.4.4 The Location HSE Manager shall ensure that compressed oxygen is not used in atmosphere-supplying respirators that have previously used compressed air.

4.4.5 The Location HSE Manager shall ensure that oxygen concentrations greater than 23.5% are used only in equipment designed for oxygen service or distribution.

4.4.6 For supplied-air respirators, only Grade D breathing air shall be used in the cylinders. The Location HSE Manager will coordinate deliveries of compressed air with the company's vendor, Compressed Air Inc., and require Compressed Air Inc. to certify that the air in the cylinders meets the specifications of Grade D breathing air.

4.4.7 The Location HSE Manager will maintain a minimum air supply of one fully charged replacement cylinder for each SAR unit. In addition, cylinders may be recharged as necessary from the breathing air cascade system located near the respirator storage area.

4.4.8 For all IDLH atmospheres, the location shall ensure that:

4.4.8.1 One employee or, when needed, more than one employee is located outside the IDLH atmosphere;

4.4.8.2 Visual, voice, or signal line communication is maintained between the employee(s) in the IDLH atmosphere and the employee(s) located outside the IDLH atmosphere;

4.4.8.3 The employee(s) located outside the IDLH atmosphere are trained and equipped to provide effective emergency rescue;

4.4.8.4 The Location HSE Manager shall be notified before the employee(s) located outside the IDLH atmosphere enter the IDLH atmosphere to provide emergency rescue;

4.4.8.5 The Location Area HSE Manager shall review the JSA and approve all respiratory protection to be used in potentially IDLH Environments.

4.4.8.6 Equivalent means for rescue where retrieval equipment is not required.

4.5 Medical Evaluation

4.5.1 Employees who are either required to wear respirators, or who choose to wear an APR voluntarily, must successfully complete a medical evaluation before being permitted to wear a respirator on the job.

4.5.2 Employees are not permitted to wear respirators until a physician has determined that they are medically able to do so. Any employee refusing the medical evaluation will not be allowed to work in an area requiring respirator use.

4.5.3 A licensed and company approved physician will provide the medical evaluations. Medical evaluation procedures are as follows:

4.5.3.1 The medical evaluation will be conducted using AMS-710-02-FM-03501. The Location HSE Manager will provide a copy of this questionnaire to all employees requiring medical evaluations. To the extent feasible, the company will assist employees who are unable to read the questionnaire (by providing help in reading the questionnaire). When this is not possible, the employee will be sent directly to the physician for medical evaluation.

4.5.3.2 All affected employees will be given a copy of the medical questionnaire to fill out, along with a stamped and addressed envelope for mailing the questionnaire to the company physician. Employees will be permitted to fill out the questionnaire on company time.

4.5.3.3 Follow-up medical exams will be granted to employees as required by the standard, and/or as deemed necessary by the company approved physician.

4.5.3.4 All employees will be granted the opportunity to speak with the physician about their medical evaluation, if they so request.

4.5.3.5 The Location HSE Manager has provided the company approved physician with a copy of this program, a copy of the Respiratory Protection standard, the list of hazardous substances by work area, and for each employee requiring evaluation:

- His or her work area or job title
- Proposed respirator type and weight
- Length of time required to wear respirator
- Expected physical work load (light, moderate, or heavy)
- Potential temperature and humidity extremes
- Any additional protective clothing required

4.5.3.6 Any employee required for medical reasons to wear a positive pressure air purifying respirator will be provided with a powered air purifying respirator.

4.5.3.7 After an employee has received clearance and begun to wear his or her respirator, additional medical evaluations will be provided under the following circumstances:

- Employee reports signs and/or symptoms related to their ability to use a respirator, such as shortness of breath, dizziness, chest pains, or wheezing.

- The company approved physician or supervisor informs the Location HSE Manager that the employee needs to be reevaluated;
- Information from this program, including observations made during fit testing and program evaluation, indicates a need for reevaluation;
- A change occurs in workplace conditions that may result in an increased physiological burden on the employee.

4.5.4 The Location HSE Manager will maintain a list of employees currently included in the respiratory protection program and having successfully completed the medical evaluation requirements of this procedure.

4.5.5 All examinations and questionnaires are to remain confidential between the employee and the physician.

4.5.6 Medical Forms

4.5.6.1 When conducting the initial medical evaluation, the Medical Questionnaire for Respirator Use (AMS-710-02-FM-03501) must be used.

4.5.6.2 In addition to the standardized questionnaire, the physician must also be furnished with a copy of the latest OSHA Standard governing the type of exposure to which the employee will be subjected. A description of the employee's duties as they relate to the exposure, the anticipated exposure level, a description of the respiratory protective equipment to be used, and any available information from previous medical evaluations of the employee must also be furnished to the physician on the Request for Medical Evaluation for Respirator Use (AMS-710-02-FM-03502).

4.5.6.3 At the conclusion of the evaluation, the physician will submit a written opinion to the Company on the bottom of AMS-710-02-FM-03502. This will contain the results of the evaluation and any recommendations from the physician regarding the employee's limitations.

4.5.6.4 The Company must furnish a copy of the physician’s opinion to the employee, within thirty (30) days of its receipt by the Company.

4.6 Fit-Testing Requirements

4.6.1 Employees who are required to wear half-facepiece APRs will be fit tested:

4.6.1.1 Prior to being allowed to wear any respirator with a tight fitting facepiece.

4.6.1.2 Annually.

4.6.1.3 When there are changes in the employee’s physical condition that could affect respiratory fit (e.g., obvious change in body weight, facial scarring, etc.).

4.6.2 Employees will be fit tested with the make, model, and size of respirator that they will actually wear. Employees will be provided with several models and sizes of respirators so that they may find an optimal fit. Fit testing of PAPRs is to be conducted in the negative pressure mode.

4.6.3 Respirators will be fitted properly and be tested for their face piece-to-face seal.

4.6.4 There are two acceptable methods for conducting these tests:

- Qualitative
- Quantitative

4.6.5 The fit test is valid only for respirators of the same model and size tested.

4.6.6 Qualitative fit testing is based on the wearer's subjective response to a challenge atmosphere, of which three popular tests are: the irritant smoke test, the saccharin solution test, and the odorous vapor test.

4.6.7 Irritant Smoke Test:

4.6.7.1 Directing an irritant smoke from a smoke tube towards the respirator being worn performs the Irritant Smoke Test. If the wearer does not detect the irritant smoke, a satisfactory fit is assumed to be achieved.

4.6.7.2 Since this type of test provokes an involuntary response from the employee, it is the preferred testing method when available.

4.6.8 Saccharin Solution Test:

4.6.8.1 This test relies on the wearer's ability to taste a saccharin solution sprayed around the outside of the respirator. The test is performed by placing an enclosure over the respirator wearer's head and shoulders and administering the solution from a nebulizer. If the wearer does not react to the chemical, then a satisfactory fit is assumed to be achieved.

NOTE: This test is dependent on the wearer's honest indication of taste. There is not an involuntary response.

4.6.8.2 The saccharin solution aerosol protocol is the only currently available, validated test protocol for use with disposable particulate respirators not equipped with high-efficiency filters.

4.6.9 Odorous Vapor Test:

The odorous vapor test relies on the respirator wearer's ability to detect an odorous material, usually isoamyl acetate (banana oil) inside the respirator. The test is performed by placing an isoamyl acetate saturated material near the respirator. If the wearer is unable to smell the chemical, then a satisfactory fit is assumed to be achieved.

4.6.10 Fit Test Card

4.6.10.1 The respirator wearer shall be issued an employee fit test card (AMS-710-02-FM-03504) with the following information:

- Name
- Date of fit test
- Manufacturer, model, and size of each successfully tested respirator
- Name and signature of the person that conducted the test
- Fit test challenge agent used
- Fit factor if a quantitative fit test was performed

4.6.11 Semi-annual Testing

The qualitative fit test should be repeated at least once every 12 months for routine use.

4.6.12 Fit Checks

There are two tests that are used in the field to check the seal of the respirator. These are known as the positive and negative fit checks. Each of these two tests must be performed every time an employee puts on a respirator and prior to entering a contaminated area.

4.7 Purchase of Approved Equipment

These requirements apply to all NIOSH/MSHA approved respirators used on APTIM locations. Non-approved “Dust Masks” with one strap shall not be used on APTIM projects.

4.8 Cleaning, Care, Maintenance, and Storage

4.8.1 Cleaning

4.8.1.1 Respirators shall be cleaned, disinfected, or sanitized as frequently as necessary recommended weekly to ensure that proper protection is provided to the user. Each worker shall be briefed on the cleaning procedure and be

assured that they will always receive a clean and disinfected/sanitized respirator. Such assurances are very important when respirators are not individually assigned to workers. Respirators maintained for emergency or general use shall be cleaned and disinfected/sanitized after each use.

4.8.1.2 The following procedure is recommended for cleaning and disinfecting/sanitizing respirators:

- Remove any filters, cartridges, canisters, speaking diaphragms or valve assemblies.
- Wash facepiece and breathing tube in cleaner-disinfectant or detergent solution (43°C or 110°F maximum temperature). Use a soft hand brush to help in removal of dirt and grime.
- Rinse completely in clean water (43°C or 110°F maximum temperature).
- Air dry in clean area or wipe dry with clean rags.
- Clean other respirator parts as recommended by the manufacturer.
- Inspect valves, headstraps, and other parts. Replace with new parts if defective.
- Insert new filters, cartridges, or canisters, and make sure seal is tight.
- After completely dry, place in a plastic zip-lock baggie or other suitable container for storage.

4.8.1.3 Cleaner-disinfectant solutions are available that effectively clean the respirator and contain a bactericidal agent.

4.8.1.4 Alternately, respirators may be washed in a liquid detergent solution, and then wiped with a clean piece of paper toweling, which has been dipped into a disinfecting/ sanitizing solution or a solution of rubbing alcohol. The respirator must then be rinsed in fresh water and air dried.

4.8.1.5 Respirators must be cleaned and disinfected after each day's use.

4.8.1.6 Respirator-freshening wipes are not an adequate substitute for this cleaning and disinfecting process.

4.8.1.7 The location shall assign specific individuals to be responsible for the cleaning and disinfecting of respirators.

4.8.1.8 A log shall be maintained which will include a record of date of cleaning and the cleaning attendant.

4.8.2 Storing the Respirator

4.8.2.1 When respirators are not being used, they shall be individually sealed in plastic bags and stored at locations established by location management in order to protect them against dust, sunlight, extreme temperatures, excessive moisture, or damaging chemicals. Respirators should not be stored (thrown) in toolboxes or gang boxes. They shall be stored in such a way that the face piece and exhalation valve are not distorted.

4.8.2.2 Atmosphere supplying respirators will be stored in the storage cabinet outside of the Location HSE Manager’s office.

4.8.3 Inspecting the Respirator

4.8.3.1 All respirators shall be inspected by the individual before and after each use, and at least monthly by the user's supervisor to ensure that they are in satisfactory working condition. These maintenance inspections will be documented by the supervisor using AMS-710-02-FM-03509.

4.8.4 Maintenance

4.8.4.1 Personnel involved in respirator maintenance shall be thoroughly trained. Substitution of parts from different brands or types of respirators invalidates approval of the device. Repairs and adjustments should never be made beyond the manufacturer's recommendations.

4.8.4.2 Respirators are to be properly maintained at all times in order to ensure that they function properly and adequately protect the employee. Maintenance involves a thorough visual inspection for cleanliness and defects. Worn or deteriorated parts will be replaced prior to use.

4.8.4.3 No components will be replaced or repairs made beyond those recommended by the manufacturer. Repairs to regulators or alarms of atmosphere-supplying respirators will be conducted by the manufacturer.

4.8.4.4 The following checklist will be used when inspecting respirators

- Facepiece:
  - cracks, tears, or holes
  - facemask distortion
  - cracked or loose lenses/faceshield
- Headstraps:
  - breaks or tears
  - broken buckles
- Valves:
  - residue or dirt
  - cracks or tears in valve material
- Filters/Cartridges:
  - approval designation
  - gaskets
  - cracks or dents in housing
  - proper cartridge for hazard
- Air Supply Systems:
  - breathing air quality/grade
  - condition of supply hoses
  - hose connections
  - settings on regulators and valves

4.8.4.5 Employees are permitted to leave their work area to perform limited maintenance on their respirator in a designated area that is free of respiratory hazards. Situations when this is permitted include to wash their face and respirator facepiece to prevent any eye or skin irritation, to replace the filter, cartridge or canister, and if they detect vapor or gas breakthrough or leakage in the facepiece or if they detect any other damage to the respirator or its components.

4.8.5 Defective Respirators

4.8.5.1 Respirators that are defective or have defective parts shall be taken out of service immediately.

4.8.5.2 If, during an inspection, an employee discovers a defect in a respirator, he/she is to bring the defect to the attention of his or her supervisor. Supervisors will give all defective respirators to the Location HSE Manager. The Location HSE Manager will decide whether to:

- Temporarily take the respirator out of service until it can be repaired.
- Perform a simple fix on the spot such as replacing a headstrap.
- Dispose of the respirator due to an irreparable problem or defect.

4.8.5.3 When a respirator is taken out of service for an extended period of time, the respirator will be tagged out of service, and the employee will be given a replacement of similar make, model, and size. All tagged out respirators will be kept in the storage cabinet inside the Location HSE Manager's office.

4.9 Training

4.9.1 All personnel shall be trained in the proper use of respirators prior to wearing one in the field.

4.9.2 The Location HSE Manager will provide training to respirator users and their supervisors on the contents of the Respiratory Protection Program and their responsibilities. Workers will be trained prior to using a respirator in the workplace. Supervisors will also be trained prior to using a respirator in the workplace or prior to supervising employees that must wear respirators.

4.9.3 The training course will cover the following topics:

- The location specific Respiratory Protection Program
- The OSHA Respiratory Protection standard
- Respiratory hazards encountered at the location and their health effects
- Proper selection and use of respirators
- Limitations of respirators
- Respirator donning and user seal (fit) checks
- Fit testing
- Emergency use procedures
- Maintenance and storage
- Medical signs and symptoms limiting the effective use of respirators

4.9.4 Employees will be retrained annually or as needed (e.g., if they change departments and need to use a different respirator). Employees must demonstrate their understanding of the topics covered in the training through hands-on exercises and a written test. Respirator training will be documented by the Location HSE Manager and the documentation will include the type, model, and size of respirator for which each employee has been trained and fit tested.

4.10 Program Evaluation

The Location Manager shall ensure that the Program is periodically evaluated to determine the effectiveness of the Program during all phases of operation in which respirators are being used. Frequent walk-through inspections during these activities shall be conducted to monitor and document supervisor and worker compliance with the requirements of the program. In addition to general assessment of the overall Respiratory Protection Program, specific evaluations of the respirator cleaning, inspection, maintenance, repair, storage, and use practices shall be conducted and documented weekly to ensure that the desired results of these operations are consistently achieved.

4.11 6.0 Documentation and Recordkeeping

4.11.1 A written copy of this program will be maintained in the Location HSE Manager's office and is available to all employees who wish to review it.

4.11.2 Also maintained in the Location HSE Manager's office are copies of training and fit test records.

4.11.3 These records will be updated as new employees are trained, as existing employees receive refresher training, and as new fit tests are conducted.

4.11.4 The Location HSE Manager will also maintain copies of the medical records for all employees covered under the respirator program. The completed medical questionnaire and the physician's documented findings are confidential and will remain at the company

approved medical provider. The company will only retain the physician's written recommendation regarding each employee's ability to wear a respirator.

## 5.0 REFERENCES

Title 30, Part II of the Code of Federal Regulations - NIOSH/MSHA Approvals for Respirators

Title 29 CFR (Code of Federal Regulation) 1926.103 Respiratory Protection

Title 29 CFR (Code of Federal Regulation) 1910.134 Respiratory Protection

Title 29 CFR (Code of Federal Regulation) 1910.1020 Hazardous waste operations and emergency response.

Title 30, Part II of the Code of Federal Regulations - NIOSH/MSHA Approvals for Respirators

American National Standards Institute - Practices for Respiratory protection Z88.2-1992

American National Standards Institute - Practices for Respiratory protection Z88.2-1992

## 6.0 TERMINOLOGY

| ***Term*** | ***Definition*** |
|---|---|
| Approved | Tested and listed as satisfactory jointly by the Mine Safety and Health Administration (MSHA) of the U. S. Department of Labor and the National Institute for Occupational Safety and Health (NIOSH) of the U. S. Department of Health and Human Services. |

## 7.0 EXHIBITS

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| Exhibit 7.1 | AMS-710-02-FM-03501 – Medical Questionnaire for Respirator Use |
| Exhibit 7.2 | AMS-710-02-FM-03502 – Request for Medical Evaluation for Respirator Use |
| Exhibit 7.3 | AMS-710-02-FM-03503 – Respirator Training and Fit Test Record |
| Exhibit 7.4 | AMS-710-02-FM-03504 – Employee Fit Test Card |
| Exhibit 7.5 | AMS-710-02-FM-03505 – Selection Table for Respiratory Protection |
| Exhibit 7.6 | AMS-710-02-FM-03506 – Respiratory Protection Training Program Certificate |
| Exhibit 7.7 | AMS-710-02-FM-03507 – Location Specific Respiratory Hazard Evaluation Form |
| Exhibit 7.8 | AMS-710-02-FM-03508 – Location Specific Voluntary and Mandatory Respirator Use |
| Exhibit 7.9 | AMS-710-02-FM-03509 – Monthly Maintenance Checklist for Respirators |
| Exhibit 7.10 | AMS-720-01-FM-00020 – Business Glossary |

Exhibit 7.11 AMS-720-01-FM-00021 – Technical Glossary

## 8.0 ATTACHMENTS

None

# PROCEDURE

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| **Procedure Title:** | **Permit to Work** | **AMS Number:** | **AMS-710-02-PR-06400** |
| **Procedure Owner:** | **HSE** | **Issuing Authority:** | **APTIM Quality Management** |

# PERMIT TO WORK

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| INT | Issued for Interim Use | M. Hadacek & S. Lachney | 7/30/2017 |
| **Rev** | **Changes** | **Approved** | **Date** |

## 1.0 PURPOSE

The purpose of this Procedure is to establish the minimum requirements for a permit to work system on APTIM sites.

## 2.0 SCOPE

This procedure applies to all APTIM employees, contractors, subcontractors, and visitors associated with a APTIM site.

## 3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure:

- APTIM Managers
- APTIM Supervisors
- APTIM Employees
- APTIM Contractors
- APTIM Subcontractors
- APTIM Visitors

## 4.0 PROCEDURE

Each site shall make every attempt to prevent the possibility of incidents and accidents to employees when performing work activities through implementation, as determined by the Site HSE Manager and the Site Manager, of this non-mandatory permit to work system.

4.1 General

4.1.1 The intent of this procedure is to describe the APTIM Permit to Work System (PTW), which is used to provide the controls necessary during construction and commissioning activities in ensuring the safe performance of potentially hazardous tasks which cannot be adequately controlled under standard work practices, procedures, or method statements.

4.1.2 This procedure specifically applies to all site activities under the control of APTIM and as determined by the Site HSE Manager and the Site Manager.

4.1.3 This procedure may be superseded by Client mandated PTW.

4.1.4 This PTW is not required to be implemented during routine/normal construction activities. Activities where PTW shall be implemented may include:

4.1.4.1 Where a task is deemed hazardous and/or specific control measures are required above and beyond standard work practices e.g.,

- Excavations.
- Hotwork.
- Confined space entry (including activities that may generate hazardous atmospheres)
- Energised systems.
- Radiography (surveys using radioactive source).
- Heavy and/or Critical Lifts

4.1.4.2 In special cases when the APTIM Site HSE Manager and/or Site Manager deems it necessary to keep adequate control of hazards on site or area construction

4.1.5 This procedure shall be applied to all APTIM and subcontractor construction activities including construction or maintenance activities.

4.1.6 Any work or activity not falling under the category of a permitted activity or type of activity as listed in 4.1.3 shall be controlled by the "Work Area Hazard Assessment Process" (AMS-710-05-PR-01700).

4.2 Key Personnel and Associated Activities

4.2.1 The Issuer (The Party who Approves the Permit)

4.2.1.1 The Issuer has the sole authority to issue and approve the permit.

4.2.1.2 The Issuer shall be fully aware of Site conditions, the type of work to be carried out, and all the requirements stated in the permit.

4.2.1.3 The Issuer shall consult with the APTIM HSE Department to ensure all required safety precautionary measures are stated in the permit.

4.2.1.4 Prior to approving a permit, the Issuer shall conduct an onsite inspection jointly together with the Executor to ensure that Site conditions are safe to work, that there are no interferences either to or from other work groups, and ensure that all requirements stated in the permit are implemented.

4.2.1.5 The Issuer shall withhold approval of the permit if the requirements are not met, or Site conditions are not safe for the work to be carried out.

4.2.1.6 The Issuer shall, if noticing the presence of any other potential hazards that may jeopardize the safety of the workers, tools, or equipment, stop the work and then advise the Executor of appropriate countermeasures to be taken before approving the permit.

4.2.1.7 The Issuer shall ensure that all required safety-monitoring measurements are properly completed prior to the approval of the permit and so stated in the permit, e.g., gas tests, isolation of potential energy releases.

4.2.1.8 Once informed that the work is complete, the Issuer shall visit the Site jointly with the Executor to ensure that the work has been completed and the site is duly reinstated and proper job site clean up is complete.

4.2.2 The Executor (Receiver of the Permit)

4.2.2.1 The Executor must be able to speak, read, and write at a level sufficient to understand the requirements of the permit.

4.2.2.2 The Executor shall accept all requirements stated in the permit and comply with them at all times.

4.2.2.3 The Executor shall ensure that his work crew fully understand requirements stated in the permit and that the pre-task safety toolbox meeting attendance is completed for every permit.

4.2.2.4 The Executor shall ensure the requirements specified in the permit are implemented prior to the commencement of the work. He shall remain at the workplace to supervise the work at all times while the work is in progress, as defined in the PTW. In the event that the supervisor must leave the workplace for any reason, he must either arrange for an alternate, competent person as a stand in or the work must cease until such a person is provided. This change over must be recorded in writing and accepted by the Issuer.

4.2.2.5 The Executor shall under no circumstances, either by his own discretion or that of his work crew, change the original scope of the work, which is described in the permit.

4.2.2.6 The Executor shall request a new permit in the event a change in the scope of the work becomes necessary.

4.2.2.7 Whenever Site conditions are drastically changed such as to create a hazard, the Executor shall immediately stop the work and inform the Issuer of the change and await further instruction from him/her.

4.2.2.8 Upon the occurrence of an emergency, the Executor shall immediately stop the work and follow emergency procedure. Upon resolution of the emergency, the Executor shall have the PTW revalidated before resuming work.

4.2.2.9 The Executor shall report the completion of the work or the expiration of the validity of the permit to the Issuer and on completion of the work ensure that the site is duly reinstated without any remaining risks.

4.2.3 Authorized Gas Testers (AGT)

4.2.3.1 All Authorized Gas Testers must undergo the AGT course which is presented by APTIM and annual training thereafter.

4.2.3.2 APTIM will maintain a register of personnel who have undertaken this course. This course will cover issues such as the physical and chemical properties of gases, the reasons for testing, and the method of testing. In addition to the classroom based course a competent person will assess the AGT in the field.

4.2.3.3 All gas detectors shall be bump tested in accordance with the manufacturer's guidelines. The bump test and reading will be documented.

4.2.3.4 All gas detectors must be calibrated by a third party at a frequency stated by the manufacturer as a minimum or when it fails a bump test. APTIM will maintain a register of records of calibration for all of their detectors.

4.2.3.5 The AGT must ensure that the gas meter in use is fully functional and has an in-date calibration certificate.

4.2.3.6 The Authorized Gas Testers approved by APTIM shall conduct any required gas testing prior to the commencement of the work and validation of the PTW.

4.2.3.7 In case the concentration of any gas is detected outside of the permissible level of concentration ($H_2S$, 0ppm, LEL >2%, $O_2$ 19.5-23%) the AGT shall withhold the permit and immediately inform the Issuer and conduct retesting. Should the re-test also show levels in excess of these concentrations then additional means of ventilation shall be employed, such as fans, air movers, etc., prior to allowing work to commence.

4.2.3.8 Gas tests shall be carried out before any entry into a Confined Space and before validation of any Hot Work Permit. The AGT will use appropriate PPE, (SCBA, SABA), while testing an unknown atmosphere in a confined space where the AGT has to enter the confined space to take the readings.

4.2.3.9 AGT's may be required, depending upon the work, to carry out further gas tests throughout the working day. Should any gas concentration exceed those stated above, then the work shall be immediately stopped and APTIM informed.

4.2.4 The APTIM Permit Coordinator

4.2.4.1 The designated Permit Coordinator reports to the APTIM Construction Manager and is responsible for daily coordination of the work permits, including maintenance of a log showing the status of all PTW's. In addition, he/she shall maintain a copy of all PTW's Job Safety Analysis and Method Statements in sequential order.

4.2.4.2 He/she is responsible for full clerical control of the permit to work system including retention of the closed out Work Permits until the end of the Site.

4.2.4.3 He/she is responsible for displaying all planned, open, and suspended work permits on visual display in the permit to work office.

4.3 Permit to Work (PTW) System Components

4.3.1 Under this procedure, individual Permit to Work Forms are issued for works as described in section 4.1.4.

4.3.2 A set of PTW Forms, applicable Certificates, Documents, and authorized Permit signatories is called a PTW System. The components of the PTW are described below.

4.3.3 Permit to Work

4.3.3.1 A Permit to Work (PTW) is an official document with which APTIM authorizes activities to be carried out under specific safe working conditions. It is a signed declaration by the Issuing Party that the worksite conditions are safe to perform the specified task within a specified period. The work shall be done in accordance with the requirements of the PTW.

4.3.3.2 Each PTW shall be uniquely and individually numbered for identification purposes with sufficient copies made for all parties involved.

4.3.3.3 Every application for a PTW must have attached to it as a minimum the following supporting documentation:

- Job Safety Analysis (JSA)
- Material Safety Data Sheet (MSDS) where applicable
- Other items that may be required include:

1. Marked up Drawings
2. Isolation details, LO/TO
3. Crane Inspection Certificate, including load test
4. Rigging Certificates
5. Competent Person Certificates.
6. Rigging/Lifting Plan

4.4 Types of Work Requiring a Permit to Work

Any work falling into the following categories may require a specific PTW issued by APTIM. The APTIM Site HSE Manager and Site Manager may designate any other works as work requiring a permit in addition to the above when deemed necessary.

4.4.1 Excavation/Ground Disturbance

The definition of an excavation shall be consistent with AMS-710-02-PR-01600. For the purposes of the PTW the definition of excavation/ground disturbance may also include, but not be limited to:

- Any excavation involving the removal of soil deeper than thirty (30) cm or driving of a peg below this depth in areas known to have underground piping/utilities
- Cutting into of ground or floors below surrounding level where there is the risk of damage to existing services or harm to personnel
- Cutting into or drilling into walls or ceilings where existing services are known to run

4.4.2 Hot Work

All work involving ignition sources performed within fifteen meters (15m) of equipment containing flammable/combustible liquids or work performed within ten meters (10m) of large quantities of ordinary combustible materials (e.g., cardboard, wood).

4.4.3 Electrical Work

Any work requiring de-energizing or isolation of electrical System and/or its associated component parts including any work on any item or piece of equipment capable of being electrically charged or activated, energized or pressurized.

4.4.4 Confined Space Entry

Any entry into an area which is not designed for human occupancy has restricted access/egress or where the presence of toxic or flammable gases or deficiency/enrichment in oxygen possibly exists, as defined in AMS-710-02-PR-01700.

4.4.5 Heavy and/or Critical Lifts

The following lifts will require a Permit to Work:

- Lifts over live Equipment or Plant
- Lifts equal to or exceeding eighty percent (80%) of crane's rated capacity.
- Lifts of > 25 tons
- Lifts requiring more than one crane.

4.4.6 Radiation Work

Any work requiring the use of radioactive sources or x-ray machines for NDE works.

4.5 Validity of the Permit

Validity of the permit shall be restricted to the number of hours or days as specified in the permit, to a maximum of seven (7) days. No works shall be carried out after the validity has expired unless the permit has been duly extended or a new permit has been obtained from the Issuer.

4.6 Revalidation of the Permit

If the validity of the permit extends across more than one working day/shift then the permit shall be re-validated by the Executor at the start of the oncoming shift.

4.7 Closure of the Permit

4.7.1 On completion of the work, the Executor shall signify that the work is complete and that they wish to close the permit by signing in the correct space on the permit and returning the permit to the Issuer.

4.7.2 The permit is only considered closed when signed by the Issuer and after the Issuer has visited the Site and confirmed that the worksite has been left in a safe condition.

4.8 Training and Authorization

4.8.1 All Permits to Work Executors are required to attend the APTIM Permit to Work Training course and must pass an accompanying written examination.

4.8.2 All Executors must be sufficiently conversant, written and verbal, to enable them to understand the requirements that the PTW places on them and their workers.

4.8.3 In the event of any incident involving non-compliance with a PTW then the relevant Executor must undergo refresher training before he is allowed to sign further permits.

4.8.4 No Executor will be permitted to undergo more than two (2) refresher courses before he/she is removed from the authorized list permanently.

4.9 Operational Procedures for the APTIM PTW System

4.9.1 Under this procedure, there are three-sheet PTW Forms.

4.9.2 Original Form of PTW shall stay at the worksite with the Executor, the subcontractor task supervisor/engineer responsible for the work as stated in the PTW. The PTW must be displayed on a stand located at the workplace; the stand should be clearly

marked and placed in a prominent location within the work area. The first copy remains with the Issuer of the permit. The second copy is held by the PTW Coordinator.

4.9.3 The description of the work shall be a precise statement of the planned activity and the location of the work by identification of the area or equipment to be worked upon. Broad scopes of work of a general nature are not acceptable.

4.9.4 Job Safety Analyses will be produced and shall be attached to form part of the permit. Such additional documents shall be attached to the original of the Permit.

4.9.5 The Executor shall submit the permits to the Issuer by 08:00 hours the day before the actual commencement of the work.

4.9.6 The Issuer shall distribute the permits to the APTIM PTW Coordinator for HSE review and verification by 11:00 hours the day before work commences.

4.9.7 The APTIM Permit Coordinator shall submit the permits to the Site Construction Manager or his designee who shall verify that all HSE requirements specified in the permits are appropriate and return the verified permits to the Permit Coordinator.

4.9.8 The APTIM Permit Coordinator shall produce all verified permits to the Issuer the evening before work is due to commence.

4.9.9 The Issuer shall review the permit to ensure that all required safety precautionary measures are stated and that concurrence has been received from all appropriate parties for authorization of the permits.

4.9.10 On the day of the work, the Issuer or his nominees together with the Executor shall go to the Site to ensure that all requirements in the permit are met and hand over the permit to the Executor. Issuance of the permit to the Executor in the office shall not take place.

4.9.11 Upon receipt of the permit from the Issuer, the Executor can commence the work after the HSE requirements of the permit have been discussed with the personnel performing the work. (JSA and 5 X 5 Pre-Task Safety Talk)

4.9.12 When the work is completed, or when no further work is to take place under a permit, the Executor shall sign in the permit and return the permit to the Issuer or his nominees to indicate he has completed the work satisfactorily.

4.9.13 Upon receipt of the permit, the Issuer and the Executor shall inspect the work Site to ensure that the work Site is duly reinstated with all waste material removed and no remaining risks. When satisfied that the site has been left in a safe condition the Executor shall sign the permit as closed.

4.9.14 The Issuer shall return the completed permit to the APTIM Permit Coordinator for file.

4.9.15 The APTIM permit coordinator shall attach the original of the closed permit to his file copy to verify closure. Copies of closed permits are to be kept for the life of the site; remaining copies may be disposed of.

4.10 Emergency and Changing Conditions

4.10.1 In the event of an emergency, the Executor shall immediately stop all works and shut down all equipment before moving to the appropriate Muster Point.

4.10.2 All permits shall be nullified and no work shall be resumed unless the permit has been revalidated or a new permit has been issued out by the Issuer.

4.10.3 Prior to the revalidation or issuance of a new permit, the Issuer shall visit the work Site to ensure that there is no imminent hazard/risk present and that the Work Site is safe to work.

4.10.4 All workers have the right to stop work should they find an unsafe condition after inspection of the Work Site and work methods that the conditions listed in the permit are not being followed.

4.10.5 Should the work conditions change significantly, e.g., underground services being found where not expected, a positive gas reading in excess of the levels mentioned above, or other such circumstances, the work must be immediately stopped and the Issuer informed. In such cases, the permit will be reviewed and if necessary cancelled and a new PTW issued taking account of new circumstances.

## 5.0 REFERENCES

| | |
|---|---|
| AMS-710-05-PR-01700 | Work Area Hazard Assessment Process |
| AMS-710-02-PR-01600 | Excavation and Trenching |
| AMS-710-02-PR-01700 | Confined Space Entry |

## 6.0 TERMINOLOGY

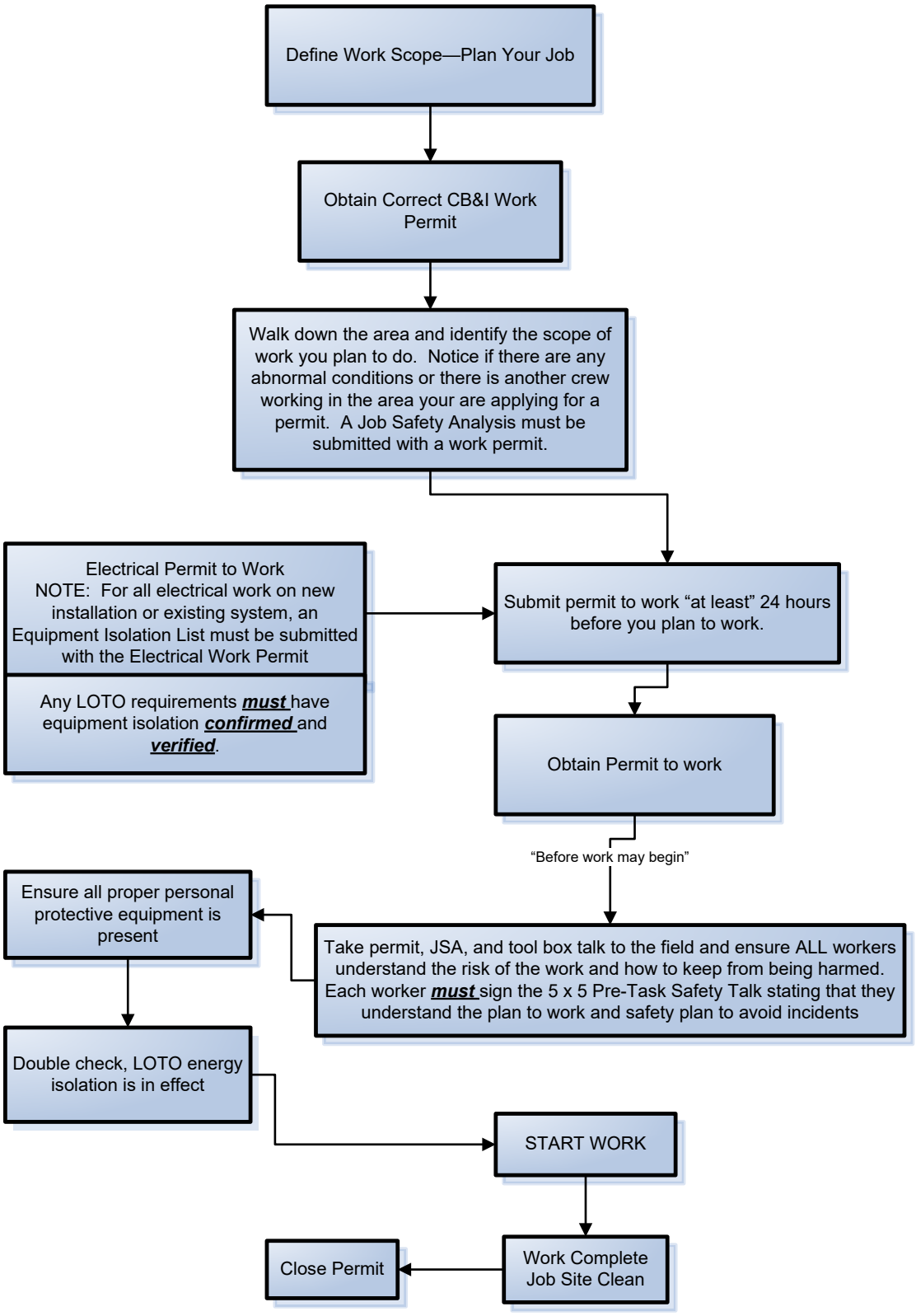
| ***Term*** | ***Definition*** |
|---|---|
| Executor | • This is the person responsible for initiating the PTW and supervising the work specified in the PTW.<br>• The Executor may be APTIM or subcontractor. |
| Issuer | • For activities taking place within the site, the Issuer will always be APTIM or supervisors nominated by the Site Construction Manager and Site HSE Manager to approve the permits.<br>• APTIM will develop and maintain a list of positions authorized to issue permits, including nominated personnel allowed to sign. |
| Site | Any location, facility, or project where APTIM is performing work. Sites may include, but are not limited to, laboratories, offices, shops, owned facilities, leased facilities and/or project sites. |
| The Authorized Gas Testers (AGT) | • The only personnel authorized to perform initial gas tests required for permit validation. Authorized Gas testers must pass the AGT training course provided by APTIM.<br>• Initial gas tests for the validation of PTW' s may only be carried out by AGT' s from APTIM, follow up testing during the working day may then be performed by AGT' s from the subcontractor. |

## 7.0 EXHIBITS

| | |
|---|---|
| Exhibit 7.1 | PTW Flow Chart |
| Exhibit 7.2 | AMS-720-01-FM-00020 – Business Glossary |
| Exhibit 7.3 | AMS-720-01-FM-00021 – Technical glossary |

## 8.0 ATTACHMENTS

None


Define Work Scope—Plan Your Job
Obtain Correct CB&I Work Permit
Walk down the area and identify the scope of work you plan to do. Notice if there are any abnormal conditions or there is another crew working in the area your are applying for a permit. A Job Safety Analysis must be submitted with a work permit.
Electrical Permit to Work
NOTE: For all electrical work on new installation or existing system, an Equipment Isolation List must be submitted with the Electrical Work Permit
Any LOTO requirements must have equipment isolation confirmed and verified.
Submit permit to work "at least" 24 hours before you plan to work.
Obtain Permit to work
"Before work may begin"
Ensure all proper personal protective equipment is present
Take permit, JSA, and tool box talk to the field and ensure ALL workers understand the risk of the work and how to keep from being harmed. Each worker must sign the 5 x 5 Pre-Task Safety Talk stating that they understand the plan to work and safety plan to avoid incidents
Double check, LOTO energy isolation is in effect
START WORK
Work Complete Job Site Clean
Close Permit

# PROCEDURE

| | | | |
|---|---|---|---|
| **Procedure Title:** | **Medical Surveillance Program** | **AMS Number:** | **AMS-710-01-PR-05000** |
| **Procedure Owner:** | **HSE** | **Issuing Authority:** | **APTIM Quality Management** |

# MEDICAL SURVEILLANCE PROGRAM

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| INT | Issued for Interim Use | M. Hadacek & S. Lachney | 7/30/2017 |
| **Rev** | **Changes** | **Approved** | **Date** |

## 1.0 PURPOSE

The purpose of this Procedure is to establish the minimum requirements for the implementation and management of the Medical Surveillance Program.

## 2.0 SCOPE

This procedure applies to all APTIM employees and temporary employees associated with a APTIM site.

Subcontractors and lower tier subcontractors (a lower tier subcontractor is any subcontractor at any level working on any company project whether directly with APTIM or through a third party) are required to provide documentation that they maintain, at a minimum, a medical surveillance program equal to this procedure.

## 3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure.

- APTIM Managers
- APTIM Supervisors
- APTIM Employees
- APTIM Contractors
- APTIM Subcontractors
- APTIM Vendors
- APTIM Site Visitors

## 4.0 PROCEDURE

4.1 Medical screening and medical surveillance are two fundamental necessities for ensuring the health and safety of employees when used in conjunction with AMS-710-01-PR-02300 Occupational Health Plan. Medical screening is, in essence, only one component of a comprehensive medical surveillance program. Occupational health regulations concerning “medical surveillance” requirements are generally a combination of medical screening and medical surveillance and are clinically focused with information obtained from the clinical processes used in the monitoring and analysis of results.

4.2 The company’s Medical Surveillance Program consists of various examination protocols which vary based upon each employee’s essential job functions, site specific requirements, and jurisdictional regulatory requirements.

4.3 General

4.3.1 APTIM reserves the right to modify this procedure at any time consistent with changes in medical procedures, technologies, laws, or APTIM's operational needs. This procedure shall not, in any event, alter the basic "at will" status of any employee, nor shall it create any expressed or implied contractual rights relative to employment with APTIM.

4.3.2 This procedure is subject to the regulations, laws, and customs of the jurisdictions in which the work will occur; therefore, each APTIM site will use this procedure as a template to create a site specific medical surveillance procedure.

4.3.3 This procedure is intended to set forth the minimum medical surveillance program standards for APTIM. In accordance with the applicable authority matrices, business groups or projects may implement more stringent requirements as needed to satisfy any specific industry concerns, additional contractual, legal, and/or regulatory obligations that may be applicable.

4.3.4 Medical surveillance exams and consultations will be performed by or under the direct supervision of a licensed physician and all medical test analyses should be performed

by a laboratory that has demonstrated satisfactory performance in an established inter-laboratory testing program and meets the minimum requirements for certification in the jurisdiction in which it is located.

4.3.5 APTIM will provide medical surveillance exams at a reasonable time and location, at no cost to the employee and without loss of pay.

4.3.6 The licensed physician providing written opinion may review the result of any associated drug screen against the medical questionnaire when evaluating the final opinion. Failure to disclose any medical condition or the use of any prescribed medication capable of affecting the employee's mental and/or physical ability to perform the essential functions of the job on the medical questionnaire is a violation of this procedure and is grounds for disciplinary action up to and including termination.

4.4 Baseline Medical Protocols

4.4.1 Employees will be subject to pre-employment and pre-placement baseline examination based on the essential functions of the job, site-specific requirements, and the regulatory requirements of the jurisdiction. Baseline examinations are performed on a conditional post offer basis, and when potential hazardous exposures are identified by the project site's hazardous risk assessment.

4.4.1.1 All baseline examinations are conducted strictly upon a post-offer of employment and/or pre-placement basis. The individual responsible for scheduling the examinations must verify that a formal offer of employment has been made and the offer accepted prior to arranging the exam.

4.4.1.2 Following an employment offer and prior to becoming an active employee, the prospective employee will be tested for alcohol and illegal drugs. No prospective employee will begin work on any project or at any subcontractor location without submitting to and successfully passing an approved pre-employment drug test pursuant to the requirements set forth in the Substance Abuse Program procedure AMS-710-01-PR-03600.

4.4.1.3 Offer letters must be provisioned that the receipt of a negative drug/alcohol screen result and physician written opinion (PWO) noting that an individual is medically fit to perform the specific job assignment is required prior to proceeding with employment.

4.4.2 All employees whose job functions involve potential exposure at or above action levels are subject to periodic/annual examinations as required by the occupational health laws of the jurisdiction.

4.4.3 Employees who participate in the asbestos medical surveillance program must follow the requirements set forth in AMS-710-01-PR-02500 Asbestos on the Job.

4.5 Periodic/Annual Medical Protocols

The frequency and content of examinations will vary based on the essential functions of the job, site-specific requirements, and the regulatory requirements of the jurisdiction. More frequent examinations may be necessary, depending on the extent of potential or actual exposure, the type of chemicals involved, the duration of the work assignment, and the individual worker's profile.

4.6 Exit Protocols

At the end of employment, all personnel in the medical surveillance program should complete an Exit Examination Acceptance/Declination form. Exit examinations are required for all employees leaving the company unless their most recent exam is less than six months old.

4.7 Medical Surveillance Protocols – Baseline, Periodic/Annual, and Exit, as applicable, includes but is not limited to:

1. 1,2-dibromo-3-chloropropane

2. 1,3-Butadiene
3. Acrylonitrile
4. Arsenic (Inorganic) (AMS-710-01-PR-02900)
5. Asbestos (Construction and Shipyards)
6. Asbestos (General Industry)
7. Benzene (AMS-710-01-PR-03000)
8. Bloodborne Pathogens (AMS-710-01-PR-00300)
9. Cadmium
10. Carcinogens (Suspect)
11. Chromium(VI), Hexavalent Chromium (AMS-710-01-PR-03800)
12. Coke Oven Emissions
13. Compressed Air Environments
14. Crane Operator Exam
15. Designated Qualified Operator Exam (DQO)
16. Diver Exam
17. Diver Medical Exam
18. DOT Exam (Department of Transportation)
19. Ethylene Oxide
20. Fit for Duty Exam – Craft, Professional/Salary, and Clean Construction (Union/Non-Union) (AMS-710-01-PR-01100)
21. Fit for Duty Exam – Field Labor (AMS-710-01-PR-01100)
22. Formaldehyde
23. Functional Assessment Exam
24. GE Hudson Exam
25. HAZWOPER Field Exposure
26. Knoll's Atomic Power Laboratory (KAPL)
27. Laboratory - Hazardous Chemicals
28. Lead (AMS-710-01-PR-02700)
29. Medical Surveillance Exams – Baseline, Periodic/Annual, and Exit (AMS-710-01-PR-03500)
30. Methylene Chloride
31. Methylenedianiline
32. Noise (AMS-710-01-PR-00900)
33. Pre-Placement General Labor Exam
34. Quantitative/ Qualitative Respirator Fit Test
35. Respirator Certification Exam (AMS-710-02-PR-03500)
36. U.S. Army Corp of Engineers (USACE)
37. Vaccinations (Business Travel and Potential Exposure)
38. Vinyl Chloride

4.8 Physician Written Opinions (PWO)

4.8.1 It is important to note that physician written opinions (PWO) are not considered confidential medical records. The physician written opinion (PWO) is designed and intended to communicate employee medical clearances, restrictions, and disqualifications to management and the employee. A physician written opinion (PWO) that notes restrictions will be signed by both the employee and the employee's manager.

4.8.2 The physician written opinion (PWO) must include:

a. Name of the individual
b. Date of the exam
c. Employee number or personal identification numbers
d. Name of the specific regulation upon which the medical opinion was based (if applicable)

e. If any detected medical conditions would place the employee at increased risk of material impairment of the employee's health while working in the specific job position

f. Recommended limitations/restrictions upon the employee's assigned work

g. If the employee is unable to perform his or her job duties with or without accommodations

h. If the employee has been informed of the examination results

i. Any medical recommendations for respirator use such as:

- No limitations,
- Medically not able to wear a respirator,
- May wear a respirator for escape only,
- Any specific limitations that have been placed on the use of the respirator, and
- If the document has been provided to the employee.

j. Date, printed name, and signature of the licensed physician providing the opinion

4.8.3 Whenever a restricted medical clearance is issued, the HSE manager, Human Resource manager, and hiring manager will be notified and will determine if the medical restriction will have an impact on the employee's ability to perform the essential duties of the intended job.

Specifically, all persons must be able to perform the essential functions of their job, with or without reasonable accommodations, and without posing a direct threat to the health and safety of themselves or others.

4.9 Re-Hiring Former Employees

4.9.1 When a former employee is being re-hired, if the most current company medical examination is less than six months old and the HSE manager can confirm that the individual was not subject to hazardous exposures during non-company employment, the HSE manager may choose to waive a new baseline examination. Periodic/Annual examinations will be based on the most recent examination date rather than a new date of hire.

4.9.2 Returning former employees shall be subject to post offer/pre-employment drug and alcohol testing at the time of re-hire unless the break in service has been less than 30 days, as permitted under the laws and customs of the jurisdiction in which the employee is employed.

## 5.0 REFERENCES

| | |
|---|---|
| AMS-710-01-PR-02900 | Arsenic Exposure Control Program |
| AMS-710-01-PR-02500 | Asbestos on the Job |
| AMS-710-01-PR-00300 | Bloodborne Pathogens |
| AMS-710-01-PR-03000 | APTIM Benzene Safety Program |
| AMS-710-01-PR-02700 | Construction Lead Hazard Abatement Program |
| AMS-710-01-PR-01100 | Fitness for Duty Program |
| AMS-710-01-PR-03800 | Hexavalent Chrome |
| AMS-710-01-PR-03500 | Medical and Exposure Records |
| AMS-710-01-PR-00900 | Noise Control and Hearing Conservation |
| AMS-710-01-PR-02300 | Occupational Health Plan |

| | |
|---|---|
| AMS-710-02-PR-03500 | Respiratory Protection |
| AMS-710-01-PR-03600 | Substance Abuse Program |

## 6.0 TERMINOLOGY

| ***Term*** | ***Definition*** |
|---|---|
| Fitness for Duty | The employees' physical, mental, and medical qualifications to perform their job duties |
| Toxic Substance or Harmful Physical Agent | Any chemical substance, biological agent (bacteria, virus, fungus, etc.), or physical stress (noise, heat, cold, vibration, repetitive motion, ionizing and non-ionizing radiation, hypo-hyperbaric pressure, etc.) which: (1) be listed in the latest edition of the NIOSH Registry of Toxic Effects of Chemical Substances, (2) have yielded positive evidence of an acute or chronic health hazard in testing conducted by or known to the employer, or (3) be the subject of a material safety data sheet (MSDS) kept by or known to the employer indicating that the material may pose a hazard to human health. |

## 7.0 EXHIBITS

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|---|---|
| Exhibit 7.1 | AMS-720-01-FM-00020 – Business Glossary |
| Exhibit 7.2 | AMS-720-01-FM-00021 – Technical Glossary |

## 8.0 ATTACHMENTS

None

# PROCEDURE

| | | | |
|---|---|---|---|
| **Procedure Title:** | **Sanitation and Potable Water** | **AMS Number:** | **AMS-710-01-PR-01000** |
| **Procedure Owner:** | **HSE** | **Issuing Authority:** | **APTIM Quality Management** |

# SANITATION AND POTABLE WATER

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| INT | Issued for Interim Use | M. Hadacek & S. Lachney | 7/30/2017 |
| **Rev** | **Changes** | **Approved** | **Date** |

| AMS Number: | Revision: | Approval Date: |
|---|---|---|
| AMS-710-01-PR-01000 | INT | 7/30/2017 |

## 1.0 PURPOSE

The purpose of this Procedure is to establish the minimum requirements for Sanitation and Potable Water on APTIM sites.

## 2.0 SCOPE

This procedure applies to all APTIM employees, contractors, subcontractors and visitors associated with an APTIM site.

## 3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure:

- APTIM Managers
- APTIM Supervisors
- APTIM Employees
- APTIM Contractors
- APTIM Subcontractors
- APTIM Visitors

## 4.0 PROCEDURE

APTIM sites shall ensure they follow the Sanitation and Potable Water requirements in this procedure.

4.1 Potable Water

4.1.1 An adequate supply of potable water shall be provided in all places of employment.

4.1.2 Portable containers used to dispense drinking water shall be capable of being tightly closed, sealed, and equipped with a tap. Water shall not be dipped from containers.

4.1.3 Any container used to distribute drinking water shall be clearly marked as to the nature of its contents and the current fill date, and shall not be used for any other purpose.

4.1.4 A common drinking cup shall not be used for potable water facilities.

4.1.5 Where single service cups (disposable) are supplied, both a sanitary container for the unused cups and a receptacle for disposing of the used cups shall be provided.

4.1.6 Drinking Water containers shall be cleaned and sanitized on a daily basis according to the following steps:

4.1.6.1 The individual assigned to the task of cleaning the containers shall wash their hands with soap and water and put on disposable or rubber gloves.

4.1.6.2 The outside of the container shall be rinsed off prior to opening the container.

4.1.6.3 Containers are to be washed with a detergent daily. Hot water shall be used when available. Dishwashing liquid and a scrub brush or sponge shall be used to clean the containers.

4.1.6.4 Containers are to be rinsed with clean water to remove all soap residues.

4.1.6.5 Containers are to be sanitized using the following method:

- Rinse containers in a solution of 2 tablespoons of chlorine bleach in one gallon of water.
- Rinse containers in clean water.
- When a location is available, the containers shall be allowed to air dry prior to refilling.

- Containers should be cleaned on an elevated or grated, platform to keep them from being subjected to dirt and grime.

4.1.6.6 Potable water shall be sampled periodically and records maintained of the sample results or appropriate documentation verifying the water meets the quality standards prescribed in the U.S. Public Health Service Drinking Water Standards, published in 42 CFR Part 72, or water which is approved for drinking purposes by the State or local authority having jurisdiction.

4.2 Non-potable Water

4.2.1 Outlets for non-potable water, such as water for industrial or fire fighting purposes only, shall be identified by signs to indicate clearly that the water is unsafe and is not to be used for drinking, washing or cooking purposes.

4.2.2 There shall be no open or potential cross-connection between a potable water system and a non-potable water system.

4.3 Toilets at Construction Projects

4.3.1 Temporary toilets shall be maintained in accordance with Federal, State, or Local ordinances.

4.3.2 Toilets shall be constructed to shield the occupants from view and protect against weather and falling objects.

4.3.3 Toilets shall be ventilated and all windows and vents screened.

4.3.4 All toilet facilities shall be cleaned and emptied on a regular basis and an adequate supply of tissue shall be made available according to project needs.

4.3.5 All toilet facilities shall be located on the project so that clear access is provided for cleaning and servicing.

4.3.6 Toilets shall be placed where users do not exit into roadways.

4.3.7 The following table provides the minimum number of toilet facilities to be provided for employees:

| Number of employees | Minimum number of facilities |
|---|---|
| 20 or less | 1 |
| 20 or more | 1 toilet seat and 1 urinal per 40 workers |
| 200 or more | 1 toilet seat and 1 urinal per 50 workers |

4.4 Washing Facilities

4.4.1 Lavatories shall be made available in all places of employment.

4.4.2 The washing facilities shall be maintained in a sanitary condition.

4.4.3 Each lavatory shall be provided with running, potable water.

4.4.4 Hand soap or similar cleansing agents shall be provided.

4.4.5 Individual hand towels or sections thereof, of cloth or paper, warm air blowers or clean individual sections of continuous cloth toweling, convenient to the lavatories shall be provided.

4.4.6 Whenever showers are required by a particular standard, the showers shall meet the following requirements:

4.4.6.1 One shower shall be provided for each 10 employees of each sex, or numerical fraction thereof, who are required to shower during the same shift.

4.4.6.2 Body soap or other appropriate cleansing agents shall be provided.

4.4.6.3 Showers shall be provided with hot and cold water feeding a common discharge line.

4.4.6.4 Employees who use showers shall be provided with individual clean towels.

4.5 Eating and drinking areas

4.5.1 No employees shall be allowed to consume food or beverages in a toilet room or in any area exposed to a toxic material.

4.5.2 Eating and drinking will be allowed only in designated areas.

4.6 Vermin Control

Every enclosed workplace shall be so constructed, equipped, and maintained so far as reasonable to prevent the entrance or harbouring of rodents, insects, and other vermin. A continuous, effective extermination program shall be instituted where their presence is detected.

4.7 Change rooms

Whenever employees are required by a particular standard to wear protective clothing because of the possibility of contamination with toxic materials, change rooms equipped with storage facilities for street clothes and separate storage facilities for the protective clothing shall be provided.

## 5.0 REFERENCES

| | |
|---|---|
| Title 29 CFR (Code of Federal Regulation) 1926.27 | Sanitation |
| Title 29 CFR (Code of Federal Regulation) 1926.51 | Sanitation |
| American National Standards Institute (ANSI) Z4.1 | Sanitation in Places of Employment-Minimum Requirements |
| ANSI Z4.3 | Sanitation-Non-sewered Waste-Disposal Systems – Minimum Requirements |
| ANSI Z4.4 | Sanitation in Fields and Temporary Labor Camps – Minimum Requirements |
| Title 42 Code of Federal Regulations (CFR) Part 72 | Occupational Injury and Illness Recording and Reporting |
| ANSI Z4.4 | Sanitation in Fields and Temporary Labor Camps – Minimum Requirements |

## 6.0 TERMINOLOGY

| ***Term*** | ***Definition*** |
|---|---|
| Potable Water | Water that meets the quality standards prescribed in the US Public Health Service Drinking Water Standards, published in 42 CFR Part 72, or water that is approved for drinking purposes by the State or local authority having jurisdiction. |
| Site | Any location, facility or project where APTIM is performing work. Sites may include, but are not limited to, laboratories, offices, |

shops, owned facilities, leased facilities and/or project sites.

## 7.0 EXHIBITS

| | |
|---|---|
| Exhibit 7.1 | AMS-720-01-FM-00020 – Business Glossary |
| Exhibit 7.2 | AMS-720-01-FM-00021 – Technical Glossary |

## 8.0 ATTACHMENTS

None

# PROCEDURE

| | | | |
|---|---|---|---|
| **Procedure Title:** | **Excavation and Trenching** | **AMS Number:** | **AMS-710-02-PR-01600** |
| **Procedure Owner:** | **HSE** | **Issuing Authority:** | **APTIM Quality Management** |

# EXCAVATION AND TRENCHING

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| INT | Issued for Interim Use | M. Hadacek & S. Lachney | 7/30/2017 |
| **Rev** | **Changes** | **Approved** | **Date** |

## 1.0 PURPOSE

This procedure establishes the minimum requirements for Excavation and Trenching activities on APTIM sites.

The following deliverables are defined within this procedure:

- Excavation Permit (AMS-710-02-FM-01601)
- Daily Excavation Inspection Form (Short) (AMS-710-02-FM-01602)
- Daily Excavation Inspection Form (long) (AMS-710-02-FM-01603)
- Soil Classification Worksheet (AMS-710-02-FM-01604)
- Excavation and Trenching Awareness training for affected employees

## 2.0 SCOPE

This procedure is to be utilized for all excavation and trenching activities on APTIM sites.

## 3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure:

- APTIM Managers
- APTIM Superintendent
- APTIM Supervisors
- APTIM Employees
- APTIM Contractors
- APTIM Subcontractors
- APTIM Visitors

## 4.0 PROCEDURE

This procedure establishes the minimum requirements for work, activities, inspections, and training, required for work in and around excavation and trenching operations on APTIM sites. This procedure will also apply to all APTIM subcontractors.

4.1 General

4.1.1 A designated Competent Person shall be onsite at all times when excavation activities are conducted.

4.1.2 APTIM Supervisors shall ensure employees, contractors, subcontractors, and visitors meet the requirements listed in this procedure when conduction excavation and trenching work.

4.1.3 Before any excavation can be started, an Excavation Permit (AMS-710-02-FM-01601) must be completed by the responsible Superintendent or equivalent with input from the Authorized Person for underground testing (utility identification) and the Excavation Competent Person. Appropriate Client approval and use of Client Excavation permit is also necessary where required by Client regulations. Client and/or utility company representatives shall be notified 24 hours prior to beginning excavations.

4.1.4 Underground Storage Tank (UST) Removal

AMS-710-02-WI-01601 contains specific instructions for trenches and excavations relating to UST removal.

4.1.5 Underground Utilities

4.1.5.1 Utility locating personnel shall locate and mark all known underground utilities within excavation area using utility locating equipment and

techniques. The utilities shall be marked with paint or flags. For more guidance, please refer to AMS-710-02-PR-01610 (Identifying Underground Installations).

4.1.5.2 At least 3 feet (0.9144 m) of clearance between any underground utility and the cutting edge or point of powered excavation equipment will be maintained until the precise location of the utility is determined. Initial excavation within this 3 foot area will be conducted manually.

4.1.5.3 All utilities exposed during an excavation will be protected from accidental damage. Machine excavation within 3 feet (0.9 m) of a located utility requires a spotter.

4.1.5.4 The underground utilities information obtained shall be provided to affected personnel via the job safety analysis (JSA). Underground utilities information, in relation to proposed excavation work, means the following information about underground essential services that may be affected by the excavation:

- The utilities that may be affected
- The location, including the depth, of any pipes, cables or other plant associated with the affected essential services
- Any conditions on the proposed excavation work.

4.1.5.5 Any essential services information obtained must be readily available for inspection. The information must be available:

- For at least two (2) years after the incident occurs
- In every other case, until the excavation work is completed.

4.1.5.6 When working on a pressurized liquid system (i.e., site service water, processed cooling water, pumped sanitary system) with piping 1” or more in diameter in an excavation 4 foot or greater in depth where an engulfment hazard exists must:

- De-energize and drain the system
- Lockout/Tagout
- All persons entering the excavation, whether working on the system or not shall apply safety locks and danger tags to the system in accordance with AMS-710-02-PR-01500, Control of Hazardous Energy.
- No personnel shall be allowed in the excavation during pressure/leak testing.

4.1.6 The work area around a excavation over 4 feet (1.2 m) deep shall be, so far is reasonably practicable, secured from unauthorized access (including inadvertent entry).

4.1.7 When mobile equipment is operated adjacent to an excavation, and the operator does not have a clear and direct view of the edge of the excavation, a warning system shall be utilized such as barricades, hand or mechanical signals, or stop logs.

4.1.8 Soil classification shall be made by the Competent Person or a registered Professional Engineer trained in soil classification. Based on the results of tests described in Exhibit 7.4, “Soil Classification Worksheet,” the competent person will classify each soil/rock deposit as stable rock, Type A, Type B, or Type C. When layers of soil/rock exist, the weakest layer will be classified; however, each layer may be classified individually when a more stable layer lies under a less stable layer. If the properties or conditions of a soil/rock deposit change in any way, re-evaluation will be required. Unclassified soil shall be assumed to be Class “C” and will be sloped 1½:1 or shored when the excavation exceeds 4 feet (1.2 m) in depth.

4.1.9 Each employee in an excavation shall be protected from cave-ins. Excavations over 4 feet (1.2 m) deep shall be shored, sloped, or benched as required. Excavations and the

work scheduled to be performed in the excavation shall be evaluated by the Competent Person to determine if the shoring, sloping, or benching needs to begin at a depth less than 4 feet (1.2 m).

4.1.10 Shoring for excavations over 20 feet deep (6 m) shall be designed by a registered Professional Engineer and shoring installed shall be approved and signed off by a registered Professional Engineer.

4.1.11 Spoils must be placed a minimum of 3 feet (0.9 m) from the edge of the excavation. Loose soil or rocks shall be removed from the sides of excavation walls.

4.1.12 Excavations 4 feet (1.2 m) in depth or greater, shall have a stairway, ladder, ramp, or other safe means of egress within 25 feet (7.6 m) of any employee. Excavations that are less than 4 feet (1.2 m) in depth shall have safe access and egress for all employees with a maximum break in elevation of 19 inches (48.3 cm).

4.1.13 Structural ramps that are used solely by employees as a means of access or egress from excavations shall be designed by a competent person.

4.1.14 Structural ramps used for access or egress of equipment shall be designed by a competent person qualified in structural design, and shall be constructed in accordance with the design.

4.1.15 Excavations shall be inspected by a Competent Person and the results recorded on either AMS-710-02-FM-01602 or AMS-710-02-FM-01603:

4.1.15.1 Prior to entry

4.1.15.2 After rain or snowfall

4.1.15.3 After freezing and/or thawing temperatures occur

4.1.15.4 After any condition that can change the integrity of the soil

4.1.16 During rainy weather, work in excavations shall cease until the Competent Person has evaluated the excavation and the effect of the rain on the excavation. The Competent Person will maintain a regular inspection schedule to ensure the excavation stability and condition during rain events if employees continue to work in the excavation. Depending on the amount of rainfall, the duration of the rainfall and the soil type, the Competent Person may need to maintain continuous observation of the excavation conditions.

4.1.17 For excavations that have the potential for oxygen deficiency or to contain hazardous atmosphere, an atmosphere evaluation shall be performed. This test will be performed by the Construction HSE Manager or their designee. Indications of the potential for a hazardous atmosphere include, but are not limited to: gas lines, sewer lines, areas with hydrocarbons, and proximity to emissions sources for $H_2S$, $SO_2$, CO, $CO_2$ and other gases that are heavier than air. Excavations with hazardous atmospheres should be treated as a confined space.

4.1.18 Excavations shall be evaluated for hazards in addition to cave-in potential and atmospheric hazards. Electrical sources, energized (pressurized) pipes, underground tanks, etc. may also present a hazard to employees who are required to enter an excavation.

4.1.19 The Competent Person responsible for the crew working in the excavation shall inspect the excavation throughout the work period, record the observations on AMS-710-02-FM-01602, and stop operations when unsafe conditions exist.

4.1.20 Water shall not be allowed to accumulate in excavations at any time. Pumps, drains, or other means shall be used to remove water constantly.

4.1.21 Where the stability of adjoining buildings, walls, or other structures is endangered by excavation operations, support systems shall be provided, such as shoring, bracing, or underpinning to ensure the stability of such structures. Excavation below the level of the

base or footing of any foundation or retaining wall that could be reasonably expected to pose a hazard to employees shall not be done unless:

- A support system, such as underpinning, is provided to ensure the safety of employees and the stability of the structure;
- The excavation is in stable rock;
- A registered professional engineer has determined that the structure is sufficiently removed from the excavation so that it will be unaffected by the excavation activity; or
- A registered professional engineer has determined that such excavation work will not pose a hazard to employees.

4.1.22 Sidewalks, pavements and appurtenant structures shall not be undermined unless a support system or another method of protection is provided to protect employees from the possible collapse of such structures. The support system shall be capable of withstanding a minimum live load of 125 lb/ft.

4.1.23 Emergency rescue plans shall be developed and rescue equipment shall be readily available.

4.1.24 Employees will not be permitted to work under loads or near digging equipment. Employees shall be required to stand away from any vehicle being loaded or unloaded to avoid being struck by spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded provided the vehicles are equipped with a cab shield and/or canopy adequate to protect the operator from shifting or falling materials.

4.1.25 Employees exposed to falls by excavation crossings and walkways will be provided with fall protection in accordance with Procedure AMS-710-02-PR-00900 - Fall Protection.

4.2 Training

4.2.1 Employee Training

4.2.1.1 Each employee who works in or around an excavation shall be trained to recognize potential hazards associated with excavations: cave-in potential, fall hazards, safe entry and exit, proximity to excavating equipment, air quality, back-filling and compacting activities, protective systems, etc. This training shall be documented in accordance with AMS-710-05-PR-01900 (HSE Education and Training) and records maintained in the Site HSE files

4.2.1.2 Each individual assigned as an Excavation Competent Person shall have documented training (see 4.2.1.1) or shall send documentation of experience and qualifications in excavation activities to the Global HSE Education and Training Director for review.

## 5.0 REFERENCES

| | |
|---|---|
| AMS-710-02-PR-00900 | Fall Protection |
| AMS-710-02-WI-01601 | Underground Storage Tank Removal |
| AMS-710-02-PR-01500 | Control of Hazardous Energy |
| AMS-710-02-PR-01610 | Identifying Underground Installations |
| AMS-710-05-PR-01900 | HSE Education and Training |

## 6.0 TERMINOLOGY

| ***Term*** | ***Definition*** |
|---|---|
| Accepted Engineering Practices | Those requirements that are compatible with standards of practice required by a registered professional engineer. |

| | |
|---|---|
| Angle of Repose | The greatest angle above the horizontal plane at which a material will lie without sliding. |
| Authorized Person for Underground Testing | The person(s) designated by the Construction Manager to identify underground utilities using a combination of blue prints and underground testing equipment. This individual shall coordinate excavation activities with the Client (as applicable) and outside utility companies. Several individuals (such as the Piping Superintendent, Electrical Superintendent, Equipment Superintendent, and Field Engineer) may serve as Authorized Persons as necessary. |
| Benching (Benching system) | A method of protecting employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels. |
| Cave-In | The separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it could entrap, bury, or other wise injure and immobilize a person. |
| Competent Person | One who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them. |
| Excavation | Any man-made cut, cavity, trench, or depression in an earth surface, formed by earth removal. |
| Excavation Competent Person | A person capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them. The Construction Manager and Construction HSE Manager shall designate the Competent Person in writing and their qualifications shall be documented. |
| Hazardous Atmosphere | An atmosphere which by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, may cause death, illness, or injury. |
| Protective System | A method of protecting employees from cave-ins, from material that could fall or roll from an excavation face, into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection. |
| Ramp | An inclined walking or working surface that is used to gain access to one point from another, and is constructed from earth or from structural materials such as steel or wood. |
| Registered Professional Engineer | A person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer, registered in any state is deemed to be a “registered professional engineer” within the meaning of this standard when approving designs for "manufactured protective systems" or “tabulated data” to be used in interstate commerce. |

| | |
|---|---|
| Sheeting | Members of a shoring system that retain the earth in position and in turn are supported by other members of the shoring system. |
| Shield | A structure that is able to withstand the forces imposed on it by a cave-in and thereby protect employees within the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Shields may be pre-manufactured or job-built in accordance with 29 CFR 1926.652(c)(3) or (c)(4). Shields used in trenches are usually referred to as "trench boxes" or "trench shields." |
| Shoring (Shoring System) | A structure such as a metal hydraulic, mechanical or timber shoring system that supports the sides of an excavation and which is designed to prevent cave-ins. |
| Site | Any location, facility or project where APTIM is performing work. Sites may include, but are not limited to, laboratories, offices, shops, owned facilities, leased facilities and/or project sites. |
| Sloping (Sloping System) | A method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads. |
| Stable Rock | Natural solid mineral material that can be excavated with vertical sides and will remain intact while exposed. Unstable rock is considered to be stable when the rock material on the side or sides of the excavation is secured against caving-in or movement by rock bolts or by another protective system that has been designed by a registered professional engineer. |
| Structural Ramp | A ramp built of steel or wood, usually used for vehicle access. Ramps made of soil or rock is not considered structural ramps. |
| Support System | A structure such as underpinning, bracing, or shoring that provides support to an adjacent structure, underground installation, or the sides of an excavation. |
| Tabulated Data | Tables and charts approved by a registered professional engineer and used to design and construct a protective system. |
| Trench (Trench Excavation) | A narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6 m). If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench. |
| Type A Soil | Cohesive soils with an unconfined compressive strength of 1.5 ton per square foot (tsf) (144kPa) or greater. Examples of cohesive soils are clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche and hardpan are also considered Type A. However, soil is not Type A if:<br>– Soil is fissured |

- Soil is subject to vibration from heavy traffic, pile driving, or similar effects
- Soil has been previously disturbed
- Soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H:1V) or greater
- Material is subjected to other factors that would require it to be classified as a less stable material

Type B Soil

This classification refers to:

- Cohesive soil with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa)
- Granular cohesionless soils including angular gravel (similar to crushed rock), silt, silt loam, sandy loam, and, in some cases, silty clay loam and sandy clay loam
- Previously disturbed soils except those which would otherwise be classified Type C soil
- Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subjected to vibration
- Dry rock that is not stable

Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B

Type C Soil

This classification refers to:

- Cohesive soil with an unconfined compressive strength of 0.5 tsf (48 kPa) or less
- Granular soils including gravel, sand, and loamy sand
- Submerged soil or soil from which water is freely seeping
- Submerged rock that is not stable
- Material in a sloped, layered system where the layers dip into the excavation or a slope of four horizontal to one vertical (4H:1V) or steeper

## 7.0 EXHIBITS

| | |
|---|---|
| Exhibit 7.1 | AMS-710-02-FM-01601 – Excavation Permit |
| Exhibit 7.2 | AMS-710-02-FM-01602 – Daily Excavation Inspection Form (Short) |
| Exhibit 7.3 | AMS-710-02-FM-01603 – Daily Excavation Inspection Form (long) |

| | |
|---|---|
| Exhibit 7.4 | AMS-710-02-FM-01604 – Soil Classification Worksheet |
| Exhibit 7.5 | AMS-720-01-FM-00020 – Business Glossary |
| Exhibit 7.6 | AMS-720-01-FM-00021 – Technical Glossary |

## 8.0 ATTACHMENTS

None

# CORONA VIRUS CONTROL PLAN

## COVID-19 CONTROL PLAN

### 1.0 GENERAL

Coronavirus Disease 2019 (COVID-19) is a respiratory disease caused by the SARS-CoV-2 virus. The COVID-19 pandemic is impacting all aspects of daily life, including travel, trade, tourism, food supplies, and financial markets. This plan defines location-specific efforts regarding:

- Awareness and Education
- Screening Methods
- Contamination Prevention and Sanitation
- Reporting and Illness/Exposure Management

This COVID-19 Control Program (CCP) is applicable to all APTIM employees at Redstone Arsenal (RSA). APTIM expects subcontractors/visitors/vendors to protect their employees through compliance with APTIM's CCP or through the development and implementation of a COVID-19 control plan specific to their risks. APTIM leadership must approve subcontractor plans, as applicable before implementation at RSA.

These requirements are in effect at least for the duration of the pandemic. The COVID-19 Management Team will amend these requirements or suspend their operation when no longer necessary.

### 2.0 CONTROLS

#### 2.1 Awareness and Education

A continual assessment of hazards is required to maintain a current awareness of exposures and the effectiveness of current controls. These methods will ensure employees have access to current information on how the pandemic is progressing, known site-specific exposures, site-specific controls and how to effectively implement them, and reporting requirements.

- At a minimum, COVID-19 training shall be provided through internal communications, new hire orientation, daily toolbox talks, risk assessment tools including JSA's, TARGET observation program, Near Miss/Great Catch reporting, findings from inspections, informational postings and informal discussions with supervision or employees.
- All employees reporting to work in an office location must complete the APTIM COVID-19 training available on-line through assignment in Talent Connection.
- On-going assessment of local, state and federal guidelines from organizations such as the Centers for Disease Control (CDC) and Occupational Safety Health Administration (OSHA), are required by all leadership employees to maintain an accurate understanding of the current hazards.
- The APTIM Corporate COVID-19 Management Team meets regularly to evaluate APTIM's pandemic efforts and implement appropriate responses.

- APTIM maintains a Corporate COVID-19 resource page providing guidance from the CDC, World Health Organization (WHO), as well as APTIM-specific information. This page is located on the company intranet and is available to all employees with a company email address.
- Signage: HSE, working with Facilities, will ensure that CDC-recommended signage reminding employees about social distancing, handwashing, and staying home when sick is posted in common areas (restrooms, bulletin boards, lobby, etc.).

### 2.2 Screening Methods

Employees can be exposed to the virus either at the work location or away from work. Fever, coughing, and shortness of breath are primary symptoms that may be present between two and fourteen days from exposure to the virus. It is critical to remind employees to identify any of these symptoms and to quickly isolate employees who are symptomatic from other employees.

- Employees are reminded to continually evaluate themselves for the onset of any symptoms, particularly tfever, coughing or shortness of breath.
- If the location requires a screening tool at arrival, APTIM will use the screening questionnaire in Appendix 1. [Client-required questionnaires may be used in lieu of Appendix 1 where applicable.]
- If the screening tool in Appendix 1 is used, APTIM may separate individuals and send individuals home or away, as warranted, depending on the answers to questions in the tool, read in accordance with current guidance from the CDC or other applicable health organization.
- Contactless thermometers will be deployed as available and as necessary to assess all individuals for potential fevers prior to entering the workspace.
    - A temperature measured as greater than 100.4 ºF is considered a fever.
        - Individuals registering a fever may sit isolated for no more than 10 minutes before being rechecked to confirm the fever. If a temperature of 100.4 ºF or greater is registered after the second reading, the individual will not be allowed into the workspace and will be turned away/sent home.
- Any employee experiencing symptoms of illness will be isolated from the workforce and turned away/sent home.
- An employee who notices a co-worker exhibiting or complaining of symptoms of acute respiratory illness (fever, coughing, shortness of breath) has Stop Work Authority if they are concerned about another's health. The immediate supervisor should be notified and HSE contacted to evaluate how to proceed and limit further exposure.
    - NOTE: Employees are expected to treat each other with respect and dignity in keeping with APTIM's policies and collaborative culture. **Harassment, bullying or other mistreatment of employees because of a suspicion of symptoms is grounds for discipline, up to and including termination of employment.**

- APTIM may require employees to complete fitness for duty evaluations as needed to respond to an objective concern for the health or safety of an employee and co-workers. A manager/supervisor must discuss a request for a fitness for duty evaluation with HR and HSE in advance; HSE will coordinate the fitness for duty process.

### 2.3 Contamination Prevention and Sanitation

Current medical understanding is that the virus is primarily transmitted via respiratory droplets when an infected person coughs, sneezes or talks. It may be possible that a person can get COVID-19 by touching a surface or object that has the virus on it and then touching their own mouth, nose or eyes. The virus can potentially survive on varying surfaces from hours to multiple days. Primary routes of entry include the mouth, eyes and nose.

#### 2.3.1 Sick Employees Stay Home

- Any employee who is experiencing symptoms of acute respiratory illness (fever, cough, shortness of breath) shall notify the employee's supervisor and not report to work.

- Employees who are well but who have a sick family member at home with COVID-19 should notify their supervisor and follow CDC recommended precautions.

#### 2.3.2 Social Distancing Practices:

- Whenever possible, everyone is to maintain a minimum 6ft. distance from other people. This practice insulates individuals from potential exposure to respiratory droplets. If situations require close contact, time within 6ft. should be minimized. Employees are also to not touch other employees unless absolutely necessary to complete a task. Any touching should be followed by appropriate disinfecting as soon as possible. Please don't shake hands with other employees; a wave or a nod is a better practice to greet others during this pandemic.
- APTIM supports remote working where it is an efficient and effective option to complete assigned work. APTIM encourages managers to consider carefully before determining that employees who are temporarily working remotely should return to the office environment. APTIM's strong preference during the pandemic is to continue efficient, effective remote working assignments instead of returning employees to office environments. Think carefully about who needs to be in the office and who can still work from home.
- Workspaces, conference rooms, etc. shall be reconfigured, to provide at least 6ft. of distancing. Please do not rearrange, place chairs closer together, or bring in additional seating.
- Avoid congregating in common areas such as lobbies, kitchens, and restrooms and always maintain 6 ft distance. Allow a person to complete their task such as using the microwave and exit the space before entering.
- Visitors, sales representatives, and others whose presence at the location is not business critical are restricted from visiting the location until further notice. The Project Manager must approve any deviation request in advance. All visitors will be required to be met by staff in the lobby where they will be asked to complete the APTIM COVID-19 Questionnaire. [Once

cleared to enter the visitor will be escorted to the temperature monitoring station. Visitors with temperatures above 100.4 degrees will not be allowed to enter and asked to leave.]

- Break times, including lunch times, have been staggered to minimize interactions with others.
- Whenever possible, meetings are to be conducted via teleconference rather than in person. In-person meetings or gatherings must not exceed 10 people and proper social distancing must be enforced.
- Other site-specific measure to maintain distance are captured on the COVID-19 Job Site Practices Activity Hazard Analysis (AHA).
- For project office facilities
    - Employees should not enter another's office until invited. Whenever possible, conduct conversation from the doorway. If privacy/confidentiality is required, the office occupant should invite the other party in, and the parties should don face masks and remain 6-foot distance throughout the discussion.
    - Employees assigned to cubicle workspaces are already limited in their ability to maintain 6-foot distance, and no employee should enter another's cubicle unless necessary and invited. Communication should be conducted via email, phone and Teams/Chat whenever possible. If a discussion is necessary, the parties should locate an available larger space such as a conference room. If the discussion requires the cubicle equipment (such as to discuss and revise a drawing) both parties shall don face masks throughout the interaction.
- Site-specific restroom use is included on the COVID-19 Job Site Practices AHA.

### 2.3.3 Sanitation Measures:

- Employees should not cover any cough or sneeze with their hands but should use a tissue or their elbow to contain the cough or sneeze. This process reduces contamination on their hands and in the air. Employees must properly wash their hands following any cough or sneeze.
- At a minimum, all employees shall conduct adequate hand washing prior to eating, before and after preparing food, following use of the restroom, following sneezing or coughing, and following touching of the face, especially the mouth, eyes or nose.
    – Adequate hand washing is achieved by following these five steps:
    1. Wet your hands with clean, running water (warm or cold); turn off the tap, and apply soap.
    2. Lather your hands by rubbing them together with the soap. Lather the backs of your hands, between your fingers, and under your nails.
    3. Scrub your hands for at least 20 seconds. Need a timer? Hum the "Happy Birthday" song from beginning to end twice.
    4. Rinse your hands well under clean, running water.
    5. Dry your hands using a clean towel or air dry them.

- An adequate supply of soap must be available to maintain the ability for effective hand washing. **If there is no soap available, hand sanitizing liquid/gel may be utilized as a substitute. If neither option is available, the office/location will be closed unless it is deemed to be "critical" by senior leadership and/or government entities.**
- Do not touch your eyes, nose or mouth. Sores should also stay covered and protected. These measures are to prevent routes of entry.
- Face Masks: Wherever possible, APTIM is working to ensure that employees can work at least 6' away from other individuals, in order to maintain the recommended social distance in this pandemic. Employees working in an area where they can avoid prolonged interaction with others can choose to use a cloth mask (as recommended by the CDC). Please see Appendix 2 for information from the CDC about making cloth masks, directions on how to don and doff these masks, and instructions for properly laundering the masks. The site has a small for use by employees in unexpected/planned close-contact situations that do not have a mask with them.
- HSE will work with employees who are working on tasks that require working within 6' feet of others for a prolonged period to help plan steps to minimize this close contact work and to ensure that, where required, employees have adequate respiratory protection suited to the job task (such as NIOSH-approved, particulate filtering masks). Cloth masks are not a good substitute in these situations.
- [for office locations]: Masks requirements:
    - Employees are not required to wear a mask when;
        - Alone or in an office/cubicle with no interaction with others closer than 6-foot distance
        - In the break room while eating or drinking. During the pandemic employees should confine break/lunchroom time to eating/drinking and avoid lingering or congregating. Stay 6' away from others.
    - Employees must wear masks;
        - Whenever engaged in an interaction/conversation within 6-foot distance
        - When engaged in a conversation inside an office; all parties should don masks upon invitation to enter by the occupant
        - In all common spaces, including conference rooms, elevators, hallways, breakrooms, restrooms, etc.
- Site-specific hand-washing solutions are included on the COVID-19 Job Site Practices AHA
- If means for handwashing are not immediately available, employees should use hand sanitizer containing at least 60% alcohol. Hand sanitizer should not be used in lieu of handwashing if hands are visibly soiled. Hand sanitizer shall be made readily available for employees to frequently disinfect their hands throughout the jobsite.
    - Use hand sanitizer in the following manner:

- Apply the gel product to the palm of one hand. (Read the label to learn the correct amount).
- Rub your hands together.
- Rub the gel over all the surfaces of your hands and fingers until your hands are dry. This process should take around 20 seconds.

- Hand sanitizer should be placed and maintained in strategic locations throughout the workspace.
- Site-specific solutions to janitorial service issues are included on the COVID-19 Job Site Practices AHA.
- Site-specific solutions to restroom cleaning are included on the COVID-19 Job Site Practices AHA.
- [for office locations:] Disinfectant wipes are also available in the printer/copier areas and the kitchens and employees are encouraged to use them to wipe/sanitize touch surfaces as desired. Employees are also encouraged to wipe/disinfect their desks, phones, and keyboards as desired and at least once a day using the wipes provided.
- The procurement and ongoing availability of materials such as soap, disinfectant, PPE, etc. is the responsibility of the site Director/Manager. HSE and Procurement are continually evaluating availability of these products and may assist in this process if requested.
- Some business processes are heavily reliant on the shared handling of paper or other office products. The site must assess and implement measures to minimize exposure to paper, limit interactions among employees, discontinue use of shared pens, use personal protective measures (such as gloves) and disinfect following handling.
- Commonly touched surfaces and items should be identified for cleaning, as well as the frequency required based on the exposure. The CDC recommends that these surfaces be cleaned at least weekly.

### 2.3.4 Travel Limitations:

- APTIM has suspended all non-essential business travel. Essential business travel must be approved by APTIM Executive Leadership. Anyone approved to travel will be screened prior to reporting back to the jobsite.
- Employees traveling domestically or internationally may be subject to a self-quarantine period and should be familiar with the federal, state and local orders prior to traveling.

## 2.4 Reporting and Illness Management

### 2.4.1 General

2.4.1.1 To ensure both prompt medical evaluation and prevention of any potential contamination to the jobsite, APTIM requires employees to immediately report any symptoms (fever, cough, or difficulty breathing), no matter how slight, to their manager, HSE and HR.

2.4.1.2 APTIM will communicate appropriate notifications in accordance with established protocols and in keeping with applicable privacy laws.

2.4.1.3 Employees experiencing symptoms of any illnesses are to stay home and not report to work until symptom and fever-free for at least 24 hours, without the assistance of fever reducing medications. Employees experiencing symptoms consistent with COVID-19 who should stay home and not report to work until the protocols for return to work are met (test based, or symptom based). See below. Please take the necessary steps for your health and safety and the health and safety of your co-workers. Notification to supervision is required.

2.4.1.4 HSE, working with site Leadership and HR, maintains a confidential log of information related to employees who are symptomatic, who test positive for COVID-19, or who were potentially exposed outside of work. The log should include the name of the affected employees, the potential exposure or test date, date of onset and description of symptoms (if symptomatic), information about the exposure event, dates of expected quarantine, and status. HSE, working with site Leadership, also maintains a confidential log of any employees assigned to the jobsite potentially exposed by "close contact" to another COVID-19 positive (test, diagnosed or suspected) employee, including the potential exposure date, any testing information, a description of the potential exposure, the dates of any quarantine period, and a status update.

2.4.1.5 Site Leadership is responsible to notify HSE and HR of any COVID-19 positive (test, diagnosis or suspicion).

2.4.1.6 If an employee's illness appears to be personal and non-emergent, APTIM will direct the employee to see his or her personal health care provider.

2.4.1.7 Cases believed to be emergent in nature without regard to work-relatedness will be handled by following this AMS.

2.4.1.8 Cases potentially work-related will be evaluated at:

Crestwood Workers Care Madison Clinic, 2236 Madison Blvd, Huntsville, AL
Crestwood Family Practice Clinic, 1868 Sparkman Dr. NW, Huntsville, AL
Huntsville Hospital, 878 Madison St. SE, Huntsville, AL

For potentially work-related cases, consideration should be given to allowing the affected employee to self-transport to seek medical care in order to maintain social distancing of 6ft. or greater. Vehicles offering adequate distance, such as passenger vans may also be used. Vehicles used for transport will be disinfected following the trip.

**2.4.1.9 Return to Work Protocol**

APTIM follows current CDC recommendations for returning employees to work after COVID-19 diagnosis or exposure. Please see Appendix 3 for a flow chart setting forth these criteria. Information about return to work protocols is also contained in the next sections.

A. Person with COVID-19 (tested, diagnosed, or suspected due to symptoms) can return to work after meeting one of the following protocols:

   – Symptom Based Strategy: At least 10 days have passed since symptoms first appeared;
   – At least 24 hours have passed since resolution of fever without the use of fever-reducing medications; and
   – Other symptoms* of COVID-19 have improved.
   – (*Note that loss of taste and smell may persist for weeks or months after recovery and need not delay the end of isolation.
   – Most people do not require testing to decide when they can be around others. However, APTIM employees should follow the advice of their healthcare provider regarding when it is safe for the employee to return to work.

B. People who have not had COVID-19 Symptoms but Tested Positive for COVID-19 can return to work after:

   - At least 10 days have passed since the date of their first positive COVID-19 diagnostic test (assuming they have not developed symptoms.)
   - If symptoms develop, then follow symptom-based or test-based strategy for the return-to work protocol.

C. People who are severely immunocompromised or who were severely ill with COVID-19Test Based Strategy: May need to stay home longer than 10 days and up to 20 days after symptoms first appeared and may require testing to determine when it is appropriate to return to work. These individuals will need a release from their healthcare provider before returning to work.

### 2.4.2 Potential or Known Exposure to COVID-19 or Employees with Symptoms:

#### 2.4.2.1 Symptomatic employees

If an employee is experiencing symptoms of acute respiratory illness and a fever (greater than 100.4 degrees Fahrenheit, or 37.8 degrees Celsius), the employee must not come to work. The employee must alert his or her supervisor that he or she is symptomatic and is staying away from work. Supervisors should alert HSE immediately once they receive information that an employee is staying home with acute respiratory illness symptoms. Please see Potential Workplace Exposure section below for the required analysis of potential exposure to symptomatic employees. Please see Return to Work Protocol for persons who are positive for COVID-19 with symptoms, above.

#### 2.4.2.2 Diagnosed Employees

Employees testing positive for COVID-19 are required to follow their health care provider's orders and will not be allowed to return to work until cleared by the health care provider to return to work. Recognizing strains on the medical system during this pandemic, APTIM will work with employees to

balance the need for information on the employee's fitness to work with the availability of a health care provider. We will follow CDC guidelines for return to work criteria for employees who test positive or are presumed positive for COVID-19. Please see Return to Work Protocol above.

Please see Potential Workplace Exposure section below for the required analysis of potential exposure to symptomatic employees.

#### 2.4.2.3 Potentially exposed but asymptomatic employees

If an employee has been exposed to:

a. a household member or intimate partner or
b. has provided care in a household without using recommended infection control precautions, or
c. has had "close contact" (< 6 feet) for a "prolonged" period of time

to a person with symptomatic COVID-19 (can be a laboratory-confirmed disease or a clinically compatible illness) but the employee does not have symptoms, the employee may also need to stay home and not come to work or may be able to continue work, subject to workplace protections being in place, if the employee is working in a critical infrastructure position. (see section below).

The potential exposure period is the 48-hour period before the person with symptomatic COVID-19 began experiencing symptoms.

Please note the following definitions of "close contact" and "prolonged" (from CDC guidance):

Factors to consider when defining close contact include proximity, the duration of exposure (e.g., longer exposure time likely increases exposure risk), whether the individual has symptoms (e.g., coughing likely increases exposure risk) and whether the individual was wearing a facemask (which can efficiently block respiratory secretions from contaminating others and the environment).

Prolonged exposure varies on the length of time of exposure from 10 minutes or more to 30 minutes or more. Brief interactions are less likely to result in transmission; however, symptoms and the type of interaction (e.g., did the person cough directly into the face of the individual) remain important.

The potentially exposed employee must alert the employee's supervisor and HSE will work with the employee to determine whether, following CDC guidelines, the employee must remain self-quarantined and return to work for 14 days from the last exposure to the confirmed or suspected COVID-19 individual.

**Asymptomatic Employees Working in Critical Infrastructure Positions:**

Potentially exposed but asymptomatic employees who are working in "Critical Infrastructure" positions whose presence is critical to the ongoing progress of the project may continue to work with the following required protective measures in place:

- Prescreen: A temperature screening to confirm the absence of a fever (100.4 ºF) and a symptom assessment is required prior to entering the workplace.

- Regular Monitoring: Ongoing self-monitoring with assistance from HSE to ensure the employee remains asymptomatic and fever-free.
- Wear a Mask: The employee should wear a face mask at all times while in the workplace for 14 days after last exposure. Employee-supplied face masks are acceptable (see Appendix 2), or a site can issue a face mask (where supplies are adequate).
- Social Distance: The employee should maintain social distancing of at least 6ft. from other individuals. Any encroaching of 6ft. requires additional controls, such as adequate respiratory protection. (Contact HSE for support)
- Disinfect and Clean: The jobsite must clean and disinfect all areas such as offices, bathrooms, common areas, and shared equipment routinely.

If the employee becomes sick during the day, the employee should be sent home immediately. Surfaces in their workspace should be cleaned and disinfected. Information on persons who had contact with the ill employee during the time the employee had symptoms and 2 days prior to symptoms should be compiled. Others at the facility with close contact within 6 feet of the employee during this time would be considered exposed.

#### 2.4.2.4 Potential Workplace Exposure

APTIM will inform employees of a potential workplace exposure while maintaining confidentiality (i.e., without revealing the infected individual's name unless otherwise directed by the CDC, applicable public health authority, or specifically required by applicable written government directive).

APTIM will analyze whether any other employees were potentially exposed to an employee diagnosed with COVID-19 through "close contact" with the diagnosed employee during the 48-hour period before the diagnosed employee started experiencing symptoms. Following CDC recommendations and directives, APTIM will direct potentially exposed asymptomatic employees to self-quarantine and remove them from the workplace for a 14-day period from the date of the employee's last exposure to the confirmed or suspected positive individual.

Please see above for information about potentially exposed, but asymptomatic, employees working in critical infrastructure. These employees can continue to work as long as they remain asymptomatic and the workplace protections set forth above are in place.

Employees are eligible to continue receiving per diem (if the employee is otherwise eligible for per diem) during the time the employee is not able to work because the employee is experiencing symptom of acute respiratory illness (fever, cough, shortness of breath) or is quarantined and away from home. The employee may need to provide medical documentation in order to be considered for continued per diem while they are not at work.

### 2.5 Roles and Responsibilities

2.5.1 Project Manager

- Responsible for oversight and coordination of the CCP implementation to ensure consistency in program content and efficient use of resources.
- Responsible for ensuring that all employees adhere to the procedures, including training and awareness of CCP issues.
- Responsible to ensure communication of project/office expectations regarding the CCP.
- Support and endorse the Project HSE Management System and CCP.
- Ensure compliance to the CCP by all employees, subcontractors, and vendors.
- Provide the resources necessary for implementation of the CCP.
- Ensure that adequate Emergency Response Procedures are in place for the evacuation of employees.
- Communicate with Facilities department regarding office closure and re-opening (to include return to work plans).

2.5.2 Project Manager Designee]

- Assists the Project Manager in ensuring that all employees adhere to the procedures, including training and awareness of CCP issues.
- Assists the Project Manager in ensuring communication of project expectations in regard to the CCP.
- Actively support the CCP.

2.5.3 HSE Manager

- Review and analyze new data on COVID-19 risk, prevention, and management.
- Identify and provide training and awareness materials.
- Provide leadership with health risk assessment efforts for each area of the project.
- Identify and communicate program expectations (i.e., diagnosis, treatment and notification) to preferred medical providers.
- Review COVID-19 incident data.

2.5.4 Employees

- Adhere to all program requirements regarding prevention and mitigation measures.
- Participate actively and vocally in the awareness program.
- Report any suspected symptoms of acute respiratory illness (fever, coughing, shortness of breath) immediately to supervision.
- Stay home when sick.

- Provide regular updates to leadership regarding anticipated return to work if the employee is required to stay home due to quarantine or illness.

2.5.5 Preferred Occupational Medical Provider

- Use rapid diagnosis method to test for COVID-19.
- Report confirmed or unconfirmed cases of COVID-19 to APTIM HSE Manager.
- Communicate with HSE Manager related to COVID-19 diagnosis and treatment as needed.
- Ensure clinic staff understands COVID-19 requirements for diagnostics and treatment.

## 3.0 RESOURCES:

Public Health Recommendations for Community-Related Exposure, https://www.cdc.gov/coronavirus/2019-ncov/php/public-health-recommendations.html

CDC RECOMMENDATIONS FOR MASK - https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/about-face-coverings.html

IMPLEMENTING SAFETY PRACTICES FOR CRITICAL INFRASTRUCTURE WORKERS WHO MAY HAVE HAD EXPOSURE TO A PERSON WITH SUSPECTED OR CONFIRMED COVID-19, https://www.cdc.gov/coronavirus/2019-ncov/community/critical-workers/implementing-safety-practices.html

DISCONTINUATION OF ISOLATION FOR PERSONS WITH COVID-19 NOT IN HEALTHCARE SETTINGS (INTERIM GUIDANCE) **HTTPS://WWW.CDC.GOV/CORONAVIRUS/2019-NCOV/HCP/DISPOSITION-IN-HOME-PATIENTS.HTML**

WHEN YOU CAN BE AROUND OTHERS: https://www.cdc.gov/coronavirus/2019-ncov/if-you-are-sick/end-home-isolation.html ENDING HOME ISOLATION: https://www.cdc.gov/coronavirus/2019-ncov/hcp/disposition-in-home-patients.html

# APPENDIX 1
# COVID-19 QUESTIONNAIRE

# CORONA VIRUS CONTROL PLAN

## APPENDIX 1 – COVID-19 QUESTIONNAIRE

| | |
|---|---|
| Name: | |
| Contact Number/Cell: | |
| Date: | |
| Department: | |
| Supervisor: | |
| For use with On-Site temperature check: Verified that temp is less than 100.4? | Yes/No |
| Self-Fever Check – did you check your temperature today? Is it less than 100.4 F? If you have a fever of greater than 100.4, stay home and do not report to this work site. | Yes/No |
| Have you read the Covid-19 Safety Plan applicable to our location, and do you understand the safety measures we are asking you to take while working at this jobsite? | |
| Do you understand that you are required to wear a mask (in accordance with CDC recommendations) when working within a 6ft. proximity of coworkers? | |
| Do you understand that when possible you are to maintain 6ft. social distancing if you are not able to wear a mask? | |
| Within the last 14 days, have you had close contact (less than 6' for 15 minutes or more) with a person with COVID-19 (diagnosed with test or symptoms)? | Yes/No |
| Are you currently experiencing (now or in the last 24 hours) any symptoms of Covid-19? (symptoms can include some or all of the following: fever, chills, cough, shortness of breath, difficulty breathing, fatigue, muscle or body ache, headache, new loss of taste or smell, sore throat, congestion or runny nose, nausea, vomiting, diarrhea)? | Yes/No |
| Are you currently diagnosed with COVID-19 or are you waiting for test results? | Yes/No |
| Do you understand that if you are running a fever or exhibiting any signs of illness you are not to come into work? | Yes/No |

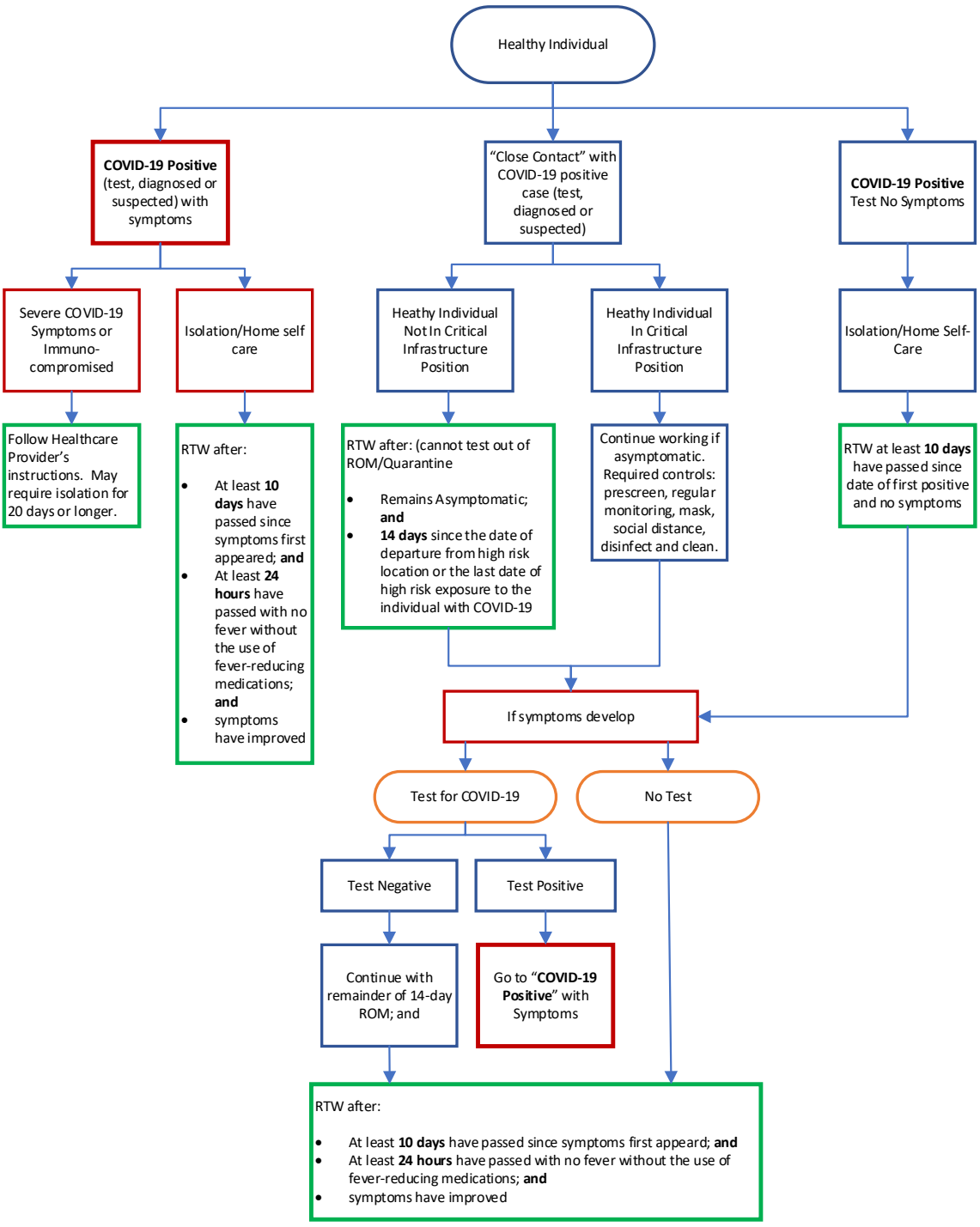
# APPENDIX 2
# INSTRUCTIONS RELATED TO CLOTH MASKS

# DIY CLOTH FACE COVERING INSTRUCTIONS

# APPENDIX 3
# RETURN TO WORK PROTOCOL

# CORONA VIRUS CONTROL PLAN

## RETURN TO WORK (RTW) FLOWCHART
## COVID-19



# MECHANIZED AND MARINE EQUIPMENT INSPECTION REPORT

| Inspector's Name Printed: | Date: |
|---|---|
| Equipment Description: | Equipment Number: |

| Item Inspected | Good | Fair | Poor | N/A | Comments |
|---|---|---|---|---|---|
| Brakes & Steering | | | | | |
| Broken, Missing, Damaged Parts | | | | | |
| Chains/Digging Boom (Trenchers) | | | | | |
| Controls Functioning Properly | | | | | |
| Deflectors & Blades (Mowers) | | | | | |
| Engine Oil/Water/Battery | | | | | |
| Falling Object Prot. Structure | | | | | |
| Fire Extinguisher | | | | | |
| Gauges | | | | | |
| Guards/Shields | | | | | |
| Horn and Back Up Alarm | | | | | |
| Hydraulic Fluid Level/Leaks/Hoses | | | | | |
| Lights | | | | | |
| Mirrors | | | | | |
| Operator Presence/Seat Interlock | | | | | |
| Other Interlock Switches | | | | | |
| Roll Over Protective Structure | | | | | |
| Seat Belt | | | | | |
| Signs/Placards | | | | | |
| Tires | | | | | |
| Windshield/Glass/Wipers | | | | | |

Comments: _____

_____

_____

Inspector's Signature: _____

**Copies:**

HSE Manager's File
Equipment Managers

**PROCEDURE**

**Procedure Number:**

**AMS-710-01-PR-00600**

**Revision:**

**1**

**Procedure Owner:**

**HSE**

**Issuing Authority:**

**VP HSE**

**Approval Date:**

**3/16/2020**


# HEAT STRESS PREVENTION AND CONTROL

| Rev | Changes | Approved | Date |
|---|---|---|---|
| | | | |
| 1 | Transferred information to new APTIM procedure template, updated reference and attachment sections, created attachments from reference forms Heat Stress Index and Urine Color Test Chart, removed reference to Evaporative Cooling Index, added reference in section 4.2.4.1 to Urine Color Test Chart | M. Karr | 3/16/2020 |
| 0 | Added section 4.3.2 | M. Hetzler | 12/20/2017 |
| INT | Issued for Interim Use | M. Hadacek & S. Lachney | 7/30/2017 |

**Parent Document:** N/A

# HEAT STRESS PREVENTION AND CONTROL

## 1.0 PURPOSE

The purpose of this procedure is to establish the minimum requirements for Heat Stress Prevention and Control on APTIM sites.

## 2.0 SCOPE

This procedure applies to all APTIM employees, contractors, subcontractors and visitors associated with an APTIM site.

## 3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure:

- APTIM Managers
- APTIM Supervisors
- APTIM Employees
- APTIM Contractors
- APTIM Subcontractors

## 4.0 PROCEDURE

APTIM sites shall use this procedure to establish the minimum guidelines to create the site-specific procedure for heat stress prevention and control.

### 4.1 Heat Stress

Heat stress is the result of the combination of several factors. The following factors should be evaluated to determine the potential for heat stress:

- Ambient temperature
- Humidity
- Radiant heat source
- Direct sun exposure
- Air movement
- Contact with hot objects
- Type of work required - heavy, moderate or light work
- Required work clothing - the potential for heat stress increases as the impermeability of the work clothing increases
- Employee conditioning and/or acclimatization
- Previous project experience or history

- Whenever it is determined that a heat stress environment exists heat stress preventive measures shall be implemented.

**4.2 Preventative Measures**

4.2.1 Heat stress is the combination of environmental and physical work factors that constitute the total heat load imposed on the body. One of the best ways to reduce heat stress on workers is to minimize the amount of heat in the workplace. However, there are some work environments where heat production is difficult to control, such as active steam lines, high ambient temperature processes, humid work areas, or radiant heat from the sun or a furnace. However, most heat related health problems can be prevented or the risk of developing them reduced. When unacceptable levels of heat stress can potentially occur, there are generally five approaches to a solution:

4.2.1.1 Modify the environment;

4.2.1.2 Modify the clothing or equipment;

4.2.1.3 Modify the work practices;

4.2.1.4 Modify the worker by heat acclimatization;

4.2.1.5 Modify production with a work/rest regiment.

4.2.2 Wearing Personal Protective Equipment (PPE) can place workers at considerable risk of developing heat stress. Health effects range from transient heat fatigue to serious illness or death. Regular monitoring and other preventive precautions shall be employed. For workers wearing semi-permeable or impermeable encapsulating ensembles, workers shall be monitored when the temperature in the work area is above 70ºF (21ºC).

4.2.3 Engineering Controls

4.2.3.1 A variety of engineering controls, including ventilation and spot cooling at points of high heat production, may be helpful. Shielding or insulation may be required as protection from radiant heat sources. Evaporative cooling and mechanical refrigeration are other ways to reduce heat by engineering controls. The use of extra air moving can be added to increase the turnover rate of interior air and remove heat inside enclosures. Cooling fans can increase air velocity and promote evaporation in hot conditions. Shutting down hot process or feed lines is most effective, but equipment modifications, such as using mechanical equipment over manual labor also reduce the exposure.

4.2.3.2 Auxiliary cooling systems can range from simple ice vests, pre-frozen and worn under the clothing, to more complex systems; however, cost of operation and maintenance vary considerably in all of these systems. Four auxiliary cooling systems presently available are:

- Water-cooled garments, such as water-cooled vest, undergarments, hoods, etc., which require a circulating pump, liquid container, and battery;

- Air-cooled garments, such as suits and hoods, that require a vortex tube, connecting hose and a constant source of compressed air;
- Ice pack vest, which although frozen before worn, do not provide continuous regulated cooling and require the use of backup frozen units every 2 to 3 hours; and
- Wetted over-garments, which can be as simple as wet cotton terry cloth coveralls worn over protective clothing; the wetted over garment works best when there is air blowing across the wet garment to increase evaporation.

4.2.4 Work Practices

4.2.4.1 Work practices can help reduce the risk of heat disorders. Making plenty of drinking water (including ice and cool water as appropriate) available at the workplace and urging workers to drink often shall be standard practice in all situations of potential heat stress. In high heat stress environments, an employee can lose as much as one quart of liquid per hour. Attachment 7.2, Urine Color Test Chart is a good resource to for employees to use to gauge their level of hydration. When possible and especially during acclimatization, products that have been formulated to replace electrolytes and match the weight of the body fluids lost by the sweating process should be used. This is necessary to enable the body to quickly absorb replacement minerals. Do not use salt tablets.

4.2.4.2

4.2.4.3 Training supervisors to recognize and be able to correctly treat heat stress disorders is essential. Prospective workers physical conditions should also be considered when determining their fitness for working in a hot environment. Older workers, obese workers, and those workers taking some type of medication are usually at a greater risk.

4.2.5 Acclimatization

Acclimatization to heat through short exposures followed by longer periods of work in the hot environment can reduce heat stress. New employees and workers returning from an absence of two weeks or more should have a five-day period of acclimatization. This period should begin with a less than normal workload and time exposure on the first day and gradually build up to normal workload and exposure on the fifth day.

4.2.6 Work/Rest Regiment

4.2.6.1 There are many times when engineering and other controls are not sufficient, and administrative controls must be instituted for worker protection. One effective administrative control is the work/rest regimen that limits the time worked in the hot environment according to the type of work, environmental conditions, and clothing requirements. Work/rest periods are generally conservative because they are:

- Based on calculated approximations of heat stress and

- Designed to protect most workers. As a result, many acclimatized workers can work longer than the allotted time period.

4.2.6.2 Alternating work and rest periods with longer rest periods in a cool area (77°F. or less) can help workers avoid heat strain. Keep in mind that poor physical condition and/or medication will also impair the ability to work in a hot environment. Older, over-weight individuals or those in poor health may not be able to follow average work/rest regimens. Supervisors shall permit employees to take additional rest breaks as needed in potential heat stress conditions.

4.2.6.3 The APTIM HSE Department should be contacted for assistance in instituting work/rest schedules for the site.

**4.3 Employee Training**

4.3.1 For both employees and supervisory personnel, heat stress training is the key to avoiding problems. Employees must understand the reasons for using appropriate work practices in order for the program to succeed. A heat stress training program for employees shall cover the following:

4.3.1.1 Heat stress, its components and effects,

4.3.1.2 Signs and symptoms of heat disorders,

4.3.1.3 First-aid Practices for and potential health effects of heat stress,

4.3.1.4 Pre-disposing factors to heat stress; drug use, (including therapeutic) and alcohol in a hot work environment,

4.3.1.5 Protective clothing, equipment and its impact in hot environments,

4.3.1.6 Environmental and medical surveillance programs,

4.3.1.7 Importance of maintaining body fluids at normal levels,

4.3.1.8 Various engineering controls to reduce the impact of hot environments,

4.3.1.9 Administrative measures such as work/rest regimens in use to prevent heat stress,

4.3.1.10 Acclimatization; how it is achieved and its limitations, and

4.3.1.11 The components of the heat stress prevention program.

4.3.2 Supervisors must be trained in heat related illness prior to supervision of employees working in the heat

### 4.4 Flagging System

4.4.1 The status of the Heat Stress and Control plan will be communicated to the work force using a flagging system to correlate with the categories in section 4.5.

4.4.2 As the Heat Index category (color) changes, an SMS and email will go out to the Project team, including field HSE Supervisors or Representatives.

4.4.3 The field HSE Supervisors or Representatives are responsible for changing out the flag to the correct color so the crew can easily identify what category and precautions are in effect.

4.4.4 Flags should be placed in locations which are readily viewable from most areas such as established water, rest, or cooling areas.

### 4.5 Heat Stress Categories

4.5.1 The severity of heat exposure is determined by the calculated heat index.

4.5.2 The heat index is broken down into five (5) separate level designated by a color code.

The five (5) levels are green, yellow, orange, red and black. The significance of these colors is discussed in section 4.3.

4.5.3 The heat index is determined by either of three (3) methods:

4.5.3.1 Direct reading instrument such as a weather station, anemometer with built in heat index function, etc.

4.5.3.2 It is recommended for each project to have a direct reading hand held instrument for determining the heat stress, during the summer months. The Kestrel 3000 or equivalent Pocket Weather Meter is a commonly used instrument that is readily available providing a wide range of functions, including accurate relative humidity measurements. A picture of the Kestrel 3000 is shown below in figure 1.


**Figure 1**

4.5.3.3 Alternatively, calculating the heat index can be accomplished by measuring the ambient temperature and humidity separately to find the corresponding heat index (Attachment 7.1 Heat Stress Index).

4.5.3.4 Lastly, obtain the temperature and humidity from a reliable local weather/news source and utilize Attachment 7.1 Heat Stress Index to determine the heat index.

4.5.4 Category precautions and water intake are captured in Attachment 7.1 Heat Stress Index as a guide to be issued to field personnel.

### 4.6 Category GREEN – Caution

The initial or least severe category is GREEN. Heat indexes in GREEN are 37°C (98.6ºF) or less. When heat indexes fall within this category, the following conditions apply:

- Heat Syndrome – Fatigue possible with prolonged exposure and physical activity. No significant risk of heat related illnesses.
- Resting Times – Normal / scheduled break are sufficient during this period.
- Water Needed – 250 ml (8.5 oz) every 20 – 30 minutes
- Ensure Adequate Medical Services are available
- Encourage workers to wear sunscreen

### 4.7 Category YELLOW – Extreme Caution

The next higher severity category is YELLOW. Heat indexes in YELLOW range between 38°C and 45°C (98.7ºF and 113ºF). When the heat index falls within this category, the following conditions apply:

- Review Heat related illness topics with workers: how to recognize heat related illnesses, how to prevent it, and what to do if someone gets sick. Monitor workers closely
- Heat Syndrome – Heat Cramps or Heat Exhaustion possible with prolonged exposure and physical activities.
- Acclimatize workers
- Resting Time – 5 minutes per each hour
- Water Needed – 250ml (8.5 oz) every 20 minutes (average)

### 4.8 Category ORANGE – Danger

The next higher severity category is ORANGE. Heat indexes in ORANGE range between 46°C and 54°C (114.8ºF and 129.2ºF). When heat indexes fall within this category, the following conditions apply:

- Limit Physical exertion
- Adjust work activities
- Use cooling techniques

- Watch/communicate with workers at all times
- Ensure Adequate Medical Services are available
- Encourage workers to wear sunscreen
- Heat Syndrome – Heat Cramps or Heat Exhaustion likely. Heat Stroke possible with prolonged exposure and physical activity.
- Resting Time – 10 minutes per each hour
- Water Needed – 250 ml (8.5 oz) every 10 minutes (average)

### 4.9 Category RED – Extreme Danger

4.9.1 The next higher severity category is RED. Heat indexes in RED range between 55°C and 59°C (129.3ºF and 138.2ºF). When heat indexes fall within this category, the following conditions apply:

- Stop work if essential control methods are inadequate or unavailable.
- Limit Physical exertion
- Adjust work activities
- Use cooling techniques
- Watch/communicate with workers at all times
- Ensure Adequate Medical Services are available
- Encourage workers to wear sunscreen
- Heat Syndrome – Heat Stroke imminent with following rest and water intake requirements.
- Resting Time – 15 minutes per each hour
- Water Needed – 250 ml (8.5 oz) every 10 minutes (average)

4.9.2 During Category RED conditions, the following additional precautions should be implemented:

- Supervision should be on active alert to monitor their crew for signs and symptoms of heat stress. Maximum supervision should be present, during category RED conditions to monitor the employees and ensure proper rest and water breaks are being followed.
- Employees who are fasting for whatever reason (i.e. dieting regimen, religious obligations, etc.) are not permitted to work during RED flag conditions. There is a significant health risk associated with fasting in RED flag conditions that can quickly progress into Heat Exhaustion or Heat Stroke.
- Project First Aiders and Nurses should be put on alert in case an employee begins to exhibit heat stress symptoms.

- Ear type thermometers with disposable covers should be available for monitoring an employee's core body temperature. Employees with core temperatures at or above 38°C (100.4°F) should remain out of the heat, until their temperature is reduced and stabilized.
- Cold, wet towels must be available for first aid to assist in the cooling of someone experiencing heat stress symptoms. Cold towels applied to the inside of the forearms and neck serves as effective thermal receptors to cool the body's core temperature.
- Air-conditioned shelters are to be made available for anyone experiencing heat stress symptoms.
- Electrolyte replenishment drink (i.e. Isostar, Pocari Sweat, etc.) should be available to first aiders for anyone exhibiting serious signs of heat stress symptoms and / or dehydration.
- Work involving considerable and / or repetitive climbing should be kept to a minimum.
- A rescue plan should be in place to retrieve anyone who is not capable of removing themselves, under their own power.

### 4.10 Category BLACK

4.10.1 All work shall stop when heat index exceeds 59°C (138.3ºF). If the ambient temperature is below 35C (95ºF), regardless of humidity, there will be no BLACK flag.

4.10.2 Dispensation for critical activities can be allowed if approved by Supt, HSE Manager and Project Manager

4.10.3 Any work allowed in BLACK flag conditions must have a specific JSA detailing the precaution to be taken for the activity.

### 4.11 Technical Assistance

In some situations, we will accept work in extremely hot environments that cannot be controlled or mitigated. When faced with this type of situation, the APTIM Safety Department shall be notified for assistance.

## 5.0 TERMINOLOGY

| Term | Definition |
|---|---|
| Heat Rash | Heat rash, also known as prickly heat, may occur in hot, humid environments where sweat is not easily removed from the surface of the skin by evaporation. This is common when using protective equipment especially impermeable clothing. Heat rash can become uncomfortable when extensive or complicated by infection. |

| | |
|---|---|
| Heat Cramps | Heat cramps, which are painful muscle spasms, are caused when workers fail to replace the body's salt loss that occurs during excessive perspiration (especially with non-acclimatized workers). |
| Heat Exhaustion | Heat exhaustion results from excessive loss of salt and/or water through sweating. The worker with heat exhaustion still sweats, but experiences extreme fatigue, weakness, giddiness, nausea or headache. The skin is clammy and moist, the complexion pale or flushed and the body temperature normal or slightly higher. |
| Heat Stroke | Heat stroke, the most serious health problem for workers in hot environments, is caused by the failure of the body's internal mechanism to regulate its core temperature. Sweating stops and the body can no longer rid itself of excess heat. Signs include: mental confusion, delirium, loss of consciousness, convulsions or coma, a body temperature of 105 degrees or higher and hot dry skin which may be red and flushed. Victims of heat stroke may die unless treated promptly and correctly. |
| Site | Any location, facility or project where APTIM is performing work. Sites may include, but are not limited to, laboratories, offices, shops, owned facilities, leased facilities and/or project sites. |

## 6.0 REFERENCES

### 6.1 Required Forms/Checklists

| | |
|---|---|
| None | |

### 6.2 Other Internal References

| | |
|---|---|
| None | |

### 6.3 Other External References

| |
|---|
| None |

## 7.0 ATTACHMENTS

| Attachment | Attachment Title |
|---|---|
| Attachment 7.1 | Heat Stress Index |
| Attachment 7.2 | Urine Color Test Chart |

# ATTACHMENT 7.1
# HEAT INDEX

# HEAT STRESS PREVENTION AND CONTROL

## RELATIVE HUMIDITY – FAHRENHEIT

| Temp | Relative Humidity | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 |
| 123.8 | | | | | | | | | | | | | | | | | | | | | |
| 122 | | | | | | | | | | | | | | | | | | | | | |
| 120.2 | 120 | 120 | 120 | 122 | 131 | 138 | | | | | | | | | | | | | | | |
| 118.4 | 118 | 118 | 118 | 120 | 127 | 135 | | | | | | | | | | | | | | | |
| 116.6 | 117 | 117 | 117 | 117 | 124 | 131 | 138 | | | | | | | | | | | | | | |
| 114.8 | 115 | 115 | 115 | 115 | 120 | 127 | 135 | | | | | | | | | | | | | | |
| 113 | 113 | 113 | 113 | 113 | 117 | 124 | 129 | 136 | | | | | | | | | | | | | |
| 111.2 | 111 | 111 | 111 | 111 | 115 | 118 | 126 | 133 | | | | | | | | | | | | | |
| 109.4 | 109 | 109 | 109 | 109 | 111 | 117 | 120 | 127 | 135 | | | | | | | | | | | | |
| 107.6 | 108 | 108 | 108 | 108 | 108 | 113 | 117 | 122 | 129 | 136 | | | | | | | | | | | |
| 105.8 | 106 | 106 | 106 | 106 | 106 | 109 | 113 | 118 | 124 | 129 | 136 | | | | | | | | | | |
| 104 | 104 | 104 | 104 | 104 | 104 | 106 | 109 | 113 | 118 | 124 | 129 | 136 | | | | | | | | | |
| 102.2 | 102 | 102 | 102 | 102 | 102 | 104 | 106 | 109 | 115 | 120 | 126 | 131 | 138 | | | | | | | | |
| 100.4 | 100 | 100 | 100 | 100 | 100 | 100 | 102 | 106 | 109 | 115 | 120 | 126 | 131 | 138 | | | | | | | |
| 98.6 | 98.6 | 98.6 | 98.6 | 98.6 | 98.6 | 98.6 | 100 | 102 | 106 | 109 | 115 | 118 | 124 | 131 | 136 | | | | | | |
| 96.8 | 96.8 | 96.8 | 96.8 | 96.8 | 96.8 | 96.8 | 96.8 | 100 | 102 | 106 | 109 | 115 | 118 | 124 | 129 | 136 | | | | | |
| 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 96.8 | 98.6 | 102 | 106 | 109 | 113 | 118 | 122 | 127 | 135 | | | | |
| 93.2 | 93.2 | 93.2 | 93.2 | 93.2 | 93.2 | 93.2 | 93.2 | 93.2 | 95 | 98.6 | 100 | 104 | 108 | 111 | 117 | 120 | 126 | 131 | 136 | 144 | |
| 91.4 | 91.4 | 91.4 | 91.4 | 91.4 | 91.4 | 91.4 | 91.4 | 91.4 | 93.2 | 95 | 96.8 | 100 | 104 | 108 | 111 | 115 | 118 | 124 | 129 | 135 | 140 |
| 89.6 | 89.6 | 89.6 | 89.6 | 89.6 | 89.6 | 91.4 | 91.4 | 91.4 | 91.4 | 91.4 | 93.2 | 96.8 | 98.6 | 102 | 104 | 108 | 111 | 117 | 120 | 126 | 129 |
| 87.8 | 87.8 | 87.8 | 87.8 | 87.8 | 87.8 | 87.8 | 87.8 | 87.8 | 87.8 | 89.6 | 91.4 | 93.2 | 95 | 96.8 | 100 | 102 | 106 | 109 | 113 | 117 | 120 |
| 86 | 86 | 86 | 86 | 86 | 86 | 86 | 86 | 86 | 86 | 86 | 87.8 | 89.6 | 91.4 | 93.2 | 95 | 96.8 | 100 | 102 | 106 | 108 | 111 |

# HEAT STRESS PREVENTION AND CONTROL

## RELATIVE HUMIDITY - CELSIUS

| | Relative Humidity | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temp | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 |
| 51 | | | | | | ---------- | | | | STOP ALL WORK | | | | ---------- | | | | | | | |
| 50 | | | | | | | | | | | | | | | | | | | | | |
| 49 | 48.9 | 48.9 | 48.9 | 50 | 55 | 58.9 | | | | | | | | | | | | | | | |
| 48 | 47.8 | 47.8 | 47.8 | 48.9 | 52.8 | 57.2 | | | | | | | | | | | | | | | |
| 47 | 47.2 | 47.2 | 47.2 | 47.2 | 51.1 | 55 | 58.9 | | | | | | | | | | | | | | |
| 46 | 46.1 | 46.1 | 46.1 | 46.1 | 48.9 | 52.8 | 57.2 | | | | | | | | | | | | | | |
| 45 | 45 | 45 | 45 | 45 | 47.2 | 51.1 | 53.9 | 57.8 | | | | | | | | | | | | | |
| 44 | 43.9 | 43.9 | 43.9 | 43.9 | 46.1 | 47.8 | 52.2 | 56.1 | | | | | | | | | | | | | |
| 43 | 42.8 | 42.8 | 42.8 | 42.8 | 43.9 | 47.2 | 48.9 | 52.8 | 57.2 | | | | | | | | | | | | |
| 42 | 42.2 | 42.2 | 42.2 | 42.2 | 42.2 | 45 | 47.2 | 50 | 53.9 | 57.8 | | | | | | | | | | | |
| 41 | 41.1 | 41.1 | 41.1 | 41.1 | 41.1 | 42.8 | 45 | 47.8 | 51.1 | 53.9 | 57.8 | | | | | | | | | | |
| 40 | 40 | 40 | 40 | 40 | 40 | 41.1 | 42.8 | 45 | 47.8 | 51.1 | 53.9 | 57.8 | | | | | | | | | |
| 39 | 38.9 | 38.9 | 38.9 | 38.9 | 38.9 | 40 | 41.1 | 42.8 | 46.1 | 48.9 | 52.2 | 55 | 58.9 | | | | | | | | |
| 38 | 37.8 | 37.8 | 37.8 | 37.8 | 37.8 | 37.8 | 38.9 | 41.1 | 42.8 | 46.1 | 48.9 | 52.2 | 55 | 58.9 | | | | | | | |
| 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37.8 | 38.9 | 41.1 | 42.8 | 46.1 | 47.8 | 51.1 | 55 | 58 | | | | | | |
| 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 37.8 | 38.9 | 41.1 | 42.8 | 46.1 | 47.8 | 51.1 | 54 | 57.8 | | | | | |
| 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 36 | 37 | 38.9 | 41.1 | 42.8 | 45 | 47.8 | 50 | 52.8 | 57 | | | | |
| 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 35 | 37 | 37.8 | 40 | 42.2 | 43.9 | 47 | 48.9 | 52 | 55 | 58 | 62 | -18 |
| 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 34 | 35 | 36 | 37.8 | 40 | 42.2 | 44 | 46.1 | 48 | 51 | 54 | 57 | 60 |
| 32 | 32 | 32 | 32 | 32 | 32 | 33 | 33 | 33 | 33 | 33 | 34 | 36 | 37 | 38.9 | 40 | 42.2 | 44 | 47 | 49 | 52 | 54 |
| 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 32 | 33 | 34 | 35 | 36 | 38 | 38.9 | 41 | 43 | 45 | 47 | 49 |
| 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 38 | 39 | 41 | 42 | 44 |

# HEAT STRESS PREVENTION AND CONTROL

| APTIM Heat Stress Guideline | | | | | |
|---|---|---|---|---|---|
| Heat Stress Index | | | | | |
| Danger Category | Heat Index | | Heat Syndrome | Resting Time | Water Needed |
| | °C | °F | | | |
| Extreme Danger | 55-59 | 129.3-138.2 | Sun stroke imminent without following rest and water intake requirements | 15 minutes / hour | 250 ml (8.5 oz) / 10 minutes |
| Danger | 46-54 | 114.8-129.2 | Heat Cramps or Heat Exhaustion likely. Heat Stroke possible with prolonged exposure and physical activity. | 10 minutes / hour | 250 ml (8.5 oz) / 10 minutes |
| Extreme Caution | 38-45 | 98.7-113 | Heat Cramps or Heat Exhaustion possible with prolonged exposure and physical activity. | 5 minutes / hour | 250 ml (8.5 oz) / 20 minutes |
| Caution | <37 | <98.6 | Fatigue possible with prolonged exposure and physical activity. | Normal / Scheduled | 250 ml (85 oz) / 30 minutes |
| Do not drink more than 1.5 liters (33.8 oz) per hour (maximum water absorption rate of human body) | | | | | |

# ATTACHMENT 7.2
# URINE COLOR TEST CHART

# HEAT STRESS PREVENTION AND CONTROL

## Are You Hydrated?
## Take the Urine Color Test

### Urine Color Chart*

HYDRATED

OPTIMAL

WELL HYDRATED

DEHYDRATED

DEHYDRATED:
You need to drink more water

SEEK MEDICAL AID:
May indicate blood in urine or kidney disease

*This color chart is not for clinical use.

### Water Consumption Table

| Heat Category | WBGT Index, °F | Easy Work | Moderate Work | Hard Work |
|---|---|---|---|---|
| | | *Water Intake (Quart/Hour)* | *Water Intake (Quart/Hour)* | *Water Intake (Quart/Hour)* |
| 1 | 78° - 81.9° | ½ | ¾ | ¾ |
| 2 | 82° - 84.9° | ½ | ¾ | 1 |
| 3 | 85° - 87.9° | ¾ | ¾ | 1 |
| 4 | 88° - 89.9° | ¾ | ¾ | 1 |
| 5 | > 90° | 1 | 1 | 1 |
| Body Armor = +5° | | Easy Work – walking on a hard surface at less than 2 mph with less than a 30 pound load, weapon maintenance, marksmanship training; drill and ceremony | Moderate Work – patrolling, walking in the sand at 2.5 mph with no load, calisthenics; patrolling; individual movement techniques (ie high/low crawl) | Hard Work – walking in the sand at 2.5 MPH with a load, field assaults |
| MOPP 4 = +10° | | | | |
| Rest - sitting or standing in the shade if possible | | | | |

The fluid replacement volumes will sustain performance and hydration for at least 4 HOURS of work in the specified heat category. Fluid needs can vary based on individual differences and exposure to full sun or full shade.

CAUTION: Hourly fluid intake should not exceed 1.5 quarts. Daily fluid intake should not exceed 12 quarts.

### Purpose

- With normal kidney function, your level of hydration is indicated by the color of your urine. Some vitamins and supplements may cause a darkening of the urine unrelated to dehydration.
- Since heat-related illness often follows dehydration, this simple test will help protect your health.
- Dehydration also increases your risk for kidney stones.

### How does it work?

- Match your urine color to closest color in the chart and read the hydration level on the chart.
- Watch the urine stream not the toilet water, as the water in the toilet will dilute your urine color.
- In response to dehydration, the kidneys conserve water and excrete more concentrated urine; the more concentrated the urine the darker the color.

### Prevent Dehydration

- No amount of training or acclimatization can reduce the body's requirement for water.
- Follow the water consumption guidelines in the water consumption table.

http://usachppm.apgea.army.mil

CP-070-0408 (Also available as a tip card.)

USACHPPM

# ATTACHMENT 3

# INCIDENT REPORTING FORMS

US Army Corps of Engineers

# USACE PRIME CONTRACTOR
# Monthly Record of Work-Related Injuries/Illnesses & Exposure

Month _____
Year _____

In accordance with the provisions of EM 385-1-1, Section 01 Program Management, Paragraph 01.D Mishap Reporting and Investigation, sub-paragraphs 01.D.05, you (APTIM) shall provide a monthly record of all exposure and accident experience incidental to the work (this includes exposure and accident experience of APTIM and its sub-contractor(s). As a minimum , these records shall include exposure work hours and a record of occupational injuries and illnesses that include the data elements listed below. Definitional criteria for each data element is found in 29 CFR Part 1904. If the maintenance of OSHA 300 Logs are required by OSHA, most of this information can be obtained from those logs. If data on log provided below is revised after it is submitted to USACE, APTIM shall provide a revised report to the GDA. You must complete the USACE ENG Form 3394, Report of Accident Investigation Report for all recordable accidents. If you're not sure whether a case is recordable, call your local Safety and Occupational Health Office for help.

USACE Command
Contractor Name
Contract Number
**Project Title**
**City** State
**USACE Office Overseeing Work**

| Identify the person | | | | | | | Describe The Case | | Classify the case | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (A) | | (B1) | (B2) | (B3) | (C) | (D) | (E) | (F) | Using these categories, check ONLY the most serious result for each case: | | | | Enter the number of days the injured or ill worker was: | | Check the "injury" column or choose one type of illness: | | | | | | | |
| | | | | | | | | | | | | | | | (M) | | | | | | | |
| Company Name | Prime or Sub (P or S) | Age | Gender | Date Employee Began Work on Job Covered by Contract | Job Title (e.g., Welder) | Date of injury or onset of illness (mo./day) | Where the event occurred (e.g. Loading dock north end) | Describe injury or illness, parts of body affected, and object/substance that directly injured or made person ill (e.g. Second degree burns on right forearm from acetylene torch) | Death | Days away from work | Remained at work | | On job transfer or restriction (days) | Away from work (days) | Injury | Skin Disorder | Respiratory Condition | Poisoning | Hearing Loss | All other Illnesses |
| | | | | | | | | | | | Job transfer or restriction | Other record-able cases | | | | | | | | | |
| | | | | | | | | | (G) | (H) | (I) | (J) | (K) | (L) | (1) | (2) | (3) | (4) | (5) | (6) |
| | | | | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**For Government Use Only**

**TYPE OF WORK ACTIVITY (Choose One):**

| | | | |
|---|---|---|---|
| Construction | | Environmental Remed. | |
| Opn & Main. | | Superfund | |
| Eng. Services | | FUDS | |
| Dredging | | IRP | |
| Rsch. & Dev. | | FUSRAP | |
| Emerg. Opns. | | Ordinance/Expl. Cleanup | |
| Other | | Environmental Other | |

**Type of Contract (Choose One):**

| | |
|---|---|
| Civil Works | |
| Military Programs | |
| Other | |

| Exposure Hours | |
|---|---|
| Month | |
| Year to Date | |

| Certification of Record | |
|---|---|
| Name of Person Submit. Record | |
| Signature | |
| Date | |

# USACE Summary of Contractor Work-Related Injuries and Illnesses

**Month Submitted** _____ **Year** _____

**US Army Corps of Engineers**

*Review the Record and verify that the entries are complete & accurate before completing this summary.*

*Using the Record, count the individual entries you made for each category. Then write the totals below, making sure you've added the entries from every page of the record. If you had no cases write "0". This summary is a cumulative record of the injury/illness experience for the year*

## Number of Cases

| Total number of deaths | Total number of cases with days away from work | Total number of cases with job transfer or restriction | Total number of other recordable cases |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| (G) | (H) | (I) | (J) |

## Number of Days

| Total days of job transfer or restriction | Total days away from work |
|---|---|
| 0 | 0 |
| (K) | (L) |

## Injury and Illness Types

Total number of…

| | (M) | | |
|---|---|---|---|
| (1) Injury | 0 | (4) Poisoning | 0 |
| (2) Skin Disorder | 0 | (5) Hearing Loss | 0 |
| (3) Respiratory Condition | 0 | (6) All other illnesses | 0 |

## Establishment information

Establishment name

Street

City State Zip

Industry description (e.g., Manufacture of motor truck trailers)

Standard Industrial Classification (SIC), if known (e.g., SIC 3715)

or

North American Industrial Classification (NAICS) if known (e.g. 336212)

## Employment information

Annual average number of employees

Total hours worked by all employees last year

# Aptim Federal Services, LLC Incident Notification, Reporting, and Management Procedure

**Directions, Notes, and Reminders**

- **Follow this procedure step-by-step for all incidents.**
- **This procedure has limited application to subcontractors. Assist subcontractors with medical emergencies (as applicable) and then immediately notify the Program H&S Manager for guidance.**
- **Periodically review this procedure in order to be familiar with the steps - prior to an incident occurring.**
- **For injuries and vehicle accidents, secure the scene to prevent additional injury/incident, administer on-site first aid, and arrange for emergency assistance prior to making any other notifications.**
- **The Site Supervisor is responsible for making all other notifications to:**
  - **CORE Health Networks (must be notified while employee is en route to medical care facility): 877-347-7429**
  - **Help Desk / Hot Line: 800-537-9540**
  - **Project Manager: Don Burton 865-207-1394 (cell)**
  - **Marcia Musgrave: 419-429-5520 or 419-819-7848**
- **The Site Supervisor (or SSHO) is responsible for notifying the Program H&S Manager or Alternate H&S Manager by telephone prior to making any other notifications (other than calling 911 and CORE).**
- **The Site Supervisor or SSHO shall accompany all injured personnel to the CORE clinic or to the hospital emergency room.**
- **The Project Manager shall notify the Program Manager in person or by telephone no later than two hours after the incident and the U.S. Army Garrison Chief, Installation Restoration Branch (256) 842-3702.**
- **All incident reports shall be completed by typing (when feasible and applicable).**
- **All incident reports shall be submitted (email or fax) to the Program H&S Manager or Alternate H&S Manager for review and distribution.**
- **Complete all the blanks on the INCIDENT NOTIFICATION AND COMMUNICATION CONTACT LIST (page 6) and post near all site telephones.**

# Aptim Federal Services, LLC Incident Notification, Reporting, and Management Procedure

| Action | Who / When | Under what circumstances | How | Notes |
|---|---|---|---|---|
| 1. Notify Site Supervisor for all incidents (no matter how minor) | Injured person, first person recognizing incident, driver/passenger, or employee causing damage *Immediately* | All incidents no matter how minor (including minor cuts, scratches, minor strains/sprains, and insect bites) | In person or by telephone | Site Supervisor to make note of very minor incidents (such as band-aid over scratch) in field logbook |
| 2. For ***life-threatening injuries / illnesses*** - make scene safe, contact local emergency personnel<br><br>For ***non life-threatening injuries / illnesses*** - make scene safe, transport injured person to doctor at an occupational medical facility See Clinic Route Maps and Directions<br><br>For ***vehicle accidents*** – make scene safe, notify police, aid injured parties<br><br>For ***equipment / property damage*** - make scene safe, prevent further damage or injuries | Site Supervisor *Immediately (concurrently with next step if injury or illness)*<br><br>Site Supervisor *Immediately (concurrently with next step if injury or illness)*<br><br>Driver/passenger *Immediately*<br><br>Employee causing damage *Immediately* | In case of serious injury or illness requiring off-site medical care | Via ambulance<br><br>Via vehicle | Site Supervisor or Site Safety Officer must immediately go to emergency care facility. Follow AMS-710-01-PR-03600 post accident alcohol and drug testing procedure.<br><br>Site Supervisor or Site Safety and Health Officer must transport and stay with injured person until released from care.<br><br>Make medical personnel aware of "restricted work will be provided" and "no prescriptions if possible" policies.<br><br>CORE clinics are the preferred urgent care facilities when possible, unless injury is severe and victim is transported by ambulance. |
| 3. Notify CORE Health Networks (for injuries / illnesses to APTIM employees only) | Site Supervisor *Immediately, prior to transporting the injured employee, unless injuries are life threatening* | • Serious injury requiring off-site medical care<br>• If employee states that he/she has been exposed to any chemical or biological substance<br>• If illness is work related | CORE Medical 877-347-7429<br><br>Note: Outside Continental US call: 225-614-9561 | Not required for temporary agency and subcontractor labor<br><br>Provide name of injured employee, name and phone # of treating medical facility, description of the incident<br><br>CORE will help with medical facility coordination and follow-up care |
| 4. Notify Program H&S Manager (if unsure, see contact list)<br>Notify Alternate H&S Manager if Program H&S Manager cannot be contacted. (if unsure, see contact list) | Site Supervisor *Immediately (concurrently with providing transportation to occupational medical facility or EMS transport to hospital)* | All incidents except on-site first aid cases | See Incident Notification and Communication Contact List (attached) | Program H&S Manager will notify H&S Director |

| Action | Who / *When* | Under what circumstances | How | Notes |
|---|---|---|---|---|
| **5.** Notify APTIM Notification Hotline / Help Desk | Site Supervisor<br>*As soon as possible. Prior to sending an individual for medical treatment* | • Illness and/or injury (doctors cases and above)<br>• Any utility damage<br>• Property damage (damage > $5,000)<br>• Vehicle accidents (All)<br>• Criminal activity (i.e. bomb threat, theft)<br>• Natural disaster (all)<br>• Explosion and/or fires<br>• Environmental spills/releases (incidents that requires regulatory notification or have an offsite impact)<br>• Regulatory agency visit<br>• Fatalities | APTIM Notification Hotline / Help Desk Phone Number: 800-537-9540<br><br>Note - Outside the Continental US call: 225-215-5056 | Request name of Hotline / Help Desk operator for future reference and note date/time of notification |
| **6.** Complete forms:<br>I*njuries and illnesses*:<br>• Authorization for Release of Protected Medical Information<br>• Authorization for Treatment of Occupational Injury/Illness<br>• Return-To-Work Examination Form<br>*and* fax to CORE<br>*and* email or fax to Program H&S Manager | Injured employee and medical facility personnel (Site Supervisor or Site Safety and Health Officer is responsible for verifying forms are completed)<br><br>*Prior to leaving medical facility* | • Serious injury requiring off-site medical care<br>• If employee states that he/she has been exposed to any chemical or biological substance | Fax to CORE: 225.292.8986<br><br>Email or fax to Program H&S Manager | Site Supervisor or Site Safety and Health Officer must take these forms (Contained in 710-01-PR-02100, AMS-710-05-PR-02200, and AMS-710-05-PR-02300) |
| **7.** Call Project Manager and notify of incident (Remind Project Manager of notification responsibilities to Program Manager) | Site Supervisor<br><br>*As soon as reasonably possible* | If Hot Line / Help Desk notification is required (see # 5 above) | See Incident Notification and Communication Contact List | Project Manager will verbally report incident to upper level of Operations/Business Line Management *As soon as reasonably possible* |
| **8.** Notify Marcia Musgrave | Site Supervisor | All incidents involving personnel (injuries, illnesses, vehicle accidents) | 419-429-5520 | |

| Action | Who / When | Under what circumstances | How | Notes |
|---|---|---|---|---|
| **9.** Call back Program H&S Manager to report on status of ***injured / ill employee*** | Site Supervisor<br><br>***Prior to employee leaving medical facility*** | All injuries and illnesses requiring off-site medical care | See Incident Notification and Communication Contact List (attached) | |
| **10.** Complete forms (typed electronically):<br>***OSHA Recordable Cases***<br>• Supervisor's Employee Injury/Illness Report Form<br>• Injured Employee Statement<br>• Witness Statement Form(s)<br><br>***First Aid Cases (Doctor's)***<br>• Supervisor's Employee Injury/Illness Report<br>• Injured Employee Statement<br>• Witness Statement Form(s)<br><br>Email or Fax completed forms to Program H&S Manager and CORE | • Site Supervisor<br><br>• Witnesses<br><br>*As soon as possible – no later than 24 hours* | All injuries, illnesses, and first aide cases | Email or fax to Program H&S Manager<br><br>See Incident Notification and Communication Contact List (attached)<br><br>Fax to CORE<br>225.292.8986 | Site Supervisor should have these forms with him/her at all times (Contained in 710-01-PR-02100, AMS-710-05-PR-02200, and AMS-710-05-PR-02300) |
| **11.** Complete forms (typed electronically):<br>***Chargeable Vehicle Accidents***<br>• Vehicle Accident Report<br>• Witness Statement Form(s)<br>• Driving Record Certification (Procedure HS800)<br><br>***Non-Chargeable Vehicle Accidents***<br>• Vehicle Accident Report<br>• Witness Statement Form(s)<br><br>***Equipment, Property Damage and General Liability Incidents***<br>• Equipment, Property Damage and General Liability Loss Report<br>• Witness Statement Form(s)<br><br>Email or Fax completed forms to Program H&S Manager | • Site Supervisor<br><br>• Witnesses<br><br>*As soon as possible – no later than 24 hours* | All vehicle accidents and /or all property damage | Email or fax to Program H&S Manager Health<br><br>See Incident Notification and Communication Contact List (attached) | Supervisor should have these forms with him/her at all times (Contained in 710-01-PR-02100, AMS-710-05-PR-02200, and AMS-710-05-PR-02300) |

| Action | Who / When | Under what circumstances | How | Notes |
|---|---|---|---|---|
| **12.** Complete these additional forms (typed electronically):<br>***OSHA Recordable Cases***<br>• Incident Investigation Report<br><br>***First Aid Cases (Doctor's)***<br>• Incident Investigation Report<br><br>***Chargeable Vehicle Accidents***<br>• Incident Investigation Report<br><br>***Non-Chargeable Vehicle Accidents***<br>• Incident Investigation Report<br><br>***Equipment, Property Damage and General Liability Incidents***<br>• Incident Investigation Report<br><br>***Near Miss***<br>• Incident Investigation Report<br><br>• SharePoint electronic Near Miss Report<br><br>Email or Fax completed forms to Program H&S Manager | Site Supervisor<br>*As soon as possible – no later than 72 hours of incident*<br><br>*As soon as possible – no later than 96 hours of incident* | Near Misses<br><br>All other Near Misses | Email or fax to Program H&S Manager<br><br>See Incident Notification and Communication Contact List (attached)<br><br>Contact Program H&S Manager | Supervisor should have these forms with him/her at all times<br><br>Contact Program H&S Manager for blank electronic forms or access:<br><br>Do not include any employee or project identification information – *these reports are anonymous* |
| **13.** Perform "Incident Review Board" (ARB) - Coordinate through Program H&S Manager<br><br>Perform "Incident Review Board" (IRB) to extract lessons learned - Coordinate through Program H&S Manager | Program H&S Manager<br>*Within 10 days of incident* | OSHA Recordable Cases<br><br>Chargeable Vehicle Accidents<br><br>Doctor's First Aid Cases<br><br>Utility damage or significant property damage | | An IRB is outside of the AMS requirements for an ARB. |

# Aptim Federal Services, LLC Incident Notification and Communication Contact List

**Project Number: 501388 Project/Office Name/Location: RSA DO W912DY 19F1116 / Redstone Arsenal, Huntsville, AL**

| Name | Phone Number(s) | Fax Number | E-mail |
|---|---|---|---|
| Federal Services Notification Hotline/Helpdesk | 800-537-9540 | N/A | N/A |
| CORE<br>(Must be notified prior to or during transport to medical treatment center) | 877-347-7429 | 225-292-8986 | N/A |
| Medical Services Administrative Manager<br>Marcia Musgrave | 419-429-5520 (office)<br>419-819-7848 (mobile) | 419-429-5526 | marcia.musgrave@aptim.com |
| APTIM H&S Manager: Doug Russell | 865-560-7918 (office)<br>865-414-9545 (cell)) | | winston.russell@aptim.com |
| APTIM Program Manager: Steven Moran | 865-560-7905 (office)<br>865-607-91484 (cell) | 865-560-7956 | Steve.g.moran@aptim.com |
| APTIM Project Manager: Don Burton | 865-207-1394 (cell) | | don.burton@aptim.com |
| APTIM CIH – Larry Verdier | 513-378-8021 (cell) | | larry.verdier@aptim.com |

# WORK SHEET FOR GOVT & CONTRACTOR PRELIMINARY ACCIDENT NOTIFICATION

This work sheet is a field tool to assist the collection of information about an accident and facilitate the completion of a Preliminary Accident Notification. For Member of the Public Recreation Visitor accidents use the Initial Notification of Public Recreation Mishap Work Sheet

| **General Information:** | | |
|---|---|---|
| 1. Project Name: | 2. HNC Project Office Symbol: | 3. Date Worksheet completed: |
| 4. Person Name Completing Worksheet: | 5. Phone Number: | 6. Contract Number: |
| 7. Date of Mishap: | 8. Time of Mishap | |
| 9. Prime Contractor: | 10. Subcontractor: | |

| **Location and Mishap Information:** | |
|---|---|
| 1. Exact Location of Mishap: | |
| 2. Number of Persons involved: | 3. Number of Properties involved: |

| **Personnel Classification:** | | | | |
|---|---|---|---|---|
| Government Civilian: ☐ | Military: ☐ | Government Direct Contractor: ☐ | Foreign National: ☐ | |
| Volunteer: ☐ | Prime Contractor: ☐ | Subcontractor: ☐ | Public: ☐ | Other: |

| **Type of Mishap:** | | | | |
|---|---|---|---|---|
| Fatality: ☐ | Injury / Illness: ☐ | Property Damage: ☐ | Fire: ☐ | Driving: ☐ |

| **Personal Data:** (Note: If more than 2 persons involved provide their personal data on a separate sheet) | | | |
|---|---|---|---|
| 1. Name: Last: First: Middle Initial: | 2. Age: | 3. Gender: | |
| 4. Job Series & Title: | | 5. Grade: | |
| 6. Duty Status: On Duty: ☐ Off Duty: ☐ TDY: ☐ | 7. Time Work Began: | | |
| 8. Unit and Station Assignment: | 9. Office Symbol: | 10. Date Hired: | |
| 11. What was Person doing before the mishap occurred? | | | |

| **Injury Information:** N/A ☐ | | |
|---|---|---|
| 1. Nature of Injury: | 2. Primary Body Part Affected: | 2.a. Secondary: |
| 3. Type of Injury: | 4. Source of Injury: | |
| 5. Severity of Injury: Fatality: ☐ Permanent Total Disability: ☐ Permanent Partial Disability: ☐ Other: ☐ If Other Describe: | | |
| 6. Estimated Days Away: | 7. Estimated Days Restricted/Transferred: | |
| 8. Primary Language Spoken: | 9. English Literate: Yes: ☐ No: ☐ | |
| 10. Does this person wish to remain anonymous: Yes: ☐ No: ☐ | | |
| 11. Was injured person hospitalized? Yes: ☐ No: ☐ | | |
| 12. Name of Physician/Health Care Professional: | | |
| 13. Medical Treatment Facility Name: | 14. Phone #: | |
| 15. Facility Address: | | |

**Summary of Mishap**

**Remarks**

**Describe Any Information Released to the Public**

**Nature of Injury**

Amputation
Abrasion
Back Strain
Burn
Contusion/Bruise
Concussion
Dislocation of joint
Drowning
Fracture
Hearing Loss
Hernia
Laceration/Cut
Puncture
Strain
Stroke
Traumatic Food Poisoning
Traumatic Heart Condition
Traumatic Mental Disorder
Traumatic Respiratory
Traumatic Skin Disease
Tuberculosis
Traumatic Virological/Infective
Parasitic Disease
Other

**Type of Injury**

Struck by/against
Fell/slipped/tripped
Caught on/in/between
Punctured/lacerated
Stung/bit by
Contact with/by
Exerted
Exposed
Inhaled
Ingested
Absorbed
Traveling In

**Severity of Injury**

Injury
Illness
Fatality
Permanent Disability

**Source of Injury**

Environmental Condition
Building or other Area
Walking surface
Electricity
Temperature Extreme
Weather
Fire
Water
Mechanical Equipment
Guard/Shield
Video Display Terminal
Heating
Motor Vehicle/Cycle
Boat
Bicycle/Other non-motorized vehicle
Noise
Radiation
Light
Ventilation
Smoke
Stress
Confined Space
Carbon Monoxide
Inanimate Object
Animal Insect
Human (Violence)
Diving Equipment
Parachute

**Body Parts**

Arm or Wrist
Breast
Testicle
Abdomen
Chest
Lower Back
Penis
Side
Upper Back
Waist
Trunk Other
Ear
Eye
Brain
Cranial Bones
Teeth
Jaw
Throat/Larynx
Mouth
Nose
Tongue
Head Other External
Elbow
Finger
Thumb
Toe
Face
Scalp
Knee
Leg
Hip
Ankle
Buttock
Hand
Feet
Collar Bone
Shoulder Blade
Rib
Sternum
Vertebrae
Trunk Bones other
Shoulder
Lung
Kidney
Heart
Liver
Reproductive Organs
Stomach
Intestines
Trunk/internal

U.S. Army Corps of Engineers (USACE)

**MISHAP NOTIFICATION AND INVESTIGATION**

For use of this form, see instructions in the attachments and USACE ER 385-1-99; the proponent agency is CESO.

***Requirement Control Symbol***

***RCS-CESO-21-0001***

**DATA REQUIRED BY THE PRIVACY ACT OF 1974**

**Authority** 10 U.S.C. 7013, Secretary of the Army; 5 U.S.C. 7902, Safety Programs; Public Law 91-596, Occupational Safety and Health Act of 1970; DoD Instruction 6055.1, DoD Safety and Occupational Health Program; Army Regulations 385-10, Army Safety Program; DoD Instruction 6055 .07, Mishap Notification, Investigation, Reporting, and Record Keeping; and E.O. 9397 (SSN), as amended.

**Principal Purpose** Information collected is to provide the USACE leaders, soldiers, families and civilians in injury, illness, and loss data to effectively manage its safety and occupational health program.

**Routine Uses** In addition to those disclosures generally permitted under 5 U.S.C. 552a(b) of the Privacy Act of 1974, these records or information contained therein may specifically be disclosed outside the DoD as a routine use pursuant to 5 U.S.C. 552a(b) as follows: To the Department of Labor, the Federal Aviation Agency, the National Transportation Safety Board, and to Federal, State, and local agencies and applicable civilian organizations, such as the National Safety Council, for use in a combined effort of accident prevention. In some cases, data must also be disclosed to an employee's representative under the provisions of 29 CFR 1960.29. Records will be made available consistent with applicable laws and regulations. Information will be withheld from the public only if authorized by 5 U.S.C. Section 552 (Freedom of Information Act (FOIA), 5 U.S.C. 552a (Privacy Act)), or other statutory or regulatory authority.

**Disclosure** Failure to provide all the required information on the report may result in the rejection of report submission.

## 1. WHO IS REPORTING MISHAP

| | |
|---|---|
| a. Name: | b. Phone number: |
| c. Email address: | d. Signature: |

| | | |
|---|---|---|
| e. Report type: | ☐ 1. Near Miss Report. *(No injury/illness, or property damage. Complete all fields with underlined text.)* | Date: |
| | ☐ 2. Initial Accident Report. (*For accident notification within 24 hrs, Complete all fields with underlined text.*) | Date: |
| | ☐ 3. Final Accident Report. *(For reporting findings from accident investigation, complete full form.)* | Date: |

f. Mishap Type. *(Check all that apply)*

| | | | |
|---|---|---|---|
| ☐ Fatality | ☐ Injury/Illness | ☐ Property Damage | ☐ Near Miss |

g. Were any of the following items associated with the mishap ? ☐ Yes ☐ No *(If yes, check all that apply)*

| | | | | |
|---|---|---|---|---|
| ☐ Electrical and/or Hazardous Energy | ☐ Working at Heights | ☐ Diving | ☐ Load Handling Equipment or Rigging | ☐ Occupational Health Exposure |

## 2. WHO WAS INVOLVED IN THIS MISHAP?

| | | |
|---|---|---|
| a. Name: | | |
| b. Personnel Classification: | c. Time employee began work: | |
| d. Gender: | e. Date of birth (for Government personnel only): | f. Age: |
| g. Date hired: | h. Primary language: | |
| i. Is individual a supervisor? ☐ Yes ☐ No | j. Duty status at time of mishap: | k. Years experience in job: |

l. What was individual doing when mishap occurred? (*Select activity from the drop downs below.*)

| | |
|---|---|
| 1. General activities: | 2. Vehicle/Equipment/Vessel: |
| 3. Sports/Recreation: | 4. Other not listed: |

m. Did individual utilize all OSHA/EM 385-1-1 required Personal Protective Equipment (PPE) for activity? ☐ Yes ☐ No ☐ N/A

If no, identify missing PPE:

| | |
|---|---|
| n. Was a Personal Flotation Device used? ☐ Yes ☐ No ☐ N/A | o. Was a seat belt used? ☐ Yes ☐ No ☐ N/A |

p. **Government personnel only:**

| 1. Job series: | 2. Rank: | 3. Grade: |
|---|---|---|
| 4. Center/Division/Lab: | | 5. District: |

q. **Contractor personnel only:**

| 1. Employer/Contractor name: | | |
|---|---|---|
| 2. Individual's occupation/trade: | | Other not listed: |

r. If mishap occurred on a contractor site, provide the following:

| 1. Prime Contractor name: | | |
|---|---|---|
| 2. Contract number: | 3. Contract type: | 4. Funding type: |

## 3. WHAT TYPE OF INJURY/ILLNESS OCCURRED?

| a. Severity of injury/illness? | b. Type of Injury/Illness: |
|---|---|
| c. Identify body part(s) affected by injury/illness: | |
| Primary body part affected: | Secondary body part affected: |
| d. Identify cause and source of injury/illness: | |
| Cause of injury/illness: | Source of injury/illness: |

e. Was employee treated by a physician or health care professional provider? ☐ Yes ☐ No

If yes, provide name of physician or health care professional provider?

| f. Was treatment given away from work site? ☐ Yes ☐ No | g. Was employee treated in an emergency room ? ☐ Yes ☐ No ☐ N/A |
|---|---|

h. If treatment was given away from the work-site, where was it given? (For Government Personnel Only)

Treatment facility name:

Address:

City: State: Zip: Country:

| i. Was employee hospitalized as an in-patient? ☐ Yes ☐ No | If yes, how many nights? | Was OSHA notified? ☐ Yes ☐ No |
|---|---|---|

**Note:** OSHA requires reporting all work-related fatalities within 8 hours and in-patient hospitalizations, amputations and loss of an eye within 24 hours to OSHA.

| j. Estimated days away from work: | k. Estimated days of restricted/transferred duty: |
|---|---|

## 4. WHAT HAPPENED?

a. What was the primary activity occurring at the time of the mishap?

Other, not listed:

b. What happened? Provide a detailed description of the mishap. (Do not include any personally identifiable information (name, etc.).)

Note: Provide supporting photos, charts, diagrams, etc. with this report.

c. What other organizations or agencies have been notified about this mishap?

## 5. WHAT TYPE OF PROPERTY/MATERIAL WAS INVOLVED?

a. List all property/material involved in the mishap. (Include damaged and undamaged property.)

| | *Item A* | *Item B* | *Item C* |
|---|---|---|---|
| i. Type of item: | | | |
| Other not listed: | | | |
| ii. Name of item(s): | | | |
| iii. Collision type: | | | |
| Other not listed: | | | |
| iv. Ownership of item: | | | |
| v. Dollar cost of damage: | | | |

## 6. WHEN DID THE MISHAP OCCUR?

| | |
|---|---|
| a. Date the mishap occurred: | b. Time mishap occurred: |
| c. What day did mishap occur on? | d. What period of day did mishap occur? |

## 7. WHERE DID THE MISHAP OCCUR?

a. Did the mishap occur on a military Base/Post? ☐ Yes ☐ No

b. USACE Office/Program/Project name:

c. Select the location type most closely associated with the mishap:

d. Identify exact location where mishap occurred:

Address:

City: State: Zip: Country:

| | |
|---|---|
| e. Latitude: | f. Longitude: |

## 8. WHY DID THE MISHAP OCCUR? (*Recommend completing this section for Near Misses.*)

### A. Performance Causal Factors

1. Did a problem with performance contribute to this mishap occurring? ☐ Yes ☐ No

If yes, select the error that contributed most to the mishap:

2. Describe action(s) taken, anticipated or recommended to eliminate cause(s):

### B. Support Causal Factors

1. Did a problem with resources contribute to this mishap occurring? ☐ Yes ☐ No

If yes, select the error that contributed most to the mishap:

2. Describe action(s) taken, anticipated or recommended to eliminate cause(s):

### C. Standards/Policy/Planning Causal Factors

1. Did an organizational standard/policy/or plan contribute to this mishap occurring? ☐ Yes ☐ No

If yes, select the error that contributed most to the mishap:

2. Was a written Activity Hazard Analysis (AHA) or equivalent completed and accepted by Government Designated Authority (GDA) for task(s) being performed at time of mishap? (If yes, attach a copy to this report) ☐ Yes ☐ No

If yes, was the AHA available and used by worker? ☐ Yes ☐ No

3. Was a written work plan (critical lift plan, fall protection plan, etc.) required, completed and accepted by the GDA for task(s) being performed at time of mishap? ☐ Yes ☐ No

If yes, was the plan available and used by worker? ☐ Yes ☐ No

4. Describe action(s) taken, anticipated or recommended to eliminate cause(s):

**D. Training Causal Factors**

1. Did a problem with training contribute to this mishap occurring? ☐ Yes ☐ No

If yes, select the error that contributed most to the mishap:

2. Was individual trained to perform the activity/task? ☐ Yes ☐ No

If yes, select type of training: ☐ Classroom ☐ Certification/License ☐ On the job

☐ Other, describe:

What was date of most recent training?

3. Describe action(s) taken, anticipated or recommended to eliminate cause(s):

**E. Leader/Supervisor Causal Factors**

1. Did any leader/supervisory mistake/task error contribute to this mishap occurring? ☐ Yes ☐ No

If yes, select the error that contributed most to the mishap:

2. Did the safety climate/culture contribute to the mishap? ☐ Yes ☐ No

3. Did challenges with teamwork contribute to the mishap? ☐ Yes ☐ No

4. Describe action(s) taken, anticipated or recommended to eliminate cause(s):

**F. Individual Causal Factors**

1. Did any individual mistakes/task errors contribute to this mishap occurring? ☐ Yes ☐ No

If yes, select the error that contributed most to the mishap:

2. Describe action(s) taken, anticipated or recommended to eliminate cause(s):

**G. Physical Environment Causal Factors**

1. Did any physical environment contribute to this mishap occurring? ☐ Yes ☐ No

If yes, select the error that contributed most to the mishap:

2. Describe action(s) taken, anticipated or recommended to eliminate cause(s):

**H. Material Causal Factors**

1. Did any material failure contribute to this mishap occurring? ☐ Yes ☐ No

If yes, select the error that contributed most to the mishap:

2. Which failure is most closely associated with the material failure/malfunction?

3. Describe action(s) taken, anticipated or recommended to eliminate cause(s):

**I. Environmental Causal Factors**

1. Did any environmental condition contribute to this mishap occurring? ☐ Yes ☐ No

If yes, select the factor that contributed most to the mishap:

2. Describe action(s) taken, anticipated or recommended to eliminate cause(s):

| J. Facility/Building Design |
|---|
| 1. Did the design of the facility/building contribute to the mishap? ☐ Yes ☐ No |
| If yes, describe: |
| 2. Describe action(s) taken, anticipated or recommended to eliminate hazard: |
| **K. Existing Hazard** |
| 1. Did a hazard(s) contribute to the mishap? ☐ Yes ☐ No |
| If yes, describe the hazard(s): |
| 2. Describe action(s) taken, anticipated or recommended to eliminate hazard(s): |
| **9. Corrective Action plan** |
| a. Have all corrective action(s) to prevent mishap recurrence been completed? ☐ Yes ☐ No |
| b. Who is responsible for the corrective action plan? |
| c. What date will/have all corrective action(s) be/been completed by: |
| d. Additional information: |
| **10. Additional Information** |

# OSHA's Form 300A (Rev. 01/2004)

# Summary of Work-Related Injuries and Illnesses

Year 2020

**U.S. Department of Labor**
**Occupational Safety and Health Administration**

Form approved OMB no. 1218-0176

*All establishments covered by Part 1904 must complete this Summary page, even if no injuries or illnesses occurred during the year. Remember to review the Log to verify that the entries are complete*

*Using the Log, count the individual entries you made for each category. Then write the totals below, making sure you've added the entries from every page of the log. If you had no cases write "0."*

*Employees former employees, and their representatives have the right to review the OSHA Form 300 in its entirety. They also have limited access to the OSHA Form 301 or its equivalent. See 29 CFR 1904.35, in OSHA's Recordkeeping rule, for further details on the access provisions for these forms.*

## Number of Cases

| Total number of deaths | Total number of cases with days away from work | Total number of cases with job transfer or restriction | Total number of other recordable cases |
|---|---|---|---|
| 0 | 2 | 1 | 10 |
| (G) | (H) | (I) | (J) |

## Number of Days

| Total number of days away from work | Total number of days of job transfer or restriction |
|---|---|
| 30 | 181 |
| (K) | (L) |

## Injury and Illness Types

| Total number of… | (M) | | |
|---|---|---|---|
| (1) Injury | 13 | (4) Poisoning | 0 |
| (2) Skin Disorder | 0 | (5) Hearing Loss | 0 |
| (3) Respiratory Condition | 0 | (6) All Other Illnesses | 0 |

## Establishment information

Your establishment name: APTIM Government

Street: 4171 Essen Lane

City: Baton Rouge State: LA Zip: 70809

Industry description (e.g., Manufacture of motor truck trailers)
Other Heavy and Civil Engineering Construction

Standard Industrial Classification (SIC), if known (e.g., SIC 3715)

OR North American Industrial Classification (NAICS), if known (e.g., 336212)
2 3 7 9 9 0

## Employment information

Annual average number of employees: 1,811

Total hours worked by all employees last year: 3,766,393

**Sign here** Alan B. Weakley

**Knowingly falsifying this document may result in a fine.**

I certify that I have examined this document and that to the best of my knowledge the entries are true, accurate, and complete.

Alan Weakley
Company executive

President
Title

865-560-7936
Phone

1/28/2021
Date

**Post this Summary page from February 1 to April 30 of the year following the year covered by the form**

# ATTACHMENT 4

# SSHO RESUME AND TRAINING CERTIFICATIONS

Talent Shaw Connection™
Building Careers For Growth, Leadership, and Opportunity

**This certificate is awarded to**

## Brian Rhodes

for the successful completion of the course

## 40-Hour HAZWOPER Training

Hours: 40 Hours 0 Min  Credits:

**Completion Date: 11/9/1998**

Virgil Barton, Sr. Vice President
Quality, EHS, Regulatory Compliance,
Process Improvement

Talent Shaw Connection™
Building Careers For Growth, Leadership, and Opportunity

**This certificate is awarded to**

## Brian Rhodes

for the successful completion of the course

## OSHA 30 Hour Construction Safety

Hours: 30 Hours 0 Min  Credits: 0

**Completion Date: 1/28/2010**


Virgil Barton, Sr. Vice President
Quality, EHS, Regulatory Compliance,
Process Improvement

Talent Shaw Connection™
Building Careers For Growth, Leadership, and Opportunity

**This certificate is awarded to**

## Brian Rhodes

for the successful completion of the course

## 8-Hour HAZWOPER Supervisor Training

Hours: 8 Hours 0 Min  Credits: 0

**Completion Date: 4/24/2003**

Virgil Barton, Sr. Vice President
Quality, EHS, Regulatory Compliance,
Process Improvement

Talent Shaw Connection™
Building Careers For Growth, Leadership, and Opportunity

**This certificate is awarded to**

## Brian Rhodes

for the successful completion of the course

## 8-Hour HAZWOPER Refresher

Hours: 8 Hours 0 Min  Credits: 0

**Completion Date: 11/28/2012**

Virgil Barton, Sr. Vice President
Quality, EHS, Regulatory Compliance,
Process Improvement

Compliance Solutions
"Today's Training...Tomorrow's Solution"

*Certificate Number:* Online

# *Certificate of Completion*

This is to certify that

## Brian Rhodes

has been tested and successfully meets the training requirments for

## 8-Hour HAZWOPER Annual Refresher

**29 CFR 1910(e) & Title 8CCR 5192(e)(3)(A}**

*Presented this:*

**Wednesday, November 21, 2018**

## *Compliance Solutions Occupational Trainers, Inc.*

Neval Gupta
*Vice President*

Jeffrey Kline
*President/CEO*

**Student Affiliation:**
APTIM
4433

Compliance Solutions
*"Today's Training...Tomorrow's Solution"*

3980 Quebec St., 2nd Floor, Denver CO 80207-1633 800-711-2706

# *Certificate of Completion*

***Brian Rhodes***

has successfully completed training and passed all testing requirements for

***8-Hour HAZWOPER Annual Refresher***
***as per 29 CFR 1910.120(e)***

Presented this
*Wednesday, November 27, 2019*

***Certificate Number: 754982334***

***Compliance Solutions Occupational Trainers, Inc.***

**Jeffrey E. Kline**
***President/CEO***

American Red Cross
Training Services

# Certificate of Completion

Brian Rhodes

has successfully completed requirements for

**Adult and Pediatric First Aid/CPR/AED**

Date Completed: 4/1/2020
Validity Period: 2 - Years

Conducted by: American Red Cross

To verify certificate, scan code or visit redcross.org/digitalcertificate and enter ID.

Learn and be inspired at LifesavingAwards.org

008FUE7

# Brian Rhodes

(256) 714-4200 | 205 Yonex Drive Madison, AL 35756 | brianrhodes24@yahoo.com

## Senior Environmental Scientist

Accomplished geologist with 20 years of environmental site investigation experience and 15+ years management experience. Experienced project geologist, waste specialist, and site manager. Expert in the collection and interpretation/evaluation of soil/groundwater samples. Adept at project management and problem-solving in hydrogeologic studies, water resources, environmental site assessments, remedial actions, soil & groundwater contamination studies, stormwater management, geotechnical investigations, land use planning, heavy metal remediation, and more.

## EDUCATION

**Bachelor of Science Degree in Geology** (1997)
*University of Alabama* | *Tuscaloosa, AL*
**Associate of Science** (1991)
*Calhoun Community College* | *Decatur, AL*

## CERTIFICATIONS

40-Hour HAZWOPER as per 29 CFR 1910.120(e)
Hazmat Transportation Security Awareness as per 49 CFR 172.704
H&S Program Management for Project Managers and Supervisors
Construction Quality Management for Contractors (Army Corps of Engineers)
OSHA 10-Hour Construction Safety
IATA Dangerous Goods Transportation as per DOT CFR 172.704(a), (1), (2) and (4)
DOT Hazardous Materials Transportation as per 49 CFR 172.704(a), (1) and (3)
OSHA 30-Hour Construction Safety
50-Hour Site Safety Officer
Level I Antiterrorism Awareness Training
OPSEC Awareness for Military Members, DOD employees and Contractors
Military Munitions Response Program (MMRP) 101 Workshop (Army Corps of Engineers)
Munitions Response Site Prioritization Protocol (Army Corps of Engineers)

## PROFESSIONAL EXPERIENCE

APTIM (Sep 2013–Present)
Shaw Group (Sep 2010–Sep 2013)

Manage environmental site investigations in the following capacities under the Army's Program Management Contract:

**Quality Control Site Manager (QCSM), Environmental Site Investigations**

★ Oversee and maintain quality control for several sites, ensuring contracts are followed and subcontractors followed due diligence, resulting in 100% completion and approval by state and national regulators

- Manage on-site and off-site QC program, including field sampling and characterization, construction, and consulting engineering activities
- Ensure overall project quality and that deliverables meet corporate quality standards; evaluate quality-related status, procedures, and non-conformances in coordination with the project QA
- Monitor all subcontractors; prepare daily QC reports; work closely with the QA/QC Manager on any adverse conditions that couldn't be resolved at the project level
- Assist with training and orientation of field staff; conduct random performance and systems inspections to verify all personnel are following implemented work plan procedures; identify and report any nonconforming items or activities

**Project Geologist, Environmental Site Investigations**

★ Achieved 125+ milestones the PMC contract team, including 85 sites with approved RCRA Facility Investigations (RFIs), 53 sites with No Further Actions (NFAs), and 22 sites with approved Corrective Measures Implementation Work Plans (CMIPs)
★ Managed 12 remediation projects of off-site shipment of contaminated soils, working directly with subcontractors during soil excavations, which resulted in meeting cleanup goals
★ Managed the construction of 2 on-site landfills, which required consolidating waste and soil and capping them with a geosynthetic clay liner, while taking precautions for contaminants including DDT, DDE, and PAHs

- Oversee all on-site geological activities, supervise subcontracted drilling, subsurface investigations, remediation, and groundwater sampling crews; conduct all geological field documentation forms and boring/drilling logs
- Manage subcontractor investigations and provide technical guidance; generate daily QC reports

- Develop technical approaches, work plans, and statements of work; evaluate, select, and oversee subcontractors; ensure contracts are properly implemented, establish safety procedures, maintain schedule and budget

Aptim Federal Services (formerly CB & I Federal Services) (Jul 2017–**Present**)
CB&I Federal Services (formerly Shaw Group) (Sep 2013–Jul 2017)

**Site Safety and Health Officer**

★ Evaluated the Health and Safety aspects of the on-site tasks to ensure that activities are performed in a safe manner
★ Coordinated with Task Managers to complete Health and Safety Work Plan agenda and worked with on-site personnel to achieve compliance with applicable Health and Safety Plans

★ Conducted site orientation training with all new onsite personnel to insure all general site hazards, project safety rules, chain of command and emergency procedures are provided

★ Worked closely with Senior Health and Safety officers and Task Managers to develop and implement Activity Hazard Analysis for any anticipated hazards for all associated tasks to include the following

- Activity Hazard Analysis includes all chemical and physical hazards that may be encountered for each task. These control measures include work practice controls, engineering controls, health and safety policy reference and use of appropriate personal protective equipment (PPE).
- Implementation of Job Safety Analysis (JSA) which is a checklist of daily hazards along with any change conditions encountered during a work period
- Daily safety hazards to be analyzed may include the following
    - Mobilization/Demobilization of heavy equipment
    - Slips, Trips and Falls
    - Heavy Lifting, Strains and Sprains
    - Use of Heavy Equipment
    - Heat Stress and Cold Stress
    - Noise Prevention
    - Spill Prevention
    - Personal Protective Equipment (PPE)
    - Air Monitoring

**Waste Specialist**

★ Successfully made off-site shipments of 5200+ drums of waste, 300,000+ gallons of liquid, and 200,000+ cubic yards of contaminated soil through the successful management of non-hazardous and hazardous waste
★ Developed a drum tracking system to address issues with drum labeling and tracking, which resulted in the proper disposal of 100% of drums generated

- Manage waste stream from approx. 300 environmental sites on RSA, ensuring all containers undergo a receipt inspection to verify proper requirements have been met
- Established and maintain a waste tracking system which tracks waste containers from “cradle to grave”
- Conduct weekly inspections on one year and 90 day hazardous waste storage areas to ensure hazardous waste are properly stored, labeled, packaged, characterized and documented in accordance with the Waste Management Plan (WMP)
- Ensure all storage areas are in compliance with RCRA standards which include proper labeling, spill containment kits and proper PPE
- Work directly with government and regulatory personnel on waste disposal, ensuring documentation is properly prepared, executed, and retained for official records; ensure all waste shipments meet the U.S. Department of Transportation (DOT) requirements
- Coordinate with Army and regulatory personnel for the off-site shipment of non-hazardous and hazardous waste streams
- Ensure all hazardous/non-hazardous waste is properly containerized in accordance with Department of Transportation, 49 CFR

**Sample Coordinator**

- ★ Managed numerous soil and groundwater sampling events and ensured that they were successful
- ★ Resolved chemical agent contamination of multiple sites by successfully managing field sampling efforts during intrusive investigation activities, including:
    - Coordinating and tracking sample status for chemical analysis (CA) screening and analyses
    - Working with several investigation teams including, Chemical, Biological, Radiological, Nuclear, and High Yield Explosives and Remediation Activity (CARA), Edgewood, Chemical and Biological Center (ECBC) and multiple laboratories to ensure that CA screening and analyses did not negatively impact analytical holding times
    - Implementing recovery plans to ensure that HTRW laboratories received CA clearance in time so that analytical holding times were met
    - Manage laboratory and facilitation of sample and documentation transfers, forwarding discrepancies to the Field Sampling Lead, the Project Chemist, and the Laboratory PM for resolution
    - Ensure all analytical samples are collected, documented, packaged, and shipped using project-specific plans and IW QAPP; assist in identifying and resolving any technical or quality issues regarding sample collection and analysis; resolve any non-conformances or quality issues

Shaw Group (Aug 2003–Sep 2010)

**Site Manager**

- Managed the coordination of work activities, quality, schedule, budget, and subcontractors; ensured compliance of the scope of work and environmental activities
- Ensured field activities are completed and meet project objectives in accordance with Redstone Arsenal and the Army Corps of Engineers; ensure all site personnel are trained in procedures, that the procedures are adhered to, and that all activities are documented
- Tracked and maintained inventory of all Government Furnished Equipment (GFE) per FAR Part 45 as by instructed by United States government.

International Technology (Nov 1998–Jan 2002)

**Project Geologist**

- Implemented and maintained a site-wide surface water monitoring system that synthesized available and newly acquired data to develop a site-wide understanding of surface water flow and discharge
- Provided field oversight to HTW drilling sites, including hollow stem auger and sonic drilling methods for the installation of monitoring wells for site investigations
- Analyzed and reported geological materials, completed field document boring and drilling logs, collected soil and groundwater samples

# APPENDIX F

# INVESTIGATION-DERIVED WASTE STANDARD OPERATING PROCEDURE 4.0

## Subject: INVESTIGATION-DERIVED WASTE

## 1.0 PURPOSE AND SUMMARY

This Standard Operating Procedure (SOP) establishes specific management practices for the in-process handling and subsequent disposition of environmental media generated as a result of investigation and removal actions at Redstone Arsenal (RSA), Madison County, Alabama. Investigation-derived waste (IDW) will be handled in accordance with the most recent versions of Alabama Environmental Investigation and Remediation Guidance and Alabama Administrative Code (AAC) 335-14. This SOP serves as an update to IDW plans previously submitted to comply with Alabama Department of Environmental Management (ADEM) Consent Order No. 97-203-CHW for the management of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) IDW.

In support of RSA's Installation Restoration Program under the Federal Facilities Compliance Act of 1992 and CERCLA and to meet the requirements of RSA's Resource Conservation and Recovery Act (RCRA) permit, RSA is conducting investigation and removal activities which generate environmental media. The media typically consist of drill cuttings and fluids, monitoring well purge and development water, spent personal protective equipment (PPE), and other inert materials (i.e., plastic, rope, tape, paper, etc.) generated during operations, well installation and sampling activities, remedial actions, and associated site activities. When accumulated, the media must be managed appropriately to minimize the exposure to human health and the environment while adhering to applicable regulatory requirements.

## 2.0 TABLE OF CONTENTS

## 3.0 RESPONSIBILITIES

### 3.1 Quality Control Site Manager

The Quality Control Site Manager (QCSM) is responsible for ensuring that field activities are completed to meet the project objectives, that they are conducted in accordance with the project plans and requirements, and that all activities are performed according to their respective procedures. The QCSM is responsible for ensuring that all site personnel are trained in the procedures, that the procedures are adhered to, and that all activities are documented.

### 3.2 Field Team

All members of the field team (samplers, technicians, field geologists, engineers, etc.) are responsible for understanding and implementing this field procedure as well as ensuring that all team members also perform work in accordance with this SOP.

### 3.3 Quality Assurance/Quality Control Manager

The Quality Assurance/Quality Control Manager is responsible for ensuring that this SOP is correctly implemented and that the quantity and quality of field- measurable physical characteristic samples collected meet the requirements of the Site-Specific Field Sampling Plans (SFSP).

## 4.0 DEFINITIONS

None.

## 5.0 TEXT

### 5.1 Required Records and Forms

For a description of required forms, refer to SOP No. 1.0, *Field Documentation*.

- Sample Collection Log (SCL)
- Field Activity Daily Log

- Sample tags/labels and the appropriate forms/documentation for sample shipment
- Material Safety Data Sheets (MSDS)
- SFSP.

## 5.2 Required Materials, Equipment, or Supplies

- Indelible black ink pens and markers
- Appropriate sample containers
- Insulated cooler and waterproof sealing tape
- Nitrile or latex gloves
- Decontamination equipment and supplies, including rinse bottles and deionized water
- Personal protective equipment (PPE)
- Socket wrench or bung wrench to access drums
- Appropriate equipment and meters for obtaining field measurements as specified in the SFSP (i.e., photoionization detector/flame ionization detector).

## 5.3 Procedures

### 5.3.1 Preparation

The following steps must be followed when preparing for management activities of IDW:

- Verify that all personnel have read and understand the approved Site-Specific Health and Safety Plan and have the proper training and certifications required under the Occupational Safety and Health Administration.
- Don the appropriate PPE as dictated by the Site-Specific Health and Safety Plan.
- Document the sampling events, recording the information on the SCL or equivalent form as specified. Document any and all deviations from standard operating procedures on the Field Activity Daily Log and include rationale for changes.

### 5.3.2 Specific Preparation

The following paragraphs detail the planned methodologies for dealing with environmental media generated during site activities. For the purpose of this document, a site, an area of contamination (AOC), and a solid waste management unit (SWMU) are all synonymous.

#### 5.3.2.1 Initial Handling Requirements

All environmental media will be managed in an effort to minimize exposure to human health and the environment. Typically, the media will be generated as a result of these

major activities: drilling soil borings; installation and development of monitoring wells; and groundwater sampling activities.

In instances where soil borings are advanced, either to retrieve soil samples or to allow for the retrieval of a groundwater sample via a hydropunch or similar sampling device (including obtaining a sample from an open borehole), the following handling protocols for IDW soil will be used:

- All soil cuttings will be placed adjacent to the borehole on plastic or other suitable material capable of preventing contact with the ground surface.
- All cuttings will be covered daily or during rainfall events to prevent contact with moisture.
- Upon completion of the downhole activity (i.e., drilling, groundwater sampling, etc.), the soil cuttings will be placed in open topped 55-gallon drums, labeled, sampled, and properly stored.

In cases where a soil test boring is advanced for the purposes of installing a monitoring well, all environmental media accumulated will be containerized to allow for characterization upon generation and situated at or near the point of generation. As solids are generated, they will first be placed into open-topped 55-gallon drums or other approved containers pending further characterization. Solids may be bulked into larger approved containers situated within the AOC. Liquids may be bulked upon generation unless directed otherwise. All solids and liquids will be separated prior to disposal.

Liquids may be held on site at the AOC or SWMU and are not required to be moved to a separate 90-day storage area. However, either the satellite accumulation restrictions regulating storage of less than 55 gallons or 90-day storage rules would apply to hazardous liquids that remain on the SWMU/AOC. Section 5.3.2.3 further discusses storage requirements. If hazardous liquids are stored on site, the satellite accumulation area or the temporary less-than-90-day storage area must meet ADEM requirements for secondary containment standards as noted in Section 5.3.2.3.

### 5.3.2.2 Labeling

After each container (i.e., drum, roll-off box, etc.) has been filled, the container and lid, if appropriate, will be labeled with a description of the media (i.e., soil, purge water, decon water, PPE), origin of media (i.e., Soil Boring A- 1, Monitor Well RS-0 1 2, etc.), date the media were placed in the container, site identification (i.e., SWMU or AOC number), date container was sealed and sampled, and a short statement stating that the contents are on hold waiting analytical test results. If the analytical results determine that the container contents are hazardous, a standard hazardous waste label will be placed on each container. The accumulation start date will be the same as the date recorded on the initial drum. A copy of correspondence (email) from ADEM clarifying their position on handling of potentially hazardous wastewater at RSA is provided as an attachment to this SOP. Nonhazardous waste containers may be labeled using a paint pen or other indelible

marker that will not fade when exposed to weather. Hazardous waste containers will be marked with labels and information pursuant 40 Code of Federal Regulations (CFR) 262.34. A record of the number of containers, their contents, and the regulatory status of the waste will be completed at each generation site and will be included in the Field Activity Daily Log before leaving each site.

#### 5.3.2.3 Storage

At the end of each day and/or field activity, all containers will be sealed or covered in such a way to prevent the introduction of rain water or surface runoff. Nonhazardous IDW will either be moved to a central IDW storage area, or, if feasible and in the best interest of operations, nonhazardous IDW will remain in the SWMU/AOC from where it was generated until final disposition is selected.

Within 72 hours of being generated, hazardous solid IDW will be moved to an RSA-approved Satellite Accumulation Area, a temporary 90-day storage area, or a fully permitted waste storage area. Wastewater IDW may be held at the AOC or SWMU in a temporary less-than-90-day storage area or it may be moved to a central 90-day storage area. Any temporary 90-day storage area established on an AOC or SWMU will meet ADEM's secondary containment standards. Wastewater or solid hazardous IDW will be labeled during storage as discussed in Section 5.3.2.2.

Waste may be transported between storage areas when required or in preparation of disposal activities without specific regulatory concurrence (i.e., RSA is not required to obtain specific regulatory approval to transport wastes within the confines of RSA). Drums of hazardous wastewater will be removed from the AOC or SWMU in less than 90 days. All hazardous IDW will be shipped off site or properly treated and managed on site within 90 days of its accumulation start date.

### 5.4 Characterization of Media

The characterization of the media will be determined by a combination of generator knowledge and use of analytical data obtained during the activity from which the materials were generated. As stated, it is anticipated that specific generation activities will include soil borings, monitoring well installations, and monitoring well purge and development actions. Water obtained from specific monitoring well sampling points (i.e., purge and development water) will be characterized using groundwater sampling data taken from the specific well site from which the water was obtained. Analytical data obtained from a particular borehole reflecting soil contaminant levels will be used to characterize solids generated from that borehole. Other solids (such as rock) will be characterized for disposal based on the analytical results of the soil and water sampled at the specific location where the solids were generated. When appropriate, analytical data will be extrapolated to reflect toxicity characteristic leaching procedure (TCLP) values (i.e., 20x divisor rule for soils). Generator knowledge may be used to evaluate the media potential for toxicity, corrosivity, ignitability, reactivity, and listed waste scenarios.

In the event generator knowledge and data associated with previous site investigations are inadequate to accurately and thoroughly characterize the IDW, waste will be managed as hazardous waste. A representative sample will be retrieved from each waste stream warranting further characterization. In addition, representative samples will be collected from all IDW determined to be nonhazardous based on generator knowledge. These samples will be taken directly from containers after the waste has been generated. The suite of analyses to be run will be determined based on suspected contaminants and any information gleaned from previously available data. Hazardous versus nonhazardous determinations will be made utilizing those parameters outlined in AAC R. 335-14-2-.02, *Criteria for Identifying the Characteristics of Hazardous Wastes and for Listing Hazardous Waste*. More specifically, hazardous characteristics will be determined utilizing the requirements of AAC R. 335-14-2-.02 (1) and 335-14-2-.03. Where listed wastes are expected or where the potential exists, specific analytes (i.e., totals as opposed to TCLP) for the listed compounds will be tested in addition to determining any hazardous characteristics. All sampling and analytical testing protocols will be consistent with ADEM/U.S. Environmental Protection Agency (EPA) requirements and methodologies.

## 5.5 Management and Disposition

Once adequately characterized, the containers will be labeled as described. U.S. Department of Transportation-approved labels will be used if transportation outside of RSA boundaries is required or anticipated. The media may also be bulked on site (within the staging area) with like waste streams possessing compatible nonreacting characteristics.

## 5.6 Wastewater

In general, all wastewater generated during the described site activities will most likely be disposed either at an RSA-approved treatment facility or at the wastewater treatment facility currently operated at RSA.

### 5.6.1 Nonhazardous Wastewater

Upon proper characterization and approval from RSA representatives, wastewater determined to be nonhazardous (Section 40 CFR Part 261) but possessing some level of contaminants can be disposed directly into RSA's sanitary sewer system, where it will ultimately be treated at the RSA wastewater treatment plant (WWTP). The RSA representative will request waste characterization data, approximate volume, and the location of disposal in making the determination to accept sewer discharge. The nonhazardous water will typically be discharged at a manhole(s) located near the generation site.

All discharges will be in accordance with provisions outlined in Division 6, *Water Quality Program*, of the AAC. More specifically, the discharge will not be greater than 5 percent of the average dry weather capacity of the WWTP, greater than 5 percent of the

design capacity of the WWTP, or subject to Section 403.6 of the Federal Water Pollution Control Act. No disposal permit is required as long as the wastewater is discharged in quantities of less than 25,000 gallons per day and the water is nonhazardous (40 CFR 261).

Wastewater generated during site activities and for which analytical tests showed no level of contamination present above approved detection limits will be considered nonregulated. The disposal means and methods of nonregulated waste water are at the discretion of RSA representatives (e.g., storm water system, open ditch, etc.) and do not require regulatory consultation or concurrence.

On a quarterly basis, RSA will submit documentation of all discharges (regulated and nonregulated) to ADEM. The documentation will contain pertinent information regarding the discharge, including, date, time, volumes, analytical data (if available), site, action, etc**.** All discharges to the sanitary sewer system will be coordinated in advance.

### 5.6.2 Hazardous Wastewater

Hazardous wastewater will be transported, when required, and treated at an off-site wastewater treatment facility when the following conditions are met:

1. The treatment facility meets the definition of a wastewater treatment unit as defined in AAC R. 335-14-1-.02.
2. The treatment facility is capable of (a) rendering characteristically hazardous wastes (AAC R. 335-14-2-.03) nonhazardous or (b) removing listed wastes (AAC R. 335-14-2-.04) from the contaminated media so that the media no longer contain the listed waste for which the media were originally considered hazardous. If after treatment, analytical tests show the listed waste is not present above laboratory detection limits, then the contaminated media will be considered to no longer contain the listed waste and will no longer be considered hazardous.
3. The wastewater treatment facility has been constructed at RSA in conjunction with a removal, interim remedial action, or remedial action at an AOC.

At no time will liquids that possess hazardous characteristics or meet the definition of a listed waste be disposed into the sanitary sewer system, unless the waste is specifically exempt under RCRA, CERCLA, or its applicable or relevant and appropriate requirement without applicable ADEM authorization.

Wastewater determined to be hazardous may be transported between AOCs and within RSA boundaries for treatment/disposition in accordance with the previously outlined provisions without specific regulatory concurrence.

On a quarterly basis, RSA will submit documentation of discharges to ADEM. The documentation will contain pertinent information regarding the discharge including date, time, volumes, analytical (if available), site, action, etc.

All discharges to the sanitary sewer system will be coordinated prior to any discharge.

In the event that RSA does not have a facility on line capable of treating the hazardous wastewater at or around the time of generation, and the water is expected to remain on site for a prolonged period of time (but not to exceed 90 days), the water will be stored in an area with an adequate secondary containment system until an approved treatment system is on line.

Unless specifically mandated by ADEM and EPA, the treatment and disposal of hazardous and nonhazardous wastewater will be performed as previously described. The wastes will be treated and disposed in a timely manner so as to expedite site activities and to ensure the protection of human health and the environment. Except where noted, specific written concurrence from ADEM and EPA prior to those actions previously described is not required.

## 5.7 Solids

Solids may include soil cuttings, rock, grout, spent PPE, plastic sheeting, rope, unused monitoring well construction materials, and other environmental media generated during field activities. All solids will be containerized at or near the point of generation and staged as described in Section 5.3.2.1. Other specific management practices are described in Sections 5.7.1 and 5.7.2.

### 5.7.1 Nonhazardous Solids

Soil cuttings and rock determined to be nonhazardous will be staged within the confines of the AOC from which they were generated or stored properly in an RSA-approved storage area. After characterizations (hazardous versus nonhazardous) are finalized and depending upon site conditions, nonhazardous cuttings will be removed from containers and replaced “at or near” the location from which they were derived. “At or near” infers media will be placed as near to their point of origin as is practical. Examples would be placing monitoring well cuttings around the monitoring well from which they originated as opposed to within it. However, when not practical, the media may be centrally located within the confines of the originating AOC in an area of minimal traffic and where the media could be managed in a manner protective of human health and the environment. At no time will contaminated media originating from one AOC be transported to another AOC for placement without prior written concurrence from ADEM and EPA.

In the event that site conditions are not conducive to the replacement of the materials (i.e., restricted space, confined area, etc.), soils and rock determined to be nonhazardous may be disposed into RSA's Solid Waste Disposal Facility-Construction/Demolition Landfill (ADEM Permit No. 45-03) or an approved off-site non-hazardous solid waste disposal facility as long as the following conditions are met:

1. Soils exhibiting contaminant levels below analytical detection limits are considered nonregulated and will be disposed at the discretion of RSA representatives.

2. The soil analytes do not exceed 50 percent of the TCLP analysis for any given compound. A disposal report is submitted within 45 days of disposal that includes a signed copy of ADEM's Solid/Hazardous Waste Determination form and any applicable analytical results.

Other nonhazardous solids such as spent PPE, plastic sheeting, rope, unused monitoring well construction materials, and other environmental media generated during field activities that have been determined to be nonhazardous will be emptied into dumpsters or roll-offs for disposal off site at a permitted solid waste disposal facility.

### 5.7.2 Hazardous Solids

Hazardous IDW solids can be segregated into two categories for purposes of waste management. The first is strictly IDW soils. Hazardous IDW soils will be immediately handled and stored as hazardous waste while on RSA. The waste soils will be analyzed, profiled, and managed off site at a permitted transportation, storage, and disposal facility for its characteristic and/or listed waste status. The second hazardous IDW solid category is essentially all non-soil-like media, generally anticipated to be in the form of debris and PPE. The soil versus nonsoil differentiation is necessary in order to select the correct treatment and disposal technology. Hazardous nonsoil and debris media can present different analytical and treatment strategies than contaminated soils.

## 6.0 EXCEPTION PROVISION

None.

## 7.0 CROSS REFERENCES AND OTHER SOURCES OF INFORMATION

This SOP will be used in conjunction with the following cross references where applicable.

SOP No. 1.0 – Field Documentation

SOP No. 11.0 – Field Generated Records Management

Alabama Department of Environmental Management (ADEM), 2009, Division 14 - Hazardous Waste Program, Revised Effective March.

Alabama Department of Environmental Management (ADEM), 2005, **Alabama Environmental Investigation and Remediation Guidance**, September.

McCoy and Associates, 1995, **RCRA Regulations and Keyword Index**, Elsevier, 1995.

U. S. Environmental Protection Agency (EPA), 1992a, **Guide to Management of Investigative-Derived Wastes**, Office of Solid Waste and Emergency Response, Publication 9345.3-03FS, April 1992.

U. S. Environmental Protection Agency (EPA), 1992b, **Management of Contaminated Media**, Region IV EPA, Guidance Number TSC-92-02, December 28, 1992.

U. S. Environmental Protection Agency (EPA), 1991, **Management of lnvestigative-**

**Derived Wastes During Site Inspections**, Office of Research and Development, Publication, EPA/540/G-91/009, May 1991.

## 8.0 ATTACHMENTS

- Attachment 1, ADEM Email Addressing IDW.

# ATTACHMENT 1

# ADEM EMAIL ADDRESSING IDW

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Attachment I
ADEM Email Addressing IDW
RSA IWSAP SOPP 4.0

**Kurth, Randy**

**Subject:** FW: Response to ADEM original comments on the IDW discussion {Update}

**Importance:** High

---

**From:** Morrissette, Krishna M [mailto:KMorrissette@adem.state.al.us]
**Sent:** Wednesday, November 17, 2010 2:54 PM
**To:** Kurth, Randy
**Cc:** Davis, Emily; Burton, Don; Hodges, Barry A Mr CIV USA USACE; Shell, Ronald T; Wilson, J Jason; Reese, Dennis
**Subject:** RE: Response to ADEM original comments on the IDW discussion {Update}
**Importance:** High

Randy,

Sorry for the confusion on the 90-day storage issue. Here are some comments to further clarify ADEM position on the handling/ staging of potentially hazardous wastewater at RSA:

1. Wastewater can be held at the AOC or SWMU site and does not have to be immediately moved to another < 90 day storage area. The holding area must meet secondary containment standards.
2. It is OK to initially label the wastewater filled drums with the following information.
   - Description of the drum contents (e.g. wastewater from RSA-XXX)
   - Accumulation start date (the date the drum was filled)
   - A short statement that states that the contents are on hold awaiting analytical test results
3. If the analytical results come back noting the drum contents are hazardous, a standard hazardous waste label must be put on the drum noting all required information. The accumulation start date for the standard HW label should be the same date as recorded on the initial drum label.
4. Drums of hazardous wastewater must be removed from the AOC or SWMU in less than 90 days.

*Remember that the generator must meet the < 90 day storage rules and regulations (e.g. weekly inspections, training, secondary containment, etc.) while holding the hazardous wastewater drums at the AOC or SWMU site.*

As for your response to the example IDW information needed to support generator knowledge determination, it is adequate for our on-site visits. Since it is late in the afternoon for you (EST), I will try to call you to confirm the information presented in this email. Thanks again for your help in this matter, Randy!

Sincerely Yours,

***Krishna "Kel" Morrissette***
ADEM - Land Division: Facilities Engineering Section
Work: (334) 394-4335
Fax: (334) 279-3050
email: kmorrissette@adem.state.al.us

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# APPENDIX G

# ALABAMA BEST MANAGEMENT PRACTICES AND NOTICE OF INTENT

# Appendix G

# Construction Best Management Practices Plan and Notice of Intent RSA-122, Dismantled Lewisite Manufacturing Plant Sites, Operable Unit 06 and RSA-183, Former Lewisite Manufacturing Plants 1 and 2 Sites, Operable Unit 05

## U.S. Army Garrison-Redstone
## Madison County, Alabama
## EPA ID No. AL7 210 020 742

**Prepared for:**

**U.S. Army Engineering and Support Center**
**Huntsville Engineering and Support Center**
**ATTN: CEHNC-OEC**
**5021 Bradford Drive East**
**Huntsville, Alabama 35805**

**Prepared by:**

**Aptim Federal Services, LLC**
**11400 Parkside Drive, Suite 400**
**Knoxville, TN 37934**

**Contract No. W912DY-17-D-0003**
**APTIM Project Number 501388**
**Delivery Order W912DY19F1116**

**May 2022**

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## List of Attachments

# G1.0 Introduction

Aptim Federal Services, LLC, on behalf of the U.S. Army Garrison-Redstone, has prepared this Construction Best Management Practices (BMP) Plan pursuant to National Pollutant Discharge Elimination System General Permit Number ALR100000, *Waste Discharge Requirements for Discharge of Stormwater Runoff Associated with Construction Activity*, which is also known as the Construction Stormwater General Permit (CSWGP).

In accordance with this plan and Section 5.2.6 of the corrective measures implementation (CMI) work plan, the Remediation Contractor shall implement and maintain appropriate structural and nonstructural BMPs for the prevention and control of nonpoint sources of pollutants, e.g., sediment, oil and grease, chemicals, etc., during project construction. In doing so, the Remediation Contractor shall abide by the regulations given in the Alabama Department of Environmental Management (ADEM) Administrative Code applicable to construction stormwater and the National Pollutant Discharge Elimination System General Permit; a copy of the CSWGP is provided as Attachment G-1.

Coverage under and compliance with the CSWGP is required if stormwater is discharged to waters of the United States from construction projects that result in a total land disturbance of 1 acre or greater and sites less than 1 acre but part of a common plan of development. The excavation of contaminated soil during CMI activities at RSA-122 and RSA-183 will result in more than 1 acre of soil disturbance from which discharges of stormwater to waters of the United States may occur. The land surface of RSA-122 slopes from the northwest to the east-southeast from a topographic high of 610 feet above mean sea level (msl) near Jungerman Road to the south-central portion of the site, immediately south of the capped disposal lagoons (RSA-056), with an elevation of 580 feet above msl (Figure 1-4 of the CMI work plan). The approximate elevation of the main creek bottom south of Viper Road is 575 feet above msl. A north-south-trending perennial unnamed creek flows through RSA-122 adjacent to the former waste ponds RSA-056 and RSA-139. The unnamed creek ultimately discharges to Huntsville Spring Branch.

The land surface in the RSA-183 Plants Area slopes toward the southeast, with ground surface elevations ranging from 630 feet to 600 feet above msl. The RSA-183 Sinkhole Area contains a south-trending drainage feature that is located within the surface expression of a large underground sinkhole feature. Elevations within Sinkhole Area fall to an elevation of 560 feet above msl (Figure 1-8 of the CMI work plan).

To obtain coverage under the CSWGP, a Notice of Intent must be submitted to ADEM prior to initiation of construction activities. A copy of the Notice of Intent Form is provided in

Attachment G-2. Compliance with the conditions of the CSWGP must be maintained throughout the project and a Notice of Termination must be submitted when construction activities are completed. A copy of the sample Notice of Termination is also provided in Attachment G-2.

## G2.0 Project Description

RSA-122 is an approximately 42-acre area located in the central portion of RSA that was the former site of lewisite manufacturing operations. This area is located just west of Patton Road, north of Viper Road, south of Metrology Drive, and east of Jungerman Road (Figure 1-1 of the CMI work plan). RSA-122 consists of an area formerly occupied by plants that manufactured the chemical agent (CA) lewisite and its raw materials. RSA-122 also includes an area formerly used to produce sulfur monochloride and arsenic trichloride, components of the lewisite manufacturing process, and includes areas historically used for materials stockpiling, waste processing, and waste disposal.

RSA-183 encompasses approximately 157 acres of land in the central portion of RSA (Figure 1-1 of the CMI work plan). The site has been divided into two areas, the Plants Area (the northern 35 acres), where the Army manufactured the CA lewisite in two plants (Plants 1 and 2), and the Sinkhole Area, which encompasses a large (122 acres) sinkhole south of the Plants Area. In addition to Lewisite Plants 1 and 2, the Plants Area includes a former motor pool (Building 4381, post-lewisite manufacture), a former unit electrical substation, and a former chemical storage facility (Building 4496, post-lewisite manufacture). A north-south-trending drainage ditch exits the Plants Area.

Remedial investigations (RI) were performed at the surface media sites designated as RSA-122, Dismantled Lewisite Manufacturing Plant Sites and RSA-183, Former Lewisite Manufacturing Plants 1 and 2 Sites, to evaluate potential environmental impacts from historical activities conducted at the site by the United States Army (Shaw, 2007a and 2007b). Surface media are defined as surface soil, subsurface soil, surface water, and sediment, as applicable. Based on available information collected during historical and recent investigation activities, the RI reports concluded that the Army's historical operations at RSA-122 and RSA-183 have resulted in concentrations of site-related constituents (arsenic) that pose unacceptable risk to human health. Corrective measures are, therefore, warranted for surface media as part of RSA-122 and RSA-183. Corrective measures are also required for groundwater beneath RSA-122 and RSA-183. The Army intends to perform corrective measures for groundwater as part of the RSA-147 and RSA-148 groundwater units.

The corrective measures to be implemented at RSA-122 and RSA-183 involve excavation and off-site disposal of arsenic -contaminated soil and removal of relict structures (i.e., piping, pits, sumps) that have the potential to serve as an ongoing source of contamination to groundwater. The projected excavation area covers approximately 5 acres. The depth of excavation for most of the areas is expected to be approximately 6 feet, although excavation in some areas is anticipated to be approximately 17 feet. The volume of material to be excavated from RSA-122 is estimated to be 5,960 cubic yards. The volume of material to be excavated from RSA-183 is estimated to be 6,311 cubic yards. The scope of work for this project is detailed in the CMI work plan for RSA-122 and RSA-183 to which this construction best management practices plan is an appendix.

## G3.0 Responsibility and Authority

Activities at the project site will be conducted under the supervision of the Project Manager. Throughout the duration of the construction activities, periodic inspections will be conducted to verify that stormwater controls are in place and effective. These inspections will ensure the following:

- Scouring and excessive sediment displacement has not occurred.
- Erosion has not damaged berms or ditches.
- Surface water is not ponding on the site.
- Sediment has not blocked silt fences, straw waddles, culverts, or plugged outlets.
- Off-site surface water migration is minimized.

Inspections will be conducted weekly during operation activities. In addition, the site will be inspected before (if possible) and immediately after (within 24 hours) each qualifying rain event. A qualifying rain event is defined as a storm that has a measurable rainfall depth of 0.75 inch or greater in any 24-hour period.

All maintenance work done on the site surface water management or erosion control systems will be recorded in the inspection log.

## G4.0 Best Management Practices and Measures

The following BMPs and measures will be followed in order to minimize the effects of runoff from the site in accordance with the *Alabama Handbook for Erosion Control, Sediment Control, and Stormwater Management on Construction Sites and Urban Areas* (Alabama Soil and Water Conservation Committee, 2018).

Site Preparation

A. Construction Exit Pad – Aggregate base construction pads will be constructed at vehicle entrances and exits to reduce the tracking of mud and caked soil from the site onto roadways.

B. Land Grading – Land grading, including soil stockpiling, will be utilized to as part of excavation activities and to manage runoff and erosion, as well as reduce ponding. Following construction, backfilled excavations will also be graded in keeping with BMPs.

Surface Stabilization

C. Dust Control – Dust at the site will be controlled with water using a water truck with hose and sprayers and mulch such as straw, as necessary.

D. Erosion Control Blanket – Erosion control blanket may be used to control erosion for areas with steep slopes.

E. Mulching – Straw mulch will be used to control runoff and erosion on disturbed land and reduce moisture loss to facilitate revegetation.

F. Permanent Seeding – Permanent seeding will be used to revegetate the excavation areas, and other areas affected by construction activities.

G. Preservation of Vegetation – Care will be taken to avoid disturbing land outside the excavation and work areas to maintain the vegetative cover surrounding the work site.

H. Temporary Seeding – Similar to permanent seeding, fast-growing temporary seeding will be used to revegetate the excavation areas and other areas affected by construction activities during seasons or under conditions where establishing vegetation is required.

Runoff Conveyance

I. Check Dam – Check dams may be used in conjunction with grass swales and diversions to slow the velocity of flow and reduce erosion.

J. Diversion – Diversions may be used to convey runoff away from construction areas or other key locations.

K. Grass Swale – Grass swales may also be used to convey runoff, especially in areas where runoff velocity and erosion are concerns.

Sediment Control

L. Filter Strip – Filter strips may be used to provide infiltration, intercept sediment, and reduce stormwater flow and velocity. Preservation of existing vegetation will be used, when possible, to serve as filter strips.

M. Sediment Barrier – Sediment barriers (i.e., silt fence) will be used to reduce the amount of sediment washed away from construction areas. Any perimeter of the excavation area that does not typically have water encroachment will have silt fence installed. In revegetated areas, the silt fence will remain in place until after the vegetation is established. Once the silt fence is removed, the posts will be cut off at ground surface and the remaining disturbed area will be reseeded.

N. Sediment Trap – Straw bales may be used for trapping sediment in minor drainage swales.

Excerpts from the handbook describing the BMPs and measures in fuller detail, as well as related log sheets, are included in Attachments G-3 and G-4, respectively. The locations of stormwater management BMPs and measures for RSA-122 and RSA-183 are presented on Figures 5-20 and 5-21 of the CMI work plan, respectively.

## G5.0 References


Alabama Soil and Water Conservation Committee, 2018, ***Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas,*** July.

Shaw Environmental, Inc. (Shaw), 2007a, ***Final Remedial Investigation Report, Baseline Human Health Risk Assessment and Screening-Level Ecological Risk Assessment, RSA-122 Dismantled Lewisite Manufacturing Plant, Operable Unit 6, Redstone Arsenal, Madison County, Alabama***, Revision 1, September.

Shaw Environmental, Inc. (Shaw), 2007b, ***Final Remedial Investigation Report, Baseline Human Health Risk Assessment and Screening-Level Ecological Risk Assessment, RSA-183 (Formerly Part of RSA-49), Former Lewisite Plants 1 and 2, Operable Unit 5, Redstone Arsenal, Madison County, Alabama***, Revision 1, September.

# ATTACHMENT G-1

# ADEM CONSTRUCTION STORMWATER GENERAL PERMIT
# (Permit No. ALR100000)

ADEM
Alabama Department of Environmental Management

# NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM GENERAL PERMIT

**DISCHARGE AUTHORIZED:** DISCHARGES FROM CONSTRUCTION ACTIVITIES THAT RESULT IN A TOTAL LAND DISTURBANCE OF ONE ACRE OR GREATER AND SITES LESS THAN ONE ACRE BUT ARE PART OF A COMMON PLAN OF DEVELOPMENT OR SALE

**AREA OF COVERAGE:** THE STATE OF ALABAMA

**PERMIT NUMBER:** ALR100000

**RECEIVING WATERS:** ALL WATERS OF THE STATE OF ALABAMA

*In accordance with and subject to the provisions of the Federal Water Pollution Control Act, as amended, 33 U.S.C. §§1251-1378 (the "FWPCA'J, the Alabama Water Pollution Control Act, as amended, Code of Alabama 1975, §§ 22-22-1 to 22-22-14 (the "AWPCA'J , the Alabama Environmental Management Act, as amended, Code of Alabama 1975, §§22-22A-1 to 22-22A-15, and rules and regulations adopted thereunder, and subject further to the terms and conditions set forth in this permit, the Permittee is hereby authorized to discharge into the above-named receiving waters.*

**ISSUANCE DATE:** March 12, 2021

**EFFECTIVE DATE:** April 1, 2021

**EXPIRATION DATE:** March 31, 2026

Jeffery W. Kitchen
Alabama Department of Environmental Management

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# PART I: Coverage Under This General Permit

## A. Permit Coverage

This permit authorizes, subject to the conditions of this permit, discharges associated with construction activity that will result in land disturbance equal to or greater than one (1) acre or from construction activities involving less than one (1) acre and which are part of a common plan of development or sale equal to or greater than one (1) acre occurring on or before, and continuing after the effective date of this permit, except for discharges identified under Part I.C. of the permit.

## B. Eligibility

1. Allowable Stormwater Discharges

   This permit authorizes the following stormwater discharges:

   (a) Stormwater associated with construction activities defined in Part I.A. of this permit;

   (b) The following stormwater discharges have been determined by the Director to require coverage under this permit:

      (i) Sites, irrespective of size, whose stormwater discharges have a reasonable potential to be a significant contributor of pollutants to a water of the State, as determined by the Department;

      (ii) Sites, irrespective of size, whose stormwater discharges have a reasonable potential to cause or contribute to a violation of an applicable Alabama water quality standard as determined by the Department.

   (c) Discharges from construction support activities provided:

      (i) The support activity is solely related to the construction site covered under this permit;

      (ii) The support activity is not an operation serving multiple unrelated construction projects and does not operate beyond the completion of the construction activity at the construction project it supports;

      (iii) The support activity is located in close proximity (two-mile radius) to the construction site covered under this permit, or as otherwise approved by the Department;

      (iv) Stormwater controls are implemented in accordance with Part III for discharges from the support activity area; and

      (v) Pollutant discharges from support activity areas are minimized to the maximum extent practicable and do not pose a reasonable potential to exceed applicable water quality standards.

2. Allowable Non-Stormwater Discharges

   This permit authorizes the following non-stormwater discharges provided the non-stormwater component of the discharge is in compliance with Part III.D.:

   (a) Discharges from fire-fighting activities;

   (b) Fire hydrant flushings;

   (c) Water used to wash vehicles and equipment where detergents are not used;

   (d) Water used to control dust;

   (e) Potable water including uncontaminated water line flushings not associated with hydrostatic testing;

   (f) Routine external building wash down associated with construction that does not use detergents;

   (g) Pavement wash waters where spills or leaks of toxic or hazardous materials have not occurred (unless all spilled material has been removed) and where detergents are not used. The operator is prohibited from directing pavement wash waters directly into any surface water, storm drain inlet, or stormwater conveyance, unless the conveyance is connected to a sediment basin, sediment trap, or similarly effective control;

   (h) Uncontaminated air conditioning or compressor condensate associated with temporary office trailers and other similar buildings;

   (i) Uncontaminated, non-turbid discharges of ground water or spring water;

   (j) Foundation or footing drains where flows are not contaminated with process materials such as solvents; and

   (k) Landscape irrigation.

## C. Exempt Discharges

1. Coverage under this permit is not required for the following:
   (a) Animal feeding operation (AFO) or concentrated animal feeding operation (CAFO) construction activity that has been granted NPDES registration coverage pursuant to Chapter 335-6-7;
   (b) Normal agricultural; and
   (c) Silvicultural activities.
2. Coverage under this permit is not required for discharges associated with minor land disturbing activities such as the following:
   (a) Home gardens or individual home landscaping;
   (b) Home repairs and/or maintenance;
   (c) Fence installation or maintenance;
   (d) Directional boring, hand hole digging; and
   (e) Guardrail, shoulder, and minor improvements associated with roadway pavement resurfacing.

## D. Prohibited Discharges

The following discharges associated with construction are not authorized by this permit:

1. Stormwater discharges that are mixed with sources of non-stormwater unless such stormwater discharges are:
   (a) In compliance with a separate NPDES permit, or
   (b) Determined by the Department not to be a contributor of pollutants to waters of the State.
2. Stormwater discharges currently covered under another NPDES permit;
3. Discharges from coal/metallic mining, dry processing, wet processing, and areas associated with these activities;
4. Wastewater from washout of concrete, unless managed by an appropriate control (Wastewater from Concrete Batch Plants are prohibited unless such discharges are authorized by and in compliance with a separate NPDES permit);
5. Wastewater from washout and cleanout of stucco, paint, form release oils, curing compounds, and other construction materials;
6. Fuels, oils, or other pollutants used in vehicle and equipment operation and maintenance;
7. Soaps or solvents used in vehicle and equipment washing;
8. Discharges from dewatering activities, including discharges of ground water or accumulated stormwater from dewatering of trenches, excavations, foundations, vaults, or other similar points of accumulation, unless managed by appropriate controls;
9. Discharges to surface waters from sediment basins or impoundments, unless an outlet structure that withdraws water from the surface, unless infeasible, is utilized;
10. Discharges where the turbidity of such discharge will cause or contribute to a substantial visible contrast with the natural appearance of the receiving water;
11. Discharges where the turbidity of such discharge will cause or contribute to an increase in the turbidity of the receiving water by more than 50 NTUs above background. For the purposes of determining compliance with this limitation, background will be interpreted as the natural condition of the receiving water without the influence of man-made or man-induced causes. Turbidity levels caused by natural runoff will be included in establishing background levels;
12. Discharges of any pollutant into any water for which a total maximum daily load (TMDL) has been finalized or approved by EPA unless the discharge is consistent with the TMDL;
13. Discharges to waters listed on the most recently approved 303(d) list of impaired streams unless the discharge will not cause or contribute to the listed impairment; and
14. Toxic or hazardous substances from a spill or release.

## PART II: Notice of Intent (NOI) Requirements

### A. Deadlines for Notices of Intent

Any person wishing to obtain coverage under this general permit shall submit an NOI in accordance with the following schedule:

1. Any person wishing to be permitted to discharge under this general permit shall submit a complete NOI and appropriate fee prior to the initiation of construction activity;
2. Any Permittee authorized to discharge under the 2016 NPDES Construction General Permit, who wishes to continue to discharge upon the expiration of that permit, shall submit a complete NOI to be covered by this reissued General Permit. Such NOI shall be submitted at least 30 days prior to the expiration date of the 2021 NPDES Construction General Permit; and
3. Failure of the Permittee to submit a complete NOI for reauthorization under this permit at least 30 days prior to the previous permit's expiration will void the automatic continuation of the authorization to discharge under that permit as provided by ADEM Admin. Code r. 335-6-6-.06. Should the permit not be reissued for any reason prior to its expiration date, Permittees who failed to meet the 30-day submittal deadline will be illegally discharging without a permit after the expiration date of the 2016 NPDES Construction General Permit.

### B. Continuation of the Expired General Permit

If this permit is not reissued or replaced prior to the expiration date, it will be administratively continued in accordance with the ADEM Administrative Code Chapter 335-6-6 and remain in force and in effect if the Permittee submits an updated and complete NOI meeting the requirements of Part II.C. at least 30 days prior to the expiration of this permit. Any Permittee who was granted permit coverage prior to the expiration date will automatically remain covered by the continued permit until the earlier of:

1. Reissuance or replacement of this permit, at which time the Permittee must comply with the Notice of Intent conditions of the new permit to maintain authorization to discharge; or
2. Issuance of an individual permit; or
3. A formal permit decision by the Department not to reissue this general permit, at which time the Permittee must seek coverage under an alternative general permit or an individual permit.

### C. Contents of the Notice of Intent (NOI)

1. The NOI shall include:
   (a) The correct fee pursuant to ADEM Admin. Code R. 335-1, Fee Schedule D;
   (b) A general description of the construction activity for which coverage is desired, which shall be in sufficient detail to allow the Department to determine that the stormwater and non-stormwater discharges are included in the authorized discharges category of this general permit;
   (c) The latitude and longitude, to the nearest second, for the entrance to the construction site, each outfall for which coverage under this general permit is desired. For the purposes of this requirement the entrance to the construction site will be identified as the primary point of access by normal vehicle traffic. For linear projects, the latitude and longitude, to the nearest second, should be provided for the starting and ending point of the project boundaries;
   (d) Identification of the waterbodies receiving discharges for which coverage under this general permit is desired;
   (e) A portion or copy of a recent map or series of maps (e.g., USGS quadrangle map or LIDAR contour map) at an appropriate contour interval, including perennial, intermittent, and ephemeral streams/lakes/springs/wetlands. Several maps/pages may be necessary depending on the size and scope of the project;
   (f) The map(s) at a minimum must include the following, which should be clearly identified (please include a key for symbols and a scale) on the map(s):
      (i) Site/project boundaries;
      (ii) Proposed permit boundaries;
      (iii) Property boundaries (non-linear project only);
      (iv) Area(s) of disturbance;
      (v) One (1) mile radius;
      (vi) Entrance(s)/Exit(s);

(vii) Outfall(s);

(viii) Receiving stream(s); and

(ix) Begin and End Project Locations (Linear project only).

(g) A current plat map for subdivisions and/or common plans of development or sale;

(h) A facility contact person, address, and phone number for the site to be covered under the general permit.

(i) For priority construction sites, the NOI must be accompanied by a copy of the CBMPP prepared and certified by a Qualified Credentialed Professional (QCP) as required by Part III.E.

(j) The number of estimated disturbed acres and total site acreage.

(k) The estimated start and completion dates of project.

(l) Provide a list of all treatment chemicals anticipated to be used at the site, including the most recent published Safety Data Sheets (SDS) and the dosage(s) to be used and the location(s) where these materials will be applied. If this information is not known at the time of the NOI submittal, the information shall be submitted to the Department through an information update as timely as possible and update the CBMPP as required by Part III.E.5.

2. The NOI shall be signed by a person meeting the requirements for signatories under ADEM Admin. Code r. 335-6-6-.09, and the person signing the NOI shall make the certification required for submission of documents under ADEM Admin Code r. 335-6-6-.09(4).

3. The NOI shall be signed by a QCP and shall have the following certification statement: "I certify under penalty of law that a comprehensive Construction Best Management Practices Plan (CBMPP) for the prevention and minimization of all sources of pollution in stormwater and authorized related process wastewater runoff has been prepared under my supervision for this site/activity, and associated regulated areas/activities. The CBMPP meets the requirements of this permit and if properly implemented and maintained by the operator, discharges of pollutants in stormwater runoff can reasonably be expected to be effectively minimized to the maximum extent practicable according to the requirements of ADEM Administrative Code r. 335-6-6-.23 and this Permit. The CBMPP describes the erosion and sediment control measures that must be fully implemented and regularly maintained as needed at the permitted site in accordance with sound sediment and erosion control practices to ensure the protection of water quality."

**D. Submittal of Documents**

The Permittee must complete and submit the NOI electronically, using the Department's Alabama Environmental Permitting and Compliance System (AEPACS), unless the Permittee submits in writing valid justification as to why the electronic submittal process cannot be utilized and the Department approves in writing the utilization of hard copy submittals. The AEPACS can be accessed at the following link: http://adem.alabama.gov/AEPACS. Permit requests for initial issuance and modifications of the existing permit should all be submitted through the AEPACS system.

**E. Additional Permittees (Co-Permittee) Under a Single NOI**

Multiple operators conducting regulated land disturbances in a common plan of development may jointly submit an NOI. An NOI covering multiple operators must include a site plan clearly describing each operator's areas of operational control.

**F. Authorization to Discharge**

1. Except as otherwise limited by Part II.F.2 or II.F.3, the operator is authorized to discharge in accordance with the requirements of this permit upon the Department's receipt of a complete and timely NOI which meets the requirements of this permit and ADEM Admin. Code r. 335-6-6-.23.

2. Coverage under this permit is conditionally granted, and the requirement to submit an NOI is suspended for governmental agencies and utilities for construction activity associated with immediate and effective emergency repairs and response to natural disasters, human health or environmental emergencies, or to avert/avoid imminent, probable, or irreparable harm to the environment or severe property damage. The operator or controlling/participating federal, State, or local government agencies/entities conducting emergency construction activity shall document the emergency condition, ensure compliance with the requirements of this permit to the extent possible, and shall notify the Department as promptly as possible regarding the occurrence of the emergency construction disturbance and measures that have been implemented and are being implemented to protect water quality. Unless the requirement to obtain a permit pursuant to the requirements of this permit are suspended or voided by the Director on a categorical or individual emergency basis, the operator shall submit the appropriate project information, NOI, and the required application fee for construction or reconstruction activity after emergency repairs have been accomplished, according to a schedule acceptable to the Department.

3. For priority construction sites, the operator is authorized to discharge thirty (30) days from the Department's receipt of a complete and technically adequate NOI and CBMPP meeting the requirements of Parts II.C. and III.E, unless, within thirty (30) days from the Department's receipt of the NOI, the Department notifies the operator that additional time is needed to review the NOI and CBMPP. Where the operator receives such notification from the Department, that operator may not discharge until the Department formally acknowledges receipt of a complete and technically adequate NOI and CBMPP.

## PART III: Stormwater Pollution Prevention Requirements

The stormwater control requirements in this Part are the technology-based, non-numeric effluent limitations and conditions that apply to all discharges from construction projects eligible for coverage under this permit. These requirements apply the national effluent limitations guidelines and new source performance standards found at 40 CFR Part 450.

Where the requirements in this Part are stricter than any corresponding federal, State, or local requirements, the requirements in this permit take precedence.

### A. Erosion Controls and Sediment Controls

The Permittee shall design, install, and maintain effective stormwater controls, erosion controls, and sediment controls appropriate for site conditions. To meet this requirement, the following factors shall be accounted for in designing controls:

1. The nature of stormwater runoff and run-on at the site, including factors such as expected flow from impervious surfaces, slopes, and site drainage features;
2. Control stormwater volume and velocity within the site to minimize soil erosion;
3. Control stormwater discharges, including both peak flowrates and total stormwater volume, to minimize channel and streambank erosion and scour in the immediate vicinity of points of discharge;
4. The soil series and range of soil particle sizes expected to be present on the site;
5. Complete installation of stormwater controls by the time each phase of construction activities has begun;
   (a) By the time construction activity in any given portion of the site begins, install and make operational any downgradient sediment controls (e.g., buffers, perimeter controls, storm drain inlet protection, etc.) that control discharges from the initial site clearing, grading, excavating, and other earth-disturbing activities; and
   (b) Following the installation of these initial controls, install and make operational all stormwater controls needed to control discharges prior to subsequent earth-disturbing activities.
   (c) The requirement to install stormwater controls prior to each phase of construction activities for the site does not apply to the earth disturbance associated with the actual installation of these controls. Operators should take all reasonable actions to minimize the discharges of pollutants during the installation of stormwater controls.
6. Ensure that all stormwater controls are properly implemented, maintained, and remain in effective operating condition during permit coverage and are protected from activities that would reduce their effectiveness;
7. Minimize the amount of soil exposed and the duration of exposure during construction activity through the use of project phasing, sequence of construction, or other appropriate techniques;
8. Provide and maintain a 25-foot natural riparian buffer around surface waters as discussed in detail in Part III.B.;
9. Implement measures or requirements to achieve the pollutant reductions consistent with a TMDL finalized or approved by EPA. Applicable TMDLs are located and/or can be accessed at the following link: http://adem.alabama.gov/programs/water/approvedTMDLs.htm
10. Minimize the disturbance of steep slopes;
11. Minimize sediment discharges from the site;
12. Minimize the generation of dust through the appropriate application of water or other dust suppression techniques;
13. Minimize all stream crossings;
14. Minimize sediment track-out:
   (a) Use appropriate stabilization techniques at all construction entrances and exits onto paved roads;
   (b) Restrict vehicle use to properly designated entrances and exits;
   (c) Implement and maintain additional track-out controls as necessary to ensure that sediment removal occurs prior to vehicle exit; and
   (d) Sediment that has been tracked-out from site onto paved roads, sidewalks, or other paved areas outside of site boundaries should be removed by the end of the same business day and/or normal operating hours. Removal shall be by sweeping, shoveling, or vacuuming the surfaces. Removal by hosing or sweeping tracked out sediment into any stormwater conveyance, storm drain inlet, or water of the State is prohibited.

15. Protect storm drain inlets, where applicable:

    (a) Install storm drain inlet protection measures that remove coarse sediment particles from discharges prior to entry into any storm drain inlet that routes stormwater flow from the site and/or to a water of the State to further prevent sediment discharges; and

    (b) Clean, remove, and replace protection measures as sediment accumulates as often as is necessary to ensure full effectiveness of protection measures and/or that performance is not compromised.

16. Direct stormwater to vegetated areas to increase sediment removal and maximize stormwater infiltration, unless infeasible;

17. Minimize soil compaction.

18. Preserve and protect topsoil for use in vegetation establishment;

19. Manage stockpiles or land clearing debris composed, in whole or in part, of sediment and/or soil:

    (a) Locate the stockpiles outside of any natural buffers established under Part III.B., and away from any stormwater conveyances, storm drain inlets, and areas where stormwater flow is concentrated;

    (b) Install a sediment barrier along all downgradient areas;

    (c) Stockpiles that will not be used for 13 days or more, provide cover or appropriate temporary stabilization;

20. Sediment basin, impoundments, or detention/retention basins used as a sediment basin during construction shall be installed and stabilized prior to commencement of other construction activities:

    (a) Locate the basin or impoundment outside of any water of the State;

    (b) Design basin or impoundment to provide appropriate storage for 3,600 cubic feet per acre drained;

    (c) Utilize outlet structures that withdraw water from the surface of the sediment basin or impoundment;

    (d) Use erosion controls and velocity dissipation devices to prevent erosion at inlets and outlets; and

    (e) Remove accumulated sediment to maintain at least one-half of the design capacity and conduct all other appropriate maintenance to ensure basin or impoundment remains in effective operating condition.

21. Treatment chemicals (e.g. polymers, flocculants, coagulants):

    (a) Use conventional erosion and sediment controls before and after the application of treatment chemicals. Treatment chemicals may only be applied where treated stormwater is directed to a sediment control practice (e.g., sediment basin, perimeter control) that allows for on-site particle settlement before final discharge;

    (b) Select appropriate treatment chemicals. Chemicals must be appropriately suited to the soil likely to be exposed during construction and present in the discharges being treated (i.e., the expected turbidity, pH, and flow rate of the stormwater flowing into the chemical treatment system or area);

    (c) Ensure proper chemical storage of all treatment chemicals, such as in leak-proof containers, spill proof pallets, covered storage, or in secondary containment designed and maintained to minimize the potential discharge of treatment chemicals in stormwater or by any other means; and

    (d) Use chemicals in accordance with good engineering practices and specification of the chemical provider/supplier. Use treatment chemicals and chemical treatment systems in accordance with dosing specifications and sediment removal design specification provided by the provider/supplier of the applicable chemicals.

22. Additional Design Requirements

    (a) Sediment control measures, erosion control measures, and other site management practices must be properly selected based on site-specific conditions and must meet or exceed the technical guidance outlined in the Alabama Handbook and the site-specific CBMPP prepared in accordance with Part III.E;

    (b) Unless specified otherwise by the Alabama Handbook, sediment control measures, erosion control measures, and other site management practices shall be designed and maintained to minimize erosion and maximize sediment removal resulting from a 2-year, 24-hour storm event.; and

    (c) The Permittee is encouraged to design the site, the erosion prevention measures, sediment control measures, and other site management practices with consideration of minimizing stormwater runoff, both during and following construction, including facilitating the use of low-impact development (LID) and green infrastructure. The Alabama Low Impact Development Handbook for the State of Alabama (LID Handbook) can be found at the following link: http://adem.alabama.gov/programs/water/waterforms/LIDHandbook.pdf

**B. Provide Natural Riparian Buffers or Equivalent Sediment Controls**

Natural riparian buffer requirements apply to all waters of the State adjacent to construction sites or contained within their overall project boundary. A 25-foot natural riparian buffer zone adjacent to all waters of the State at the construction site shall be preserved, to the maximum extent practicable, during construction activities at the site. The natural riparian buffer should be preserved between the top of stream bank and the disturbed construction area. The water quality buffer zone aids in the protection of waters of the State (e.g., perennial and intermittent streams, rivers, lakes, wetlands) located within or immediately adjacent to the boundaries of the project. Natural riparian buffers are not primary sediment control measures and should not be relied on as such. The natural riparian buffer requirement applies to new construction sites, or new additional acreage not previously covered by the initial permit.

1. Compliance Alternatives
   (a) Provide and maintain a 25-foot undisturbed natural riparian buffer;
      (i) If land disturbances are located 25 feet or farther from surface water, then compliance with this alternative has been achieved.
      (ii) Rehabilitation and enhancement of a natural riparian buffer is allowed, if necessary, for improvement for its effectiveness of protection of the waters of the State.
      (iii) Any preexisting structures (e.g., buildings, parking lots, roadways, utility lines, structures, impervious surfaces) are allowed in the natural riparian buffer; provided the Permittee retains and protects from disturbance any additional natural buffer area contained within the natural riparian buffer but outside the preexisting structures footprint.
   (b) Provide and maintain an undisturbed natural riparian buffer that is less than 25 feet and is supplemented by additional erosion and sediment controls, which in combination achieves the sediment load reduction equivalent to a 25-foot undisturbed natural riparian buffer;
   (c) If it is infeasible to provide and maintain an undisturbed natural riparian buffer of any size, the Permittee must implement erosion and sediment controls that achieve the sediment load reduction equivalent to a 25-foot undisturbed natural riparian buffer;
   (d) All discharges from the area of earth disturbance to the natural riparian buffer must first be treated by erosion and sediment control on the site. Velocity dissipation devices should be used if necessary to prevent erosion caused by stormwater within the natural riparian buffer;
   (e) All compliance alternatives must be documented in the CBMPP and comply with all requirements. The natural riparian buffer boundary should be indicated on the site plan;
   (f) Compliance alternatives must be maintained throughout the duration of permit coverage; and
   (g) All natural riparian buffer areas should be delineated and clearly marked off with flags, tape, or similar marking device.
2. If there is no discharge of stormwater to waters of the State through the areas between the construction site and any waters of the State located within 25 feet of the construction site, compliance with this requirement is achieved;
3. Where no natural riparian buffer exists due to preexisting development disturbances (e.g., buildings, parking lots, roadways, utility lines, structures, impervious surfaces) that occurred prior to the initiation of planning for the current development of the site, the Permittee is not required to comply with the requirements in this section, unless portions of the preexisting development will be removed;
4. Where some natural riparian buffer exists but portions of the area within 25 feet of the waters of the State are occupied by preexisting development disturbances (e.g., buildings, parking lots, roadways, utility lines, structures, and impervious surfaces), the Permittee is required to comply with the requirements in this section. Only the portion of the buffer zone that contains the footprint of the existing "structure" is exempt from the natural riparian buffer. Activities necessary to maintain uses are allowed provided that no additional vegetation is removed from the natural riparian buffer;
5. For "linear construction projects" the Permittee is not required to comply with the requirements in this section if site constraints (e.g., limited right-of-way) prevent the Permittee from meeting any of the compliance alternatives provided that, to the extent practicable, disturbances within 25 feet of the water of the State are limited and/or supplemental erosion and sediment controls to treat stormwater discharges from earth disturbances within 25 feet of the waters of the State are provided. It must be documented in the CBMPP as to why compliance with this section is infeasible and describe any buffer width retained and/or supplemental erosion and sediment controls installed; and

6. The following disturbances within 25 feet of a water of the State are exempt from the requirements in this Part:
   (a) Construction approved under a CWA Section 404 permit; or
   (b) Construction of a water-dependent structure or water access area (e.g., pier, boat ramp, seawall, bridge, drainage structure, trail, etc.)

**C. Soil Stabilization**

The Permittee should minimize, as feasible, the area disturbed to maintain the natural soil cover for stability. The Permittee must stabilize the exposed bare soil portions of the site:

1. Implement and maintain stabilization measures (e.g., seeding protected by erosion controls until vegetation is established, sodding, mulching, erosion control blankets, hydromulch, gravel) that minimize erosion from exposed portions of the site.
2. Temporary stabilization of disturbed areas must be initiated immediately whenever work toward project completion and final stabilization of any portion of the site has temporarily ceased on any portion of the site and will not resume for a period exceeding thirteen (13) calendar days.
3. Final stabilization of disturbed areas must, at a minimum, be initiated immediately whenever any clearing, grading, excavating, or other earth disturbing activities have permanently ceased on any portion of the site.
4. The requirement to initiate stabilization immediately is triggered as soon as you know that construction work on a portion of the site is temporarily ceased and will not resume for more than thirteen (13) calendar days, or as soon as you know that construction work has permanently ceased. In the context of this provision, "immediately" means as soon as practicable, but no later than the end of the next business day, following the day when the construction activities have temporarily or permanently ceased.
5. Both temporary and permanent vegetation shall be completed as provided by the guidance in the Alabama Handbook.

**D. Pollution Prevention Measures**

The Permittee must design, install, implement, and maintain effective pollution prevention measures to minimize the discharge of pollutants. At a minimum, such measures must be designed, installed, implemented, and maintained to:

1. Provide an effective means of minimizing the discharge of pollutants from equipment and vehicle washing, wheel wash water, concrete washout, washing applicators and/or containers used for stucco, paint, concrete, or other compounds/materials and other wash waters;
   (a) Wash waters must be treated in a sediment basin or alternative control (e.g., sediment trap, filtration device, filter bags, or similar effective controls) that provides equivalent or better treatment prior to discharge;
   (b) Liquid waste shall not be directly discharged into storm sewers;
   (c) Washout and cleanout activities should be located as far away as possible from surface waters, natural buffer areas, stormwater inlets, and conveyances; and
   (d) For storage of soaps, detergents, or solvents, provide either (1) cover (e.g., plastic sheeting or temporary roofs) to minimize exposure of these detergents to precipitation and to stormwater or (2) a similarly effective means designed to minimize the discharge of pollutants from these areas.
2. Provide an effective means of minimizing the exposure of building materials, building products, construction wastes, trash, landscape materials, fertilizers, pesticides, herbicides, detergents, sanitary waste, and other materials present on the site to precipitation and to stormwater;
   (a) Provide either (1) cover (e.g., plastic sheeting or temporary roofs) to minimize exposure of these detergents to precipitation and to stormwater or (2) a similarly effective means designed to minimize the discharge of pollutants from these areas;
   (b) Provide waste containers (e.g., dumpster, trash receptacle) of sufficient size and number to contain construction wastes;
   (c) Locate waste containers as far away as possible from waters of the State and stormwater inlets or conveyances so that stormwater coming into contact with these activities cannot reach water of the State;
   (d) For sanitary waste, position portable toilets so that they are on level ground and are located as far away as possible from waters of the State and stormwater inlets or conveyances; and
   (e) Comply with all application and disposal requirements included on the fertilizer, pesticide, herbicide, or detergent label.

3. Provide an effective means of minimizing the discharge of pollutants caused by spills and leaks from, including but not limited to, vehicles, mechanical equipment, chemical storage, and refueling activities;

   (a) Locating activities away from waters of the State and stormwater inlets or conveyances so that stormwater coming into contact with these activities cannot reach water of the State;

   (b) Providing secondary containment and cover where appropriate;

   (c) Ensure adequate supplies are available at all times to handle spills, leaks, and disposal of used liquids. Have a spill kit available on site and ensure personnel are available and trained to respond expeditiously in the event of a leak or spill; and

   (d) Clean up spills or contaminated surfaces immediately (do not clean contaminated surfaces by hosing the area down) and eliminate the source of the spill to prevent a discharge or a continuation of an ongoing discharge.

4. Apply treatment chemicals at the site only where treated stormwater is directed to a sediment control (e.g., sediment basin, perimeter control) that allows for on-site particle settlement before final discharge.

**E. Construction Best Management Practices Plan (CBMPP)**

1. Except as provided by Part II.F.2, construction activity may not commence until a CBMPP has been prepared in a format acceptable to the Department and certified by a QCP as adequate to meet the requirements of this permit;

2. The NOI and CBMPP must be prepared in accordance with the requirements of this permit by the QCP prior to commencing construction at a new construction site or prior to continued construction at an existing construction site, or as otherwise required by the Director;

3. The Permittee shall properly implement and regularly maintain the controls, practices, devices, and measures specified in the CBMPP;

4. The CBMPP shall include:

   (a) A general description of the construction site activity, including:

      (i) The function of the construction site activity (e.g. residential subdivision, shopping mall, highway, etc.); and

      (ii) Identification of all known operators of the construction site and the areas of the site over which each operator has control.

   (b) A description of the intended sequence of major activities which disturb soils, including but not limited to, grubbing, excavation, and/or grading. The sequence shall be accomplished in a manner which minimizes the area disturbed at any one time and minimizes the duration that the areas are disturbed;

   (c) Estimates of the total area expected to be disturbed by grubbing, excavation, and/or grading, including offsite borrow and fill areas (if areas are to be included in permit coverage);

   (d) A detailed description (including but not limited to site specific dimensions, storage capacity, and drainage calculations are required for engineered BMPs) of the erosion controls, sediment controls, and management practices to be implemented at the site during each sequence of activity in accordance with Part III.A;

   (e) A clear outline and identification of the 25-foot natural riparian buffer for all sites that discharge directly to waters of the State and where a water of the State lies within the boundaries of the project;

   (f) A detailed description of controls needed to meet State water quality standards, waste load allocations, or other measures necessary for consistency with applicable TMDLs finalized or approved by EPA;

      (i) Provide a calculation based on the control measures to be implemented for the pollutant of concern to confirm the controls as designed in the CBMPP meet the required percent reduction for the applicable TMDL;

      (ii) Reduction capabilities shall assume the control measures have been appropriately installed and maintained. See Part III.L.2.

   (g) A detailed description of BMPs needed to prevent or eliminate discharges of sediment and other pollutants of concern from priority construction sites;

   (h) A description of temporary and permanent stabilization practices, including a schedule and/or sequence for implementation;

   (i) A description of energy or flow velocity dissipation devices at discharge locations and along the length of any outfall channel;

(j) Identification of all allowable sources of non-stormwater discharges listed in Part I.B.2, except for flows from firefighting activities that are or may be combined with stormwater discharges associated with construction activity at the site;

(k) A description of the pollution prevention measures used to manage non-stormwater discharges;

(l) A description of the best management practices to be installed during site construction and operated and maintained following final stabilization at sites where the post-construction volumes or velocities of stormwater runoff are significantly different from conditions existing prior to the construction activity;

(m) A listing of all treatment chemicals to be used at the site, including Safety Data Sheets (SDS), the dosage(s) to be used and the location(s) where these materials will be used;

(n) The most recent site topographic map (e.g. USGS quadrangle map or LIDAR contour map) at an appropriate contour interval, clearly showing:

(i) Sufficient detail to identify the location of the construction site;

(ii) Existing topography and drainage patterns and features, existing structures proposed roads, utilities, rights-of-way (ROWs), and waterbodies;

(iii) Drainage patterns and approximate slopes anticipated after major grading activities;

(iv) The external and internal (if subdivided) property boundaries of the project;

(v) Areas to be disturbed by excavation, grading, or other activities;

(vi) Identification of sediment control measures, erosion control measures, planned stabilization measures, and other site management practices;

(vii) Locations of all waters of the State within a one (1) mile radius of the site;

(viii) Locations of wetlands and riparian zones; and

(ix) Locations of all outfalls.

(o) A description of procedures for:

(i) Sweeping or removal and proper disposal or utilization of sediment and other debris that has been tracked from the site or deposited from the site onto streets and other paved surfaces;

(ii) Removal and proper disposal or utilization of sediment or other pollutants that have accumulated in or near any sediment control measures, stormwater conveyance channels, storm drain inlets, or water course conveyance within or immediately outside of the construction site; and

(iii) Removal and proper disposal or utilization of accumulated sediment that has been trapped by sediment control measures at the site, in accordance with applicable maintenance requirements covered under this permit;

(p) A description of the procedures for handling and disposing of wastes generated at the site, including, but not limited to, clearing and demolition debris, sediment removed from the site, construction and domestic waste, hazardous or toxic waste, and sanitary waste.

5. Maintain an Updated CBMPP

(a) The CBMPP shall be updated as necessary to address changes in the construction activity, site weather patterns, new TMDLs finalized or approved by EPA, new 303(d) listings approved by EPA, or manufacturer specifications for specific control technologies;

(b) The CBMPP shall be amended if inspections or investigations by site staff or by local, state, or federal officials determine that the existing sediment control measures, erosion control measures, or other site management practices are ineffective or do not meet the requirements of this permit. All necessary modifications to the CBMPP shall be made within seven (7) calendar days following notification of the inspection unless granted an extension of time by the Department;

(c) If existing sediment control measures, erosion control measures, or other site management practices prove ineffective in protecting water quality or need to be modified; or if additional sediment control measures, erosion control measures, or other site management practices are necessary to meet the requirements of this permit, implementation shall be completed as soon as possible, but not to exceed five (5) days of the observation or site inspection unless prevented by unsafe weather conditions. If unsafe weather conditions are present, they should be documented. If implementation before the next storm event is impracticable, then new land disturbance activities must cease until the modified or additional controls can be implemented; and

(d) A copy of the CBMPP shall be maintained at the site during normal operating hours as defined by Part V of this permit when regulated land disturbing activities are occurring.

**F. Spill Prevention, Control, and Management**

1. The Permittee shall prepare, implement, and maintain a Spill Prevention, Control and Countermeasures (SPCC) Plan in accordance with 40 CFR Part 112 and ADEM Admin Code r.335-6-6-.12(r) for all applicable onsite petroleum storage tanks;

2. The Permittee shall prepare, implement, and maintain a SPCC Plan in accordance with ADEM Admin Code r.335-6-6-.12(r) for any stored pollutant(s) that may, if spilled, be reasonably expected to enter a water of the state or the collection system for a publicly or privately owned treatment works;

   (a) The SPCC Plan(s) shall be maintained as a separate document or as part of the CBMPP Plan required in Part III.E. above;

   (b) The Permittee shall implement appropriate structural and/or non-structural spill prevention, control, and/or management sufficient to prevent any spills of pollutants from entering a water of the State or a publicly or privately owned treatment works. The plan(s) must be consistent with the requirements of 40 CFR Part 112 and/or ADEM Admin Code r.335-6-6-.12(r). Any containment system used to implement this requirement shall be constructed of materials compatible with the substance(s) contained and of materials which shall prevent the contamination of groundwater and shall be capable of retaining 110 percent of the volume of the largest container of pollutants for which the containment system is provided;

   (c) The Permittee shall maintain onsite or have readily available sufficient oil & grease absorbing material and flotation booms to contain and clean-up fuel or chemical spills and leaks; and

   (d) Soil contaminated by paint or chemical spills, oil spills, etc. must be immediately cleaned up, remediated, or be removed and disposed of in a Department approved manner.

3. Discharges of toxic or hazardous substances from a spill to other release or prohibited, consistent with Part I.D.

   (a) Where a leak, spill, or other release containing a hazardous substance or oil in an amount equal to or in excess of a reportable quantity established under either 40 CFR 110, 40 CFR 117, or 40 CFR 302 occurs during a 24-hour period, the National Response Center (NRC) must be notified at (800) 424-8802, in accordance with the requirements of 40 CFR 110, 40 CFR 117, or 40 CFR 302 as soon as the Permittee has knowledge of the release; and

   (b) Within five (5) calendar days of knowledge of the release, the Permittee must provide a description of the release, the circumstances leading to the release, and the date of the release.

**G. Training**

Unless the Permittee has employed or contracted with a QCP that performs duties as required by this permit, and the QCP is readily available and able to be present onsite as often as is necessary to ensure full compliance with the requirements of this permit, the Permittee shall ensure that:

1. At least one onsite employee shall be certified as a Qualified Credentialed Inspector (QCI) by completing an initial training and annual refresher training course through an ADEM-approved Qualified Credentialed Inspector Program (QCIP) conducted by a cooperating training entity;

2. The QCIP must be approved by the Department prior to use and provide training in the following areas:

   (a) The applicable requirements of the Alabama NPDES rules;

   (b) The requirements of this permit;

   (c) The evaluation of construction sites to ensure that erosion controls and sediment controls designed and certified by a QCP detailed in a site-specific CBMPP are effectively implemented and maintained;

   (d) The evaluation of conveyance structures, receiving waters, and adjacent impacted offsite areas to ensure the protection of water quality and compliance with the requirements of this permit; and

   (e) The general operation of a turbidity meter or similar device intended for the measurement of turbidity.

3. Each individual holding a QCI Certification need not be on-site continuously and they may conduct site inspections at multiple sites permitted by them or their employer;

4. Each individual holding QCI certification shall obtain annual certification of satisfactory completion of formal refresher education or training regarding general erosion controls and sediment controls, the requirements of this permit, and the general operation of a turbidity meter or similar device intended for the measurement of turbidity. The refresher training

requirements, including but not limited to, appropriate curricula, course content, course length, and any participant testing, shall be subject to acceptance by the Director prior to use.

**H. Inspection Requirements**

1. Pre-Construction Observations

   (a) A pre-construction site inspection shall be conducted prior the placement of any BMPs, or the commencement of land disturbing activities.

   (b) Pre-construction site inspection shall consist of a complete and comprehensive inspection of the entire proposed construction site including all proposed areas of land disturbance, proposed areas used for storage of materials that may be exposed to precipitation, affected ditches, and other stormwater conveyances, as well as all proposed outfalls, receiving waters and stream banks to determine if there are pre-existing areas of concern.

   (c) Pre-construction inspections shall be conducted by the QCP, or by a qualified person under the direct supervision of a QCP;

   (d) The inspection shall be documented and made available to the Department upon request;

   (e) Pre-construction inspection shall include dated electronic photographic documentation of all areas described in paragraph (b) above; and

   (f) The Permittee shall maintain record of the pre-construction site inspection pursuant to Part IV.K.

2. Daily Observations

   (a) Each day there is activity at the site, the Permittee shall visually observe that portion of the construction project where active disturbance, work, or construction occurred to note any rainfall measurements occurring since the previous observation and any apparent BMP deficiencies in the area of active disturbance;

   (b) Such daily observations may be performed by appropriate site personnel; and

   (c) The Permittee shall maintain a log of all daily observations and record in such log any rainfall measurements and BMP deficiencies observed.

3. Site Inspections

   (a) Site inspections shall be performed by a QCI, QCP, or a qualified person under the direct supervision of a QCP;

   (b) A site inspection shall consist of a complete and comprehensive observation of the entire construction site including all areas of land disturbance, areas used for storage of materials that are exposed to precipitation, equipment storage and maintenance areas, affected ditches and other stormwater conveyances, as well as all outfalls, receiving waters, and stream banks to determine if, and ensure that:

      (i) Effective erosion controls and sediment controls have been fully implemented and maintained in accordance with this permit, the site CBMPP, and the Alabama Handbook;

      (ii) Pollutant discharges are being prevented/minimized; and

      (iii) Discharges do not result in a contravention of applicable State water quality standards for the receiving stream(s) or other waters impacted or affected by the Permittee.

   (c) For non-linear projects, a site inspection shall be performed once each month and after any qualifying precipitation event since the last inspection, commencing as promptly as possible, but no later than 24-hours after resuming or continuing active construction or disturbance and completed no later than 72-hours following the qualifying precipitation event;

   (d) For linear projects, a site inspection shall be performed at least once a month and after any qualifying precipitation event since the last inspection, beginning as promptly as possible, but no later than 24-hours after resuming or continuing active construction or disturbance and completed no later than five (5) days after the qualifying precipitation event, on areas of active construction and/or where perennial vegetation has not been fully established, or meeting the definition of final stabilization;

   (e) A site inspection shall also be performed as often as is necessary until any poorly functioning erosion controls or sediment controls, non-compliant discharges, or any other deficiencies observed during a prior inspection are corrected and documented as being in compliance with the requirements of this permit;

   (f) On all active disturbance, dredging, excavation, or construction undertaken or located within the banks of a waterbody, including but not limited to, equipment/vehicle crossings, pipelines, or other transmission line installation, conveyor structure installation, and waterbody relocation, streambank stabilization, or other alterations, a site inspection shall

be performed at least once a week and as often as is necessary until the disturbance/activity impacting the waterbody is complete and reclamation or effective stormwater quality remediation is achieved;

(g) The inspection shall be recorded in a written format acceptable to the Department. The inspection record shall include:

(i) The site name and location, date and entry/exit time, outfall identification(s), date, time and exact place of any turbidity sampling performed;

(ii) The name(s) of person(s) who performed the inspection and/or obtained any turbidity samples or measurements;

(iii) The analytical results of any samples or measurements performed;

(iv) A description of any sampling and analytical techniques or methods used, including source of method and method number;

(v) Weather conditions at the time of the inspection;

(vi) Description of any discharges of sediment or other pollutants from the site;

(vii) Locations of discharges of sediment or other pollutants from the site;

(viii) Locations of BMPs that need repair, replacement and/or maintenance;

(ix) Locations of BMPs that failed to operate as designed;

(x) Locations where BMPs required by the CBMPP are not installed or installed in a manner inconsistent with the CBMPP; and

(xi) Locations where additional BMPs are needed that did not exist at the time of the inspection. This requirement is applicable only to site inspections performed by a QCP or qualified persons under the direct supervision of a QCP.

(h) Results of all required inspections shall be available for inspection no later than 15 days following the date of the inspection, monitoring, or sampling; and

(i) Reports shall be legible and bear an original signature or in the case of electronic reports, an electronic signature.

4. CBMPP Evaluations

(a) The QCP shall perform an onsite evaluation of all erosion and sediment controls being implemented for adequacy and consistency with site conditions;

(b) The CBMPP evaluation shall be performed as often as necessary until poorly functioning or damaged erosion controls or sediment controls are corrected and, at a minimum, once every three (3) months for a priority construction site or once every six (6) months for non-priority construction site;

(c) If, based on the CBMPP evaluation, the QCP identifies any needed modifications or additions to erosion and sediment controls, the CBMPP shall be updated in accordance with Part III.E.4; and

(d) The Permittee shall maintain appropriate documentation of the CBMPP evaluation.

**I. Corrective Action**

1. Any poorly functioning erosion controls or sediment controls, non-compliant discharges, or any other deficiencies observed during daily observations or site inspections required under Part III.H, shall be corrected as soon as possible, but not to exceed five (5) days of the observation or site inspection unless prevented by unsafe weather conditions. If unsafe weather conditions are present, they should be documented.

2. In the event of a breach of a sediment basin/pond temporary containment measures shall be taken within 24 hours after the inspection. Permanent corrective measures shall be implemented within five (5) days of the inspection. However, if permanent corrective measures cannot be implemented within the timeframes provided herein the Permittee shall notify the Department; and

3. The operator shall promptly take all reasonable steps to remove, to the maximum extent practical, pollutants deposited offsite or in any waterbody or stormwater conveyance structure.

**J. Suspension of Monitoring**

Suspension of applicable monitoring and inspection requirements for phased projects or developments may be granted provided:

1. The Department is notified in writing at least thirty (30) days prior to the requested suspension;

2. The Permittee and the QCP certify in the request that all disturbance has been graded, stabilized, and/or fully vegetated or otherwise permanently covered, and that appropriate, effective steps have been and will be taken by the Permittee to ensure compliance with the requirements of this permit and commit that these measures will remain continually effective until the permit is properly terminated;

3. The request should be accompanied by a construction stormwater inspection report confirming permanent stabilization of all previously disturbed areas, including material storage areas, and associated support activities. In addition, photo documentation may be submitted for confirmation purposes; and

4. The Permittee notifies the Department in writing within fifteen (15) days prior to resumption of disturbance or commencement of the next phase of development and the Permittee complies with the requirements of this Permit prior to commencement of additional disturbance.

**K. Precipitation Measurement**

1. The Permittee shall measure and record all precipitation occurring at the construction site (including rainfall and snowfall). Precipitation measurements must be representative of the Permittee's site. Records shall be maintained and available for inspection.

2. Precipitation measurements should be read and recorded during normal operating hours, even if no precipitation occurs. To facilitate determination of a qualifying precipitation event, the measuring device or method should have a scale that is readable to 0.5 inches or smaller unit.

3. Recording of rainfall outside of normal operating hours may be read and recorded on the next business day and noted as "accumulated." If the outside of normal operating hours accumulation is greater than 0.75 inches, a qualifying rainfall event inspection must occur regardless of whether that accumulation occurred over 24 hours, as described in Part III.H.

4. Precipitation measurements shall be taken using one or more of the following:

   (a) Continuous recorders,

   (b) Daily readings of an onsite rain gauge,

   (c) Daily readings of an offsite precipitation gauge located adjacent to or in close proximity (for non-linear projects a maximum one (1) mile distance) to the facility, or

   (d) Other measurement devices acceptable to the Department (e.g., online resources).

**L. Impaired Waters and Total Maximum Daily Load (TMDL) Waters**

1. Permittees discharging from construction sites into waters included on the latest EPA Approved §303(d) List or designated by the Department as impaired.

   (a) The Permittee must determine whether the discharge from any part of the construction site contributes directly or indirectly to a waterbody that is included on the latest EPA Approved §303(d) List or designated by the Department as impaired.

   (b) If the construction site discharges either directly or indirectly to a waterbody included on the latest EPA Approved §303(d) List or designated by the Department as impaired, then the CBMPP must detail the BMPs that are being utilized to control discharges of pollutants of concern associated with the impairment of the waterbody.

   (c) The Permittee must demonstrate the discharges, as controlled by the Permittee, and in conjunction with the implementation of the CBMPP, do not cause or contribute to the impairment of the waterbody.

   (d) If during this permit cycle a new EPA Approved §303(d) List is published, or Department designation, includes any waterbody into which the construction site discharges, the Permittee and QCP must review the CBMPP and the site to determine if existing BMPs are sufficient and discharges do not cause or contribute to the impairment of the waterbody. If existing BMPs are not sufficient to achieve this demonstration, the Permittee must, within sixty (60) days following the publication of the latest final §303(d) List, Department designation, or the effective date of this permit, submit a revised CBMPP detailing new or modified BMPs. The CBMPP must be revised as directed by the Department and the new or modified BMPs must be implemented within ninety (90) days from the publication of the latest final §303(d) list or Department designation.

2. Permittees discharging from construction sites into waters with EPA-Approved TMDLs and/or EPA-Established TMDLs

   (a) The Permittee must determine whether its construction site discharges to a waterbody for which a TMDL has been established or approved by EPA.

   (b) If a construction site discharges into a water body with an EPA approved or established TMDL, then the CBMPP must include BMPs targeted to control the discharges of pollutants of concern and to meet the assumptions and requirements

of the TMDL. If additional BMPs will be necessary to meet the requirements of the TMDL, the CBMPP must include a schedule for installation and/or implementation of such BMPs.

(c) If, during this permit cycle, a TMDL is approved by EPA or a TMDL is established by EPA for any waterbody into which a construction site discharges, the Permittee must review the applicable TMDL to see if it includes requirements for control of storm water discharges from the construction site.

(d) If it is found that the Permittee must implement specific allocations of the TMDL, it must assess whether the assumptions and requirements of the TMDL are being met through implementation of existing BMPs or if additional BMPs are necessary. The CBMPP must include BMPs targeted to meet the assumptions and requirements of the TMDL. If existing BMPs are not sufficient, the Permittee must, within sixty (6o) days following the approval or establishment of the TMDL by EPA, submit a revised CBMPP detailing new or modified BMPs to be utilized along with a schedule of installation and/or implementation of such BMPs. Any new or modified BMPs must be implemented within ninety (90) days, unless an alternate date is approved by the Department, from the establishment or approval of the TMDL by EPA.

## PART IV: Standard and General Permit Conditions

### A. Duty to Comply

1. The Permittee must comply with all terms and conditions of this permit. Any permit noncompliance constitutes a violation of the AWPCA and the FWPCA and is grounds for: enforcement action, termination, or suspension of coverage under this permit; denial of a NOI for renewal; a requirement that the Permittee submit an application for an individual NPDES permit.
2. For any violation(s) of this Permit, the Permittee may be subject to a civil penalty as authorized by the AWPCA, the FWPCA, and Code of Alabama 1975, §§22-22A-1 et. seq., as amended, and/or a criminal penalty as authorized by Code of Alabama 1975, §22-22-1 et. seq., as amended.
3. The discharge of a pollutant from a source not specifically identified in the NOI to be covered under this Permit and not specifically included in the description of an outfall (where applicable) in this permit is not authorized and shall constitute noncompliance with this permit.
4. Nothing in this Permit shall be construed to preclude or negate the Permittee's responsibility or liability to apply for, obtain, or comply with other ADEM, federal, state, or local government permits, certifications, licenses, or other approvals.

### B. Duty to Reapply

1. The Permittee authorized to discharge under this General Permit, who wishes to continue to discharge upon the expiration of this permit, shall submit a NOI to be covered by the reissued General Permit. Such NOI shall be submitted at least 30 days prior to the expiration date of this General Permit.
2. Failure of the Permittee to submit a complete NOI for reauthorization under this permit at least 30 days prior to the permit's expiration will void the automatic continuation of the authorization to discharge under this permit as provided by ADEM Admin. Code r. 335-6-6-.06. Should the permit not be reissued for any reason prior to its expiration date, Permittees who failed to meet the 30-day submittal deadline will be illegally discharging without a permit after the expiration date of the permit.

### C. Need to Halt or Reduce Activity Not a Defense

It shall not be a defense for the Permittee in an enforcement action that it would have been necessary to halt or reduce construction activities in order to maintain compliance with the conditions of the permit.

### D. Duty to Mitigate

The Permittee shall take all reasonable steps to mitigate or prevent any violation of the permit or to minimize or prevent any adverse impact of any permit violation.

### E. Proper Operation and Maintenance

The Permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the Permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training, and adequate laboratory and process controls, including appropriate quality assurance procedures. This provision requires the operation of backup or auxiliary facilities only when necessary to achieve compliance with the conditions of this permit.

### F. Permit Modification, Revocation and Reissuance, Suspension, and Termination

1. During the term of this General Permit the Director may, for cause, and subject to the public notice procedure of ADEM Administrative Code r. 335-6-6-21, modify or revoke and reissue this General Permit. The causes for this action include the causes listed below:
   (a) When the Director receives any information that was not available at the time of permit issuance and that would have justified the application of different permit conditions at the time of issuance;
   (b) When the standards or regulations on which the permit was based have been changed by promulgation of amended standards or regulations or by judicial decision after the permit was issued;
   (c) Upon failure of the state to notify, as required by Section 402(b)(3) of the FWPCA, another state whose waters may be affected by a discharge;
   (d) When the level of discharge of any pollutant which is not limited in the permit exceeds the level which can be achieved by the technology based treatment requirements appropriate to the discharge under 40 CFR 125.3(c)(1994);

(e) To correct technical mistakes, such as errors in calculations, or mistaken interpretations of the law made in determining permit conditions;

(f) When the permit limitations are found not to be protective of water quality standards; or

(g) For any applicable cause set forth in 40 CFR Sections 122.61, 122.62, 122.63, and 122.64 (1994).

2. Subject to the public notice procedures of rule 335-6-.6-21, the Director may terminate this General Permit during its term for any of the causes for modification listed in ADEM Admin Code r. 335-6-6-.23(7)(a).

3. The Director may terminate coverage of a discharge under this general permit for cause. Cause shall include, but not be limited to, noncompliance with Department rules; or a finding that the general permit does not control with wastewater discharge sufficiently to protect water quality or comply with treatment-based limits applicable to the discharge.

4. Any person may petition the Director for withdrawal of this General Permit authority from a discharger. The Director shall consider the information submitted by the petitioner and any other information he may be aware of and may obtain additional information from the discharger and through inspections by Department staff and shall decide if coverage should be withdrawn. The petitioner shall be informed of the Director's decision and shall be provided a summary of the information considered.

## G. Property Rights

This permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to persons or property or invasion of other private rights, or any infringement of federal, state, or local laws or regulations, nor does it authorize or approve the construction of any physical structures or facilities or the undertaking of any work in any waters of the State or of the United States.

## H. Duty to Provide Information

1. The Permittee shall furnish to the Director, within a reasonable time, any information which the Director may request to determine whether cause exists for modifying, revoking and re-issuing, suspending, or terminating this permit or to determine compliance with this Permit. The Permittee shall also furnish to the Director upon request, copies of records required to be kept by this Permit.

2. The Permittee shall inform the Director in writing of any change in the Permittee's mailing address or telephone number or in the Permittee's designation of a facility contact or officer having the authority and responsibility to prevent and abate violations of the AWPCA, the Department's rules and the terms and conditions of this permit no later than ten (10) days after such change. Upon request of the Director, the Permittee shall furnish an update of any information provided in the NOI.

3. If the Permittee becomes aware that it failed to submit any relevant facts in the NOI; or submitted incorrect information in the NOI; or in any report to the Director, it shall promptly submit such facts or information with a written explanation for the mistake and/or omission.

4. All information and/or documents required to be submitted to the Department by this general permit shall be submitted via the AEPACS, which can be accessed at the following link, http://adem.alabama.gov/AEPACS, or delivered to the following address: Alabama Department of Environmental Management Water Division, Stormwater Management Branch, Post Office Box 301463, Montgomery, Alabama 36130-1463, or 1400 Coliseum Boulevard, 36110-2400, Montgomery, Alabama.

## I. Inspection and Entry

The Permittee shall allow the Director, or an authorized representative, upon the presentation of credentials and other documents as may be required by law to:

1. Enter upon the Permittee's premises where a regulated activity is located or conducted, or where records must be kept under the conditions of this Permit;

2. Have access to and copy, at reasonable times, any records that must be kept under the conditions of this Permit;

3. Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this Permit; and

4. Sample or monitor at reasonable times, for the purposes of assuring permit compliance or as otherwise authorized by the AWPCA, any activities, substances or parameters at any location.

**J. Noncompliance Notification**

1. The Permittee must notify the Department if, for any reason, the Permittee's discharge:
   (a) Potentially threatens human health or welfare;
   (b) Threatens fish or aquatic life;
   (c) Causes an in-stream water quality criterion as stated in ADEM. Admin. Code Ch. 335-6-10 to be exceeded;
   (d) Does not comply with an applicable toxic pollutant effluent standard or prohibition established under Section 307(a) of the FWPCA, 33 U.S.C. §1317(a); or
   (e) Contains a quantity of a hazardous substance which has been determined may be harmful to the public health or welfare under Section 311(b)(4) of the FWPCA, 33 U.S.C. §1321(b)(4).
2. The Permittee shall orally report the occurrences, describing the circumstances and potential effects of such discharge to the Director no later than 24-hours after the Permittee becomes aware of the occurrence of such discharge. In addition to the oral report, the Permittee shall submit to the Director a written report as provided in Part IV.J.3 below, no later than five (5) days after becoming aware of the occurrence of such discharge.
3. The written report shall be in a format acceptable to the Department and shall include:
   (a) A description of the noncompliant event, its cause, if known, and location;
   (b) The period of noncompliance, including exact dates and times or, if not corrected, the anticipated time the noncompliance is expected to continue; and
   (c) A description of the steps taken and/or being taken to reduce or eliminate the noncomplying discharge and to prevent its recurrence.

**K. Retention of Records**

1. The Permittee shall retain records of all inspection records, monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by the permit, and records of all data used to complete such reports, for a period of at least three (3) years from the date of the inspection, sample measurement, or report. This period may be extended by request of the Director at any time. If litigation or other enforcement action, under the AWPCA and/or the FWPCA, is ongoing which involves any of these records, the records shall be kept until the litigation is resolved.
2. All records required to be kept for a period of three (3) years shall be kept at the permitted facility or an alternate location identified to the Department in writing and shall be available for inspection upon request.

**L. Signatory Requirements**

The NOI and all reports or information submitted to the Director shall be signed and certified according to the requirement of ADEM Admin Code r. 335-6-6-.09. Where required by this Permit, documents will also be signed by a QCP or QCI.

**M. Transfers**

This Permit may not be transferred without notice to the Director and subsequent modification or revocation and reissuance of this Permit. In the case of a change in name, ownership, or control of the Permittee’s premises, a request for permit modification in a format acceptable to the Director is required within fifteen (15) days of the change occurring.

**N. Bypass**

Any bypass of erosion controls, sediment controls, or any other stormwater management/treatment controls specified in the CBMPP is prohibited except as provided by ADEM Admin Code r. 335-6-6-.12(m).

**O. Upset**

1. Effect of an Upset. An upset constitutes an affirmative defense to an action brought for noncompliance with technology-based permit limitation if the requirements of subparagraph 335-6-6-.12(n)2. are met.
2. Conditions Necessary for Demonstration of an Upset. A Permittee who wishes to establish the affirmative defense of an upset shall demonstrate through properly signed, contemporaneous operating logs, or other relevant evidence that:
   (a) An upset occurred and that the Permittee can identify the specific cause(s) of the upset;
   (b) The treatment facility was at the time being properly operated;
   (c) The Permittee submitted notice of the upset as required in subparagraph 335-6-6-.12(l)6.; and

(d) The Permittee complied with any remedial measures required under paragraph 335-6-6-.12(d).

3. Burden of Proof. In any enforcement proceeding the Permittee seeking to establish the occurrence of an upset has the burden of proof.

**P. Severability**

The provisions of this permit are severable, and if any provision of this permit or the application of any provision of this permit to any circumstance is held invalid, the application of such provision to other circumstances, and the remainder of this permit shall not be affected thereby.

**Q. Issuance of an Individual Permit**

The Director may require the Permittee to obtain an individual permit for discharges covered by this permit in accordance with ADEM Admin. Code r. 335-6-6-.23(9).

**R. Request for Individual Permit by General Permit Holder**

1. Any person covered by this General Permit may apply for termination of coverage by applying for an individual NPDES permit.

2. A permit application submitted voluntarily or at the direction of the Director for the purpose of termination of coverage by this General Permit shall be processed in accordance with the rules found in ADEM Admin. Code Ch. 335-6-6 applicable to individual permits.

**S. Termination of Coverage**

1. The Director may suspend or terminate coverage under this permit for cause without the consent of the Permittee. Cause shall include, but not be limited to, noncompliance with this permit or the applicable requirements of Department rules, or a finding that this permit does not control the stormwater discharge sufficiently to protect water quality.

2. Voluntary Notice of Termination – Initiated by Permittee

   The Permittee must submit a Notice of Termination (NOT) request electronically, using the Department's AEPACS at http://adem.alabama.gov/AEPACS , within thirty (30) days of one of the following conditions:

   (a) Final stabilization as defined in Part V has been achieved on all portions of the site;

   (b) Another operator has assumed control over all areas of the site that have not achieved final stabilization and the new operator has submitted an NOI for coverage under this permit; or

   (c) Coverage under an individual permit or alternative general permit has been obtained.

3. Content of the Voluntary Notice of Termination

   (a) The Permittee name, permit number, and location of the site;

   (b) Certification by the Permittee and the QCP that all construction activity covered by this permit has been completed, all temporary BMPs have been removed and final stabilization has been achieved; or

   (c) Identification, including complete contact information, of the person that has assumed legal or operational control over the construction site.

      (i) Loss of operational control does not relieve the operator from liability and responsibility for compliance with the provisions of this permit until the complete and correct request for termination is received by the Department.

      (ii) Sale or transfer of operational responsibility for the site by the operator prior to the succeeding operator obtaining permit coverage required by this chapter does not relieve the operator from the responsibility to comply with the requirements of this permit.

**T. Facility Identification**

The Permittee shall post and maintain sign(s) at the front gate/entrance, and if utility installation, where project crosses paved county, State, or federal highways/roads, and/or at other easily accessible location(s) to adequately identify the site prior to commencement of and during NPDES construction until permit coverage is properly terminated. Such sign shall be legible and display the name of the Permittee, "ADEM NPDES ALR10" followed by the four-digit NPDES permit number, facility or project name, and other descriptive information deemed appropriate by the Permittee.

**U. Schedule of Compliance**

The Permittee shall achieve compliance with the requirements of this permit on the effective date of coverage under this permit.

**V. Discharge of Wastewater Generated by Others**

The discharge of wastewater generated by any process, facility, or by any other means not under the operational control of the Permittee or not identified in the application for this permit or not identified specifically in the description of an outfall in this permit is not authorized by this permit except as allowed by Part I.

**W. Compliance with Water Quality Standards and Other Provisions**

1. On the basis of the Permittee's application, plans, or other available information, the Department has determined that compliance with the terms and conditions of this Permit will assure compliance with applicable water quality standards. However, this Permit does not relieve the Permittee from compliance with applicable State water quality standards established in ADEM Admin. Code Ch. 335-6-10, and does not preclude the Department from taking action as appropriate to address the potential for contravention of applicable State water quality standards which could result from discharges of pollutants from the permitted facility.
2. Compliance with Permit terms and conditions notwithstanding, if the Permittee's discharge(s) cause(s) or contribute(s) to a condition in contravention of State water quality standards, the Department may require abatement action to be taken by the Permittee, modify the Permit pursuant to the Department's rules and regulations, or both.
3. If the Department determines, on the basis of any investigation, inspection, or sampling, that a modification of this Permit is necessary to assure maintenance of water quality standards or compliance with other provisions of the AWPCA or FWPCA, the Department may require such modification and, in cases of emergency, the Director may prohibit the noticed act until the Permit has been modified.

**X. Civil and Criminal Liability**

1. Tampering: Any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained or performed under this Permit shall, upon conviction, be subject to penalties and/or imprisonment as provided by the AWPCA and/or the AEMA.
2. False Statements: Any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this Permit, including monitoring reports or reports of compliance or noncompliance shall, upon conviction, be punished as provided by applicable State and federal law.
3. Permit Enforcement: This NPDES Permit is a Permit for the purpose of the AWPCA, the AEMA, and the FWPCA, and as such all terms, conditions, or limitations of this Permit are enforceable under State and federal law.
4. Relief From Liability: Except as provided in Part IV.M. (Bypass) and Part IV.N. (Upset), nothing in this Permit shall be construed to relieve the Permittee of civil or criminal liability under the AWPCA, AEMA, or FWPCA for noncompliance with any term or condition of this Permit.

**Y. Oil and Hazardous Substance Liability**

Nothing in this Permit shall be construed to preclude the institution of any legal action or relieve the Permittee from any responsibilities, liabilities, or penalties to which the Permittee is or may be subject to under Section 311 of the FWPCA, 33 U.S.C. §1321.

**Z. Availability of Reports**

Except for data determined to be confidential under Code of Alabama 1975, §22-22-9(c), all reports prepared and submitted in accordance with the terms of this Permit shall be available for public inspection at the offices of the Department or the Department’s electronic filing system (eFile) at http://app.adem.alabama.gov/eFile/. Effluent data shall not be considered confidential. Knowingly making any false statement in any such report may result in the imposition of criminal penalties as provided for in Section 309 of the FWPCA, 33 U.S.C. §1319, and Code of Alabama 1975, §22-22-14.

**AA. Coastal Zone Management for Baldwin and Mobile Counties**

1. Except for those activities described in Part IV.AA.2 below, this permit is conditionally consistent with the Alabama Coastal Area Management Plan (ACAMP) upon continued compliance with the ACAMP.
2. The Permittee shall obtain, as appropriate, a coastal permit or coastal consistency determination from the Department if any activity constitutes a use as described in ADEM Admin. Code r. 335-8-1-.08, 335-8-1-.09, 335-8-1-.10 or 335-8-1-.11.

**BB. Removed Substances**

Solids, sludges, or any other pollutants or other wastes removed in the course of treatment or control of stormwater shall be disposed of in a manner that complies with all applicable Department rules and regulations.

## CC. Compliance with Statutes and Rules

3. This permit has been issued under ADEM Admin. Code Ch. 335-6-6. All provisions of this chapter, that are applicable to this permit, are hereby made a part of this permit. A copy of this chapter can be found on the ADEM website at: http://adem.alabama.gov/alEnviroRegLaws/files/Division6Vol1.pdf

4. This permit does not authorize the noncompliance with or violation of any Laws of the State of Alabama or the United States of America or any regulations or rules implementing such laws. FWPCA, 33 U.S.C. Section 1319, and Code of Alabama 1975, Section 22-22-14.

## PART V: Definitions

***2-year, 24-hour storm event*** means the maximum 24-hour precipitation event with a probable recurrence interval of once in two years as defined by the National Weather Service and Technical Paper No. 40, "Rainfall Frequency Atlas of the U.S.," May 1961, or equivalent regional or rainfall probability information developed there from.

***24-hour precipitation event*** means that amount of precipitation which occurs within any 24-hour period.

***AEMA*** means the Alabama Environmental Management Act, Code of Alabama 1975, §§ 22-22A-1, et seq.

***Alabama Handbook*** means the current edition of the Alabama Handbook for Erosion Control, Sediment Control, and Stormwater Management on Constructions Sites and Urban Areas, published by the Alabama Soil and Water Conservation Committee (ASWCC) at the time permit coverage is obtained.

***ADEM*** means the Alabama Department of Environmental Management.

***Agricultural Practices*** means practices commensurate with the size of the farming operation that are implemented in a manner that meet or exceed Natural Resources Conservation Service technical standards and guidelines, including but not limited to, farm ponds that are constructed for the primary purpose of irrigation and/or watering of livestock, terraces, grassed waterways, vegetative filter strips, cropland grade stabilization measures, drainage tiles, underground outlets, land leveling, dike/diversion structures, and other grade stabilization structures.

***AWPCA*** means the Alabama Water Pollution Control Act.

***Best Management Practices or BMPs*** means implementation and continued maintenance of appropriate structural and non- structural practices and management strategies to prevent and minimize the introduction of pollutants to stormwater and to treat stormwater to remove pollutants prior to discharge.

***Borrow Area "Pit"*** means the activity of removing material (soil, gravel, sand) from one area to use in another area. For the purposes of this permit, this activity is solely in conjunction with the project requesting permit coverage and the material is not to be sold for profit. The borrow area and associated activity shall be located within a two-mile radius of the project requesting permit coverage to be considered as part of the project and will open and close with the project requesting permit coverage.

***Chronic and Catastrophic Precipitation*** means precipitation events which may result in failure of the properly designed, located, implemented, and maintained BMPs or other structure/practices required by this permit. Catastrophic precipitation conditions means any single event of significant total volume, or of increased intensity and shortened duration, that exceeds normally expected or predicted precipitation over the time period that the disturbance is planned or is ongoing, as determined by the Department. Catastrophic conditions could also include tornadoes, hurricanes, or other climatic conditions which could cause failure due to winds or mechanical damage. Chronic precipitation is also that series of wet-weather conditions over a limited time-period which does not provide any opportunity for emergency maintenance, reinstallation, and corrective actions and which equals or exceeds the volume of normally expected or predicted precipitation for the time period that the disturbance is planned or is ongoing.

***Common Plan of Development or Sale*** means any announcement or piece of documentation (e.g., sign, public notice, or hearing, sales pitch, advertisement, drawing, permit application, zoning request, computer design, etc.) or physical demarcation (e.g., boundary signs, lot stakes, surveyor markings, etc.) indicating construction activities may occur on a specific plot.

***Construction*** means any land disturbance or discharges of pollutants associated with, or the result of building, excavation, land clearing, grubbing, placement of fill, grading, blasting, reclamation, areas in which construction materials are stored in association with a land disturbance or handled above ground and other associated areas including, but not limited to, construction site vehicle parking, equipment or supply storage areas, material stockpiles, temporary office areas, and access roads. Construction also means significant pre-construction land disturbance activities performed in support or in advance of construction activity including, but not limited to, land clearing, excavation, removal of existing buildings, dewatering, and geological testing. For the purposes of this Permit, any activity related to mining operations is excluded.

***Construction Activity*** means the disturbance of soils associated with clearing, grading, excavating, filling of land, or other similar activities which may result in soil erosion. For the purposes of this Permit, construction activity does not include mining operations, agricultural and silvicultural practices. However, construction activity does include the construction of agricultural buildings.

***Construction Best Management Practices Plan (CBMPP)*** means any research, planning considerations, systems, procedures, processes, activities, and practices implemented for the prevention and/or minimization of pollutants in stormwater to the maximum extent practicable, and collection, storage, treatment, handling, transport, distribution, land application, or disposal of construction stormwater and onsite management of construction waste generated by the construction activity, and to comply with the requirements of this permit. The CBMPP shall be prepared and certified, and when necessary updated by a qualified credentialed professional (QCP) in accordance with the requirements of this permit.

***Construction Site*** means any site regardless of size where construction or construction associated activity has commenced, or is continuing, and associated areas, including sites where active work is suspended or has ceased, until the activity is completed and effective reclamation and/or stormwater quality remediation has been achieved.

***Construction Support Activity*** a construction-related activity that specifically supports the construction activity solely related to the construction site covered under this permit and involves earth disturbance or pollutant-generating activities of its own, and may include activities including but not limited to equipment staging yards, materials storage areas, excavated material disposal areas, and temporary borrow areas.

***Construction Waste*** means construction and land disturbance generated materials, including but not limited to, waste chemicals, sediment, trash, debris, litter, garbage, construction demolition debris, land clearing and logging slash, or other materials or pollutants located or buried at the site prior to disturbance activity or that is generated at a construction site.

***Control Measure*** refers to any Best Management Practice or other method used to prevent or reduce the discharge of pollutants to waters of the State.

***CWA or The Act*** means the Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972) Pub.L. 92-500, as amended Pub. L. 95-217, Pub. L. 95-576, Pub. L. 96-483 and Pub. L. 97-117, 33 U.S.C. 1251 et.seq.

***Department*** means the Alabama Department of Environmental Management or an authorized representative.

***Director*** means the Director of the Department or his designee.

***Discharge***, "[t]he addition, introduction, leaking, spilling or emitting of any sewage, industrial waste, pollutant or other waste into waters of the State." Code of Alabama 1975, §22-22-1(b)(8).

***EPA*** refers to the U.S. Environmental Protection Agency.

***Ephemeral Stream*** means a stream or portion of a stream which flows briefly in direct response to precipitation in the immediate vicinity and whose channel is at all times above the ground-water reservoir.

***Facility*** see the definition for construction site

***Final Stabilization*** means the application and establishment of the permanent ground cover (vegetative, pavements of erosion resistant hard or soft material, or impervious structures) planned for the site to permanently eliminate soil erosion to the maximum extent practicable. Established vegetation will be considered final if 100% of the soil surface is uniformly covered in permanent vegetation with a density of 85% or greater. Permanent vegetation shall consist of planted trees, shrubs, perennial vines; and/or an agricultural or a perennial crop of vegetation appropriate for the region and accomplished according to the Alabama Handbook. Final stabilization applies to each phase of construction.

***FWPCA*** means the Federal Water Pollution Control Act

***Green Infrastructure*** refers to systems and practices that use or mimic natural processes to infiltrate, evapotranspirate (the return of water to the atmosphere either through evaporation or by plants), or reuse storm water or runoff on the site where it is generated.

***Intermittent Stream*** means a stream where portions flow continuously only at certain times of the year. At low flow there may be dry segments alternating with flowing segments.

***Linear Project*** means land disturbing activities conducted by an underground /overhead utility or highway department, including, but not limited to any cable line or wire for the transmission of electrical energy; any conveyance pipeline for transportation of gaseous or liquid substance; any cable line or wire for utility communications; or any other energy resource transmission ROW or utility infrastructure, e.g., roads and highways. Activities include the construction and installation of these utilities within a corridor. Linear project activities also include the construction of access roads, staging areas, and borrow/spoil sites associated with the linear project.

***Low Impact Development or LID*** is an approach to the maintenance of predevelopment hydrology in land development (or re- development) that works with nature to manage storm water as close to its source as possible. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that treat storm water as a resource rather than a waste product.

***Maximum extent practicable (MEP)*** means full implementation and regular maintenance of available industry standard technology and effective management practices, such as those contained in the Alabama Handbook and site-specific CBMPP, designed to prevent and/or minimize discharges of pollutants and ensure protection of groundwater and surface water quality.

***Mining Operations*** shall mean all or any part of the process of recovering coal, lignite, iron, clay, sand, bauxite, gravel, ores, gold, marble or any other material or mineral by removal of such mineral from the surface or by removal or displacement of the strata or material which overlies such mineral deposits in its natural condition, and shall include but not be limited to the open-pit or open-cut method, the auger method, and the highwall mining method. For the purposes of this permit, mining operations are commercial operations that do not meet the definition of a construction support activity. Additionally, this permit does not cover pre-mining construction and land preparation, including but not limited to, clearing, grubbing, testing, and advanced prospecting in advance of mining activity/operations.

***Minor Land Disturbing Activities*** means activities which will result in minor soil erosion such as home gardens or individual home landscaping, repairs, maintenance work, fences, routine maintenance and other related activities.

***National Pollutant Discharge Elimination System "NPDES"*** means the national program for issuing, modifying, revoking, and reissuing, terminating, monitoring, and enforcing permits for the discharge of pollutants into waters of the State.

***Natural Buffer (Riparian buffer)*** means a strip of dense undisturbed perennial native vegetation, either original or re-established, that borders streams and rivers, ponds and lakes, and wetlands. Buffer zones are established for the purposes of slowing water runoff, enhancing water infiltration, and minimizing the risk of any potential nutrients or pollutants from leaving the upland area and reaching surface waters. Natural buffers help stabilize streambanks and therefore are important in minimizing production of sediment from bank erosion. The importance increases in relation to the size of the stream. Buffer zones are most effective when stormwater runoff is flowing into and through the buffer zone as shallow sheet flow, rather than in concentrated form such as in channels, gullies, or wet weather conveyances.

***Nephelometric Turbidity Unit or NTU*** means a numerical unit of measure based upon photometric analytical techniques for measuring the light scattered by fine particles of a substance in suspension.

***New Construction Site*** means any initial construction or construction activity covered under this General Permit where the disturbance begins after the effective date of this permit. This includes subsequent phases of a previously permitted development.

***Non-stormwater Discharges*** means discharges that do not originate from storm events. They can include, but are not limited to, discharges of process water, air conditioner condensate, non-contact cooling water, vehicle wash water, sanitary wastes, concrete washout water, paint wash water, irrigation water, or pipe testing water.

***Normal Operating Hours*** means from 6:00 a.m. to 6:00 p.m., Monday through Friday, excluding federal holidays established pursuant to 5 U.S.C. § 6103. Normal operating hours also include any time when workers are present or when construction activity is occurring, regardless of the particular day or time of day.

***NOI*** means Notice of Intent.

***Operator*** means any person or other entity that owns, operates, directs, conducts, controls, authorizes, approves, determines, or otherwise has responsibility for, or exerts financial control over the commencement, continuation, or daily operation of activity regulated by this permit. An operator includes any person who treats and discharges stormwater, or in the absence of treatment, the person who generates and/or discharges stormwater, or pollutants. An operator may include but may not be limited to, property owners, agents, general partners, LLP partners, LLC members, leaseholders, developers, builders, contractors, or other responsible or controlling entities.

***Outfall*** means the location where stormwater in a discernible, confined and discrete conveyance leaves a facility or construction site prior to discharging into the receiving water.

***Perennial Stream*** means a stream or portion of a stream that flows year-round, is considered a permanent stream, and for which base flow is maintained by ground-water discharge to the streambed due to the ground-water elevation adjacent to the stream typically being higher than the elevation of the streambed.

***Permittee*** means a person to whom a permit has been issued.

***Plan or Sale as included in the phrase "larger common plan of development or sale"*** is broadly defined to mean any announcement or documentation, sales program, permit application, presentation, zoning request, physical demarcation, surveying marks, etc., associated with or indicating construction activities may occur in an area.

***Pollutant of concern*** refers to sediment, turbidity, and any other pollutant known or reasonably expected to be found in untreated discharges associated with the construction site.

***Post-construction*** refers to any phase of construction where final stabilization has been achieved and all but minor construction activities have been completed. The term post-construction is not affected by the final operational status of the site or whether the site has been placed into operation according to its final intended use.

***Priority construction site*** means any site that discharges to a waterbody which is listed on the most recently EPA approved 303(d) list of impaired waters for turbidity, siltation, or sedimentation, any waterbody for which a TMDL has been finalized or approved by EPA for turbidity, siltation, or sedimentation, any waterbody assigned the Outstanding Alabama Water use classification in accordance with ADEM Admin. Code r. 335-6-10-.09, and any waterbody assigned a special designation in accordance with ADEM Admin. Code r. 335-6-10-.10.

***Qualified Credentialed Inspector or QCI*** means a permittee, permittee employee, or permittee designated qualified person who has successfully completed initial training and annual refresher Qualified Credentialed Inspection Program (QCIP) training, and holds a valid certification from a Department approved cooperating training entity. A QCI is familiar with current industry standards for erosion and sediment controls and able to inspect and assure that BMPs or other pollution control devices (silt fences, erosion control fabric, rock check devices, etc.) and erosion control efforts (grading, mulching, seeding, growth management, etc.) or management strategies have been properly implemented and regularly maintained. Such individual may not certify the CBMPP or modifications to the CBMPP.

***Qualified Credentialed Inspector Program or QCIP*** means a Department approved program conducted by a cooperating training entity. Approved programs provide training in the requirements of the Alabama NPDES rules and regulations to ensure that QCP designed and certified BMPs detailed in a CBMPP are effectively implemented and maintained, and evaluation of conveyance structures, receiving waters and adjacent impacted offsite areas to ensure the protection of water quality and compliance with the requirements of this Permit.

***Qualified Credentialed Professional or QCP*** means a licensed (in the State of Alabama) professional engineer (PE) or a Certified Professional in Erosion and Sediment Control (CPESC) as determined by EnviroCert International. Other registered or certified professionals eligible to be classified as a QCP include registered landscape architect, licensed land surveyor, registered geologist, registered forester, Registered Environmental Manager as determined by the National Registry of Environmental Professionals (NREP), or Certified Professional and Soil Scientist (CPSS) as determined by the Soil Science Society of America. The QCP shall be in good standing with the authority granting the registration or designation. The design and implementation of certain structural BMPs may involve the practice of engineering and require the certification of a professional engineer pursuant to Alabama law.

***A qualified person under the direct supervision of a QCP*** refers to an individual who is an employee of the QCP or the QCP's firm, and is familiar with current industry standards for erosion and sediment controls. This individual is able to inspect and assure that BMPs or other pollution control devices (silt fences, erosion control fabric, rock check devices, etc.) and erosion control efforts (grading, mulching, seeding, growth management, etc.) or management strategies have been properly implemented and regularly maintained. Such individual may not certify the CBMPP or modifications to the CBMPP.

***Qualifying precipitation event*** refers to any precipitation of 0.75 inches or greater in any 24-hour period.

***Receiving Stream*** means the "waters" receiving a "discharge" from a construction site.

***Severe property damage*** means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

***Silvicultural Operations:***

> ***Non-point source Silvicutural activities*** means activities such as nursery operations, site preparation, reforestations, and subsequent cultural treatment, thinning, prescribed burning, pest and fire control, harvesting operations, surface drainage, or road construction and maintenance from which there is natural runoff.

***Point source Silvicultural activities*** means any discernable, confined and discrete conveyance related to rock crushing, gravel washing, log sorting, or log storage facilities which are operated in conjunction with silvicultural activities and from which pollutants are discharged into waters of the State. Silvicultural point sources, excluding mining operations regulated pursuant to ADEM Administrative Code rule 335-6-9; 40 CFR Part 122.27 (1994).

***Site*** means the land or water area where any facility or activity for which coverage under this permit is required is physically located or conducted, including adjacent land use in connection with the facility or activity. See also the definition of Construction Site.

***State water quality standards*** refer to numeric and narrative standards set forth at ADEM Admin Code chaps. 335-6-10 and 335-6-11.

***Steep Slope*** means a slope of 15% or greater.

***Stormwater*** means runoff, accumulated precipitation, process water, and other wastewater generated directly or indirectly as a result of construction activity, the operation of a construction material management site, including but not limited to, precipitation, upgradient or offsite water that cannot be diverted away from the site, and wash down water associated with normal construction activities. Stormwater does not mean discharges authorized by the Department via other permits or regulations.

***Stormwater control*** refers to any BMP or other method used to prevent or reduce the discharge of pollutants to waters of the State.

***Surface water*** means a water of the State of Alabama as defined in ADEM Admin. Code R. 335-6-10-.02.

***Temporary Stabilization*** means the application and establishment of temporary ground cover (vegetative, pavements of erosion resistant hard or soft materials, or impervious structures) for the purpose of temporarily reducing raindrop impact and sheet erosion in areas where final stabilization cannot be established due to project phasing, seasonal limitations, or other project related restrictions.

***Total Maximum Daily Load or TMDL*** means the calculated maximum permissible pollutant loading to a waterbody at which water quality standards can be maintained. The sum of waste load allocations (WLAs) and load allocations (LAs) for any given pollutant.

***Treatment Chemicals*** refers to polymers, coagulants, flocculants, or other chemicals used to reduce turbidity in stormwater. For the purposes of this permit, treatment chemicals are used to control erosion on soil or to enhance the sediment removal capabilities of sediment traps or basins. Common construction site polymers include polyacrylamide (PAM) and chitosan.

***Treatment facility and treatment system*** means all structures which contain, convey, and as necessary, chemically or physically treat stormwater. This includes all pipes, channels, ponds, tanks, and all other equipment serving such structures.

***TSS*** means the pollutant parameter Total Suspended Solids.

***Turbidity*** means a condition of water quality characterized by the presence of suspended solids and/or organic material. Sources of turbidity include soil erosion, waste discharge, urban runoff, eroding streambanks, and excessive algal growth.

***Upset*** means an exceptional incident in which there is unintentional and temporary noncompliance with technology-based permit effluent limitations because of factors beyond the reasonable control of the Permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventative maintenance, or careless or improper operation. For purposes of this definition, Chronic and Catastrophic Precipitation constitutes an exceptional incident.

***Waters of the State*** means "[a]ll waters of any river, stream, watercourse, pond, lake, coastal, ground or surface water, wholly or partially within the State, natural or artificial. This does not include waters which are entirely confined and retained completely upon the property of a single individual, partnership, or corporation unless such waters are used in interstate commerce." Code of Alabama 1975, §22-22-1(b)(2). "Waters" include all "navigable waters" as defined in §502(7) of the FWPCA, 33 U.S.C. §1362(7), which are within the State of Alabama.

***Week*** means the period beginning at twelve midnight Saturday and ending at twelve midnight the following Saturday.

# ATTACHMENT G-2

# NOTICE OF INTENT AND TERMINATION REQUEST (GENERAL PERMIT NO. ALR100000)

# NOTICE OF INTENT – GENERAL PERMIT NUMBER ALR100000

NPDES PERMIT NUMBER ALR100000 IS A GENERAL PERMIT AUTHORIZING DISCHARGES ASSOCIATED WITH CONSTRUCTION ACTIVITIES THAT RESULT IN A TOTAL LAND DISTURBANCE OF ONE ACRE OR GREATER AND SITES LESS THAN ONE ACRE BUT ARE PART OF A LARGER COMMON PLAN OF DEVELOPMENT OR SALE

**Mail to: Alabama Department of Environmental Management**
**Water Division**
**Stormwater Management Branch**
**Post Office Box 301463**
**Montgomery, Alabama 36130-1463**

PLEASE COMPLETE ALL QUESTIONS. INCOMPLETE OR INCORRECT ANSWERS, OR MISSING SIGNATURES WILL DELAY PROCESSING. IF SPACE IS INSUFFICIENT, CONTINUE ON AN ATTACHED SHEET(S) AS NECESSARY. ATTACH CBMPP AND OTHER INFORMATION AS NEEDED. PLEASE TYPE OR PRINT LEGIBLY IN INK.

I. PERMITTEE INFORMATION Initial: ■ Modification: ☐ Transfer: ☐ Renewal: ☐ Previous ALR10 _____

| | |
|---|---|
| Permittee Name (Legal Name)<br>U.S. Army Garrison - Redstone | Responsible Official Phone Number<br>256-842-3702 |
| Responsible Owner/Operator or Official, and Title<br>Clint Howard, Acting Chief, Environmental Management Division | Responsible Official E-Mail Address<br>Joseph.c.howard1.civ@mail.mil |
| Responsible Official (RO) Street/Physical Address<br>4488 Martin Road, Room A-336 | City, State, and Zip Code<br>Redstone Arsenal, AL 35898 |
| Responsible Official (RO) Mailing Address<br>same as above | City, State, and Zip Code<br>same as above |
| ☐ Corporation ☐ Individual ☐Sole Proprietorship ☐ Partnership ☐ LLC ☐ LLP ■ Government Agency ☐ Other _____ | |

II. FACILITY INFORMATION

| | |
|---|---|
| Facility/Site Name<br>Redstone Arsenal, RSA-122/183 | Facility Contact and Title<br>Kenneth Hurley, P.E. |
| Facility Street Address or Location Description<br>RSA-122/183, Former Lewisite Manufacturing Plants | Facility Contact Company Name<br>APTIM |
| City / Zip Code / County(s)<br>Redstone Arsenal 35898 Madison | Facility Contact Phone Number<br>865-560-7831 |
| Facility Front Gate Latitude and Longitude (For linear projects, please include coordinates for both the beginning and ending points of the project.)<br>34º 41' 55.42" N, 86º 40' 17.55" W | Facility Contact e-Mail Address:<br>kenneth.hurley@aptim.com |
| Detailed Directions to the Site | |

III. ACTIVITY DESCRIPTION

| | |
|---|---|
| Brief Description of Construction / Land disturbance activity(s):<br>Excavation of contaminated soil | |
| (For Modifications Only) Brief description of the action/change that has resulted in the request for permit modification: | |
| Primary SIC Code: | Primary NAICS Code: |

IV. PROPOSED SCHEDULE

| | | |
|---|---|---|
| Anticipated Activity schedule: | Commencement date: | Completion date: |
| Area of the Registered site: | Total site area in acres: | Total disturbed area in acres: 5 ac |

V. PRIORITY CONSTRUCTION SITE

Is this a Priority Construction Site as defined by Part V of the construction stormwater general permit? Yes ☐ No ☐ If yes, attach/submit a copy of the CBMPP that meets or exceeds the requirements of Parts III A. and E. of the construction stormwater general permit.

VI. TOPOGRAPHIC MAP SUBMITTAL

Please attach a recent 7.5 minute series USGS topographic map(s) no larger than 11 by 17 inches (several pages may be necessary), showing the location of the Facility including site boundaries, area of disturbance, a 1 mile radius, perennial, intermittent, and ephemeral streams, lakes/springs/wells/wetlands and contour lines. The map should also show the point(s) at which stormwater runoff will exit (outfall) the facility and the point(s) where stormwater runoff from the site will enter the receiving water.

VII. RECEIVING WATERS

Are there any surface waters within 25 feet of your project's earth disturbances? YES ☐ NO ■

List name of receiving water(s), latitude & longitude (decimal or deg, min, sec) of location(s) that run-off enters the receiving water, and the waterbody classification. Please refer to ADEM Admin. Code 335-6-11 for a detailed list of water use classifications. (Attach a separate list if necessary)

| Receiving Water | Latitude | Longitude | Waterbody Classification |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
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| | | | |
| | | | |

VIII. GENERAL INFORMATION

Will flocculants or other chemical stabilization products be used on site? Yes ☐ No ☐

IX. QUALIFIED CREDENTIALED PROFESSIONAL (QCP) CERTIFICATION

"I certify under penalty of law that a comprehensive Construction Best Management Practices Plan (CBMPP) for the prevention and minimization of all sources of pollution in stormwater and authorized related process wastewater runoff has been prepared under my supervision for this site/activity, and associated regulated areas/activities. The CBMPP meets the requirements of this permit and if properly implemented and maintained by the operator, discharges of pollutants in stormwater runoff can reasonably be expected to be effectively minimized to the maximum extent practicable according to the requirements of ADEM Administrative Code Chapter 335-6-6-.23 and this Permit. The CBMPP describes the erosion and sediment control measures that must be fully implemented and regularly maintained as needed at the permitted site in accordance with sound sediment and erosion control practices to ensure the protection of water quality."

QCP Designation/Description: _____

Address _____ Registration / Certification: _____

Name and Title (type or Print) _____ Phone Number _____

Signature _____ Date Signed _____

X. OPERATOR - RESPONSIBLE OFFICIAL SIGNATURE

Pursuant to ADEM Administrative Code Rule 335-6-6-.09, this NOI must be signed by a Responsible Official of the permittee who is the operator, owner, the sole proprietor of a sole proprietorship, a general/controlling member or partner, a ranking elected official or other duly authorized representative for a unit of government; or an executive officer of at least the level of vice-president for a corporation, having overall responsibility and decision making for the site/activity. "I certify under penalty of law that this form, the CBMPP, and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the qualified credentialed professional (QCP) and other 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, correct, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine or imprisonment for knowing violations. I certify that this form has not been altered, and if copied or reproduced, is consistent in format and identical in content to the ADEM approved form. I further certify that the proposed discharges described in this registration have been evaluated for the presence of any non-construction and/or coal/mineral mining stormwater, or process wastewaters have been fully identified."

Name and Title (type or Print) Kenneth J. Hurley, P.E. Official Title Project Engineer

Signature _____ Date Signed _____

Print Form

# TERMINATION REQUEST – GENERAL PERMIT NUMBER ALR100000

NPDES PERMIT NUMBER ALR100000 IS A GENERAL PERMIT AUTHORIZING DISCHARGES ASSOCIATED WITH CONSTRUCTION ACTIVITIES THAT RESULT IN A TOTAL LAND DISTURBANCE OF ONE ACRE OR GREATER AND SITES LESS THAN ONE ACRE BUT ARE PART OF A LARGER COMMON PLAN OR DEVELOPMENT OR SALE

**Mail to: Alabama Department of Environmental Management**
**Water Division**
**Post Office Box 301463**
**Montgomery, Alabama 36130-1463**

PLEASE COMPLETE ALL QUESTIONS. RESPOND WITH "N/A" AS APPROPRIATE. INCOMPLETE OR INCORRECT ANSWERS, OR MISSING SIGNATURES WILL DELAY PROCESSING. IF SPACE IS INSUFFICIENT, CONTINUE ON AN ATTACHED SHEET(S) AS NECESSARY. ATTACH CBMPP AND OTHER INFORMATION AS NEEDED. PLEASE TYPE OR PRINT LEGIBLY IN INK.

Item I.

| Permittee Name | | Facility/Site Name |
|---|---|---|
| NPDES Permit Number<br>ALR10 | Facility Street Address or Location Description | |
| County(s) | | City, State, and Zip Code |

Item II.

1. ☐ Yes ☐ No Has all regulated activity authorized by this Permit at this facility been completed? (i.e. construction/industrial effects removed; solid waste/debris properly disposed; all disturbed areas have been fully reclaimed, permanently stabilized, or perennial vegetative cover established; and stormwater discharges do not represent an adverse impact to water quality.)

2. ☐ Yes ☐ No Has the Permittee lost operational control of the facility/site?

3. ☐ Yes ☐ No Has the Permittee lost legal responsibility for the facility/site?

If "Yes" to any or all of questions 2 or 3, in order for this termination request to be granted, the Name, Phone Number, and Address of the succeeding responsible permittee/operator(s) must be listed and the succeeding responsible operator must obtain coverage:

_____

"I understand that discharging pollutants in storm water associated with regulated activity to waters of the State that is not authorized by NPDES permit coverage is a violation of State law. I also understand that the submittal of this request for termination does not release the operator from liability for any violations of this permit, ADEM Administrative Code Chapter 335-6-6, or other ADEM rules until a complete and correct request for termination of the permit is received by the Department. I understand that the permittee, operator, owner, developer, contractors, home builder(s), property owners association, etc., separately or collectively, must retain permit coverage for subdivision developments or other phased developments until all disturbance activity, including individual home construction, is substantially complete. I understand that should an inspection or complaint reveal significant noncompliance with ADEM rules, an environmental problem related to the discharge of stormwater from the site or that incorrect information has inadvertently been provided, implementation of remedial measures may be required, to include resubmittal of the NOI in order to correct any deficiencies, comply with federal stormwater permitting requirements, and provide for the protection of water quality. "I certify under penalty of law that this form, the CBMPP, and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the qualified credentialed professional (QCP) and other 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, correct, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine or imprisonment for knowing violations.

| Name & Designation of QCP | Signature | Date |
|---|---|---|
| | | |

| Name & Title of Responsible Official | Signature | Date |
|---|---|---|
| | | |

Print Form

# TERMINATION REQUEST – GENERAL PERMIT NUMBER ALR100000

NPDES PERMIT NUMBER ALR100000 IS A GENERAL PERMIT AUTHORIZING DISCHARGES ASSOCIATED WITH CONSTRUCTION ACTIVITIES THAT RESULT IN A TOTAL LAND DISTURBANCE OF ONE ACRE OR GREATER AND SITES LESS THAN ONE ACRE BUT ARE PART OF A LARGER COMMON PLAN OR DEVELOPMENT OR SALE

**Mail to: Alabama Department of Environmental Management**
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Item I.

| Permittee Name | Facility/Site Name |
|---|---|
| NPDES Permit Number<br>ALR10 | Facility Street Address or Location Description |
| County(s) | City, State, and Zip Code |

Item II.

1. ☐ Yes ☐ No Has all regulated activity authorized by this Permit at this facility been completed? (i.e. construction/industrial effects removed; solid waste/debris properly disposed; all disturbed areas have been fully reclaimed, permanently stabilized, or perennial vegetative cover established; and stormwater discharges do not represent an adverse impact to water quality.)

2. ☐ Yes ☐ No Has the Permittee lost operational control of the facility/site?

3. ☐ Yes ☐ No Has the Permittee lost legal responsibility for the facility/site?

If "Yes" to any or all of questions 2 or 3, in order for this termination request to be granted, the Name, Phone Number, and Address of the succeeding responsible permittee/operator(s) must be listed and the succeeding responsible operator must obtain coverage:

_____

"I understand that discharging pollutants in storm water associated with regulated activity to waters of the State that is not authorized by NPDES permit coverage is a violation of State law. I also understand that the submittal of this request for termination does not release the operator from liability for any violations of this permit, ADEM Administrative Code Chapter 335-6-6, or other ADEM rules until a complete and correct request for termination of the permit is received by the Department. I understand that the permittee, operator, owner, developer, contractors, home builder(s), property owners association, etc., separately or collectively, must retain permit coverage for subdivision developments or other phased developments until all disturbance activity, including individual home construction, is substantially complete. I understand that should an inspection or complaint reveal significant noncompliance with ADEM rules, an environmental problem related to the discharge of stormwater from the site or that incorrect information has inadvertently been provided, implementation of remedial measures may be required, to include resubmittal of the NOI in order to correct any deficiencies, comply with federal stormwater permitting requirements, and provide for the protection of water quality. "I certify under penalty of law that this form, the CBMPP, and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the qualified credentialed professional (QCP) and other 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, correct, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine or imprisonment for knowing violations.

| Name & Designation of QCP | Signature | Date |
|---|---|---|
| | | |

| Name & Title of Responsible Official | Signature | Date |
|---|---|---|
| | | |

# ATTACHMENT G-3

# STORMWATER BEST MANAGEMENT PRACTICES

(Alabama Soil and Water Conservation Committee, 2018)

Site Preparation

A. Construction Exit Pad (CEP)
B. Land Grading (LG)

Surface Stabilization

C. Dust Control (DC)
D. Erosion Control Blanket (ECB)
E. Mulching (MU)
F. Permanent Seeding (PS)
G. Preservation of Vegetation (PV)
H. Temporary Seeding (TS)

Runoff Conveyance

I. Check Dam (CD)
J. Diversion (DV)
K. Grass Swale (GS)

Sediment Control

L. Filter Strip (FS)
M. Sediment Barrier (SB)
N. Sediment Trap (ST)

# Construction Exit Pad (CEP)

## Practice Description

A construction pad is a stone base pad or manufactured product designed to provide a buffer area where mud and caked soil can be removed from the tires of construction vehicles to avoid transporting it onto public roads. This practice applies anywhere traffic will be leaving a construction site and moving directly onto a public road or street.

## Planning Considerations

Roads and streets adjacent to construction sites should be kept clean for the general safety and welfare of the public. A construction exit pad (Figure CEP-1) should be provided where mud can be removed from construction vehicle tires before they enter a public road.

Where possible the construction exit pad should be located and constructed at a site where surface runoff from the pad will not transport sediment from the pad off the site. If the pad slope toward the road exceeds 2%, a diversion ridge 6” to 8” high with 3:1 side slopes should be constructed across the foundation approximately 15 feet from the entrance. This diversion ridge should divert surface runoff from the pad away from the road and into a sediment trap or basin.

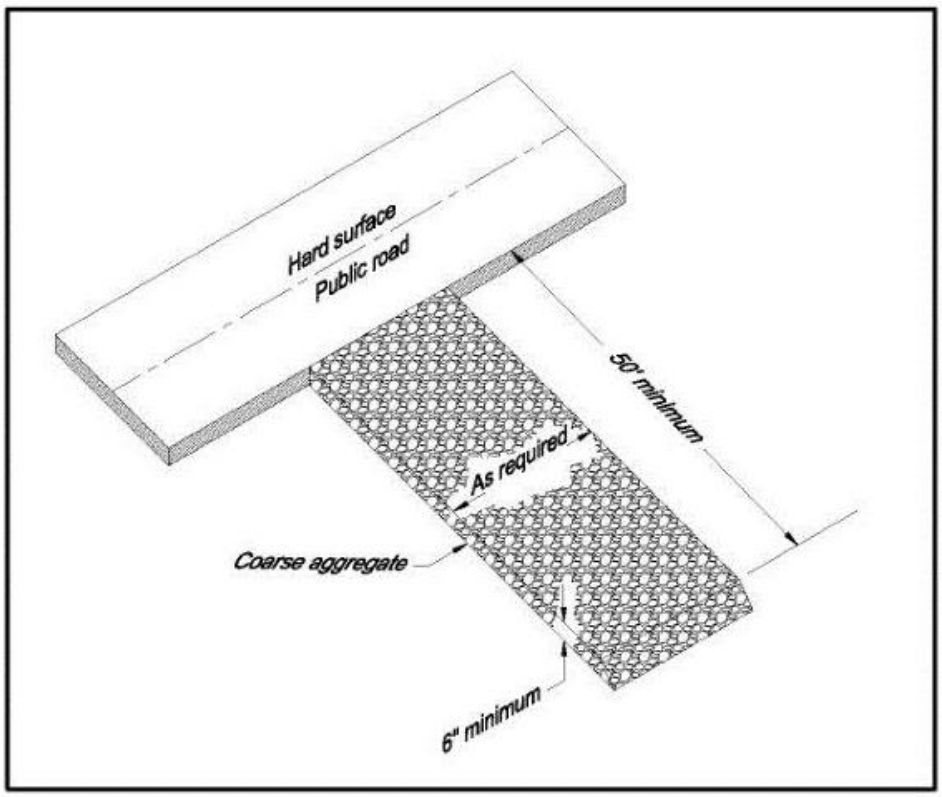


Figure CEP-1 Gravel Construction Exit

If the action of the vehicle traveling over the gravel pad does not sufficiently remove the mud or if the site is in a particularly sensitive area, a washing facility should be included with the pad (Figure CEP-2). When a washing facility is required all wash water shall be diverted to a sediment trap or basin.

If the construction exit pad is located in an area with soils that will not support traffic when wet, an underliner of geotextile will be required to provide stability to the pad.

Construction of stabilized roads throughout the development site should be considered to lessen the amount of mud transported by vehicular traffic. The construction exit pad should be located to provide for maximum use by construction vehicles.

Consideration should be given to limiting construction vehicles to only one ingress and egress point. Measures may be necessary to make existing traffic use the construction exit pad.

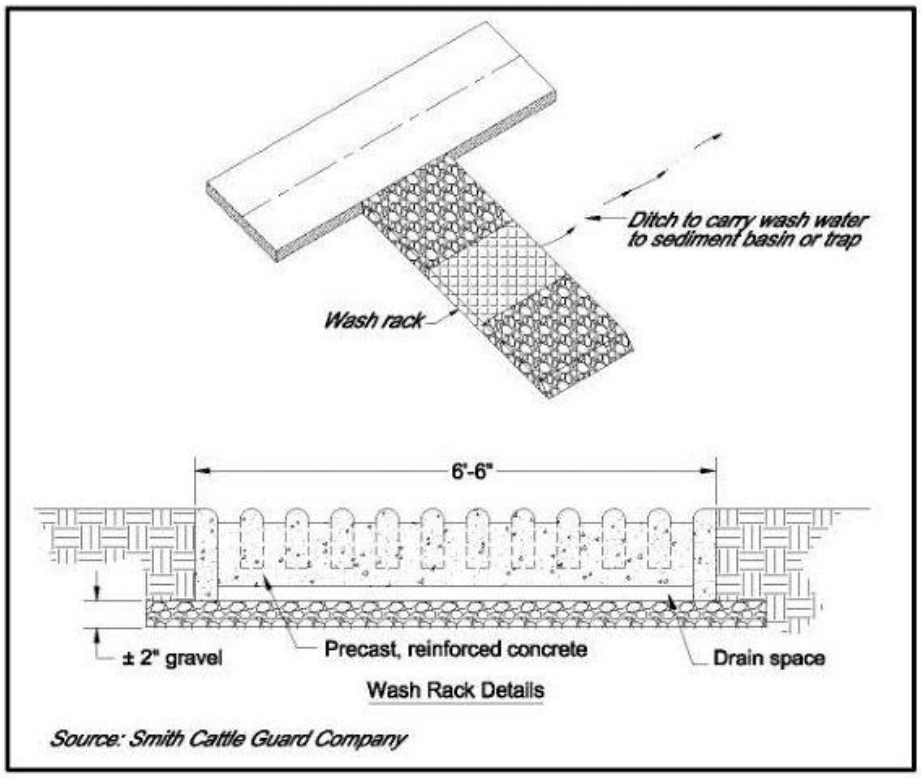


Figure CEP-2 Construction Exit with Wash Rack

## Design Criteria

*Aggregate size*

Aggregate should be Alabama Highway Department coarse aggregate gradation No.1.

*Pad Thickness*

The exit pad shall have a minimum aggregate thickness of 6”.

*Geotextiles*

A non-woven geotextile shall be placed underneath the aggregate. The geotextile shall be of the strength and durability required for the project to ensure the aggregate and soil base are stable. Generally, the non-woven geotextile should meet the requirements for a Class 2 geotextile used for separation that is found in the current version of AASHTO M288.

*Pad Length*

The exit pad should provide for entering and parking the longest anticipated construction vehicles. A pad is typically 50 feet long but the required length may be longer or shorter.

### *Pad Width*

The exit pad width is typically 20 feet but may be narrower or wider to equal the full width of the vehicular egress.

### *Washing*

A washing facility shall be provided if necessary to prevent mud and caked soil from being transported to public streets and highways. It shall be constructed of concrete, stone, and/or other durable materials. Provisions shall be provided for the mud and other material to be carried away from the washing facility to a sediment trap or basin to allow for settlement of the sediment from the runoff before it is released from the site.

# Land Grading (LG)

## Practice Description

Land grading is reshaping of the ground surface to provide suitable topography for buildings, facilities and other land uses, to control surface runoff, and to minimize soil erosion and sedimentation both during and after construction. This practice applies to sites where the existing topography must be modified to prepare for another land use, or where adapting proposed development to the existing landscape can reduce the erosion potential of the site and the cost of installing erosion and sediment control measures. In some instances, other practices such as diversions or benches can be used to reduce the length of continuous slopes and reduce erosion potential.

## Planning Considerations

A detailed plan should be developed by a qualified design professional for all land grading activities at the project site. The plan should show all areas to be disturbed, the areas of cut, areas of fill, and the finished elevation for all graded areas. Areas that will be mowed after the site is developed should have slopes planned that are not too steep for the type of mowing equipment that will be used for regular maintenance.

The grading plan should be designed to protect existing vegetation where possible, especially around natural drainageways. Grading activities should be scheduled to minimize the area disturbed at any one time during the construction process. The plan should include provisions for stabilizing disturbed areas immediately after final grading is completed. Provisions should also be made to protect existing

underground utilities. Finally, topsoil should be removed and stockpiled for use in revegetating the site.

The grading plan should also include necessary practices for controlling sediment and erosion at the site. These practices could include stable outlets and slope breaks such as diversions or benches.

## Design Criteria

### *Site Preparation*

A detailed survey of the construction site should be performed by a qualified surveyor prior to grading plan development. This survey should include existing topographic information at the site including existing elevations, existing drainage patterns, locations of existing overhead and underground utilities, and construction limit boundaries.

The grading plan should require that the existing topsoil at sites to be graded be removed as the first step in the grading process. The plan should include a location on the construction site where topsoil will be stockpiled. Stockpiled topsoil should be protected by temporary vegetation (see Temporary Vegetation practice) or other appropriate temporary cover, such as plastic, until it is used to cover disturbed areas in advance of permanent vegetation of the site.

The grading plan should include a schedule of disturbance activities that minimizes the area disturbed at any point in time using sequencing and staging concepts. In areas where clearing of existing vegetation is planned, the area should be cleared and grubbed by removing trees, vegetation, roots and other debris such as trash. In areas to be filled all loose or weak soil and oversized rocks should be removed from the area. The foundation of the area to be filled should consist of soil or rock material of adequate strength to support the proposed fill material and the structures to be built at the site. The exact depth of material to be removed should be determined by a qualified geotechnical professional according to accepted engineering standards.

### *Grading*

A plan for placement of fill should be developed by a qualified geotechnical professional. The plan should specify the source of fill materials, which should be obtained on site if possible. Materials used for fill, when placed according to the plans and specifications, should provide sufficient strength to support structures planned for construction at the location.

Loose fill material should be placed in layers not exceeding 9” in thickness. The materials should be compacted to a moisture content and to a dry density that will produce the design bearing strength required for structures planned at the site. A qualified geotechnical engineer should provide fill placement specifications using standard accepted engineering practices.
Long and/or steep slope lengths can result in rill and gully erosion on slopes. Erosion on these type slopes can be minimized by breaking the slope with

diversions or benches (see Diversion practice). Diversion widths should be compatible with the expected maintenance equipment. Care is needed in locating outlets that will be stable and not cause gully erosion. The following table gives general guidance on the horizontal spacing of slope breaks:

Table LG-1 Guidelines for Spacing Slope Breaks [1]

| Slope (H:V) | Horizontal Spacing (Ft) |
|---|---|
| 1:1 | 20 |
| 2:1 | 40 |
| 3:1 | 60 |
| 4:1 and 5:1 | 80 |
| 6:1 to 9:1 | 120 |
| 10:1 or flatter | 200 |

[1] Adjustments in spacing may be made to account for soil and site conditions and professional experience of the site designer.

In areas where seepage and ground water are present subsurface drains should be installed to improve slope stability or soil bearing capacity (see Subsurface Drain practice).

Steep slopes should be avoided if possible. Slopes that are to be vegetated should be 2 horizontal to 1 vertical or flatter. If the slope is to be maintained by tractor or other equipment the slope should be 3 horizontal to 1 vertical or flatter. Slopes should be designed to blend with surrounding topography as much as possible.

### *Erosion Control*

The grading plan should include provisions for stabilization of graded areas immediately after final grading is completed. On areas that will have no additional disturbance, permanent vegetation should be applied immediately to the site (see Permanent Seeding practice) if grading is finished during the planting season. If grading is finished outside of the recommended planting dates a temporary cover should be installed using a Temporary Seeding or other appropriate cover and the Permanent Seeding planned for the next planting period. On areas where work is to be interrupted or delayed for 14 calendar days or longer, such as topsoil stockpiles, the area should be stabilized using mulch or temporary seeding (see Mulching or Temporary Seeding practice). Other stabilization measures such as hydraulic mulch or erosion control blankets should be used in extreme conditions, such as steep slopes and channels.

Where practical, runoff from undisturbed off-site areas should be diverted around the construction site to prevent erosion on the disturbed areas (see Diversion practice).

### *Sediment Control*

Required sediment control practices should be installed before the land disturbance activities in the drainage area of the sediment control practices. Until disturbed

areas can be stabilized, appropriate sediment control measures will be maintained to minimize sediment delivery off-site. Measures should include as a minimum:

- Sediment Barriers – Placed along toes of slopes (see Sediment Barrier practice).

- Sediment Basins – Divert sediment laden runoff to basins as needed to minimize off-site sedimentation (see Sediment Basin practice).

- Inlet Protection – Where sediment-laden runoff is diverted to on-site stormwater drain inlets, the inlets should be protected with an appropriate sediment control practice.

- Stabilized Outlets – All runoff from the site should be conveyed in stabilized channels (see Grassed Swale, Lined Swale, Rip-rap Lined Swale, or other appropriate channel stabilization).

# Dust Control (DC)

## Practice Description

Dust control includes a wide range of techniques that prevent or reduce movement of wind-borne soil particles (dust) during land disturbing activities. This practice applies to construction routes and other disturbed areas where on-site and off-site damage or hazards may occur if dust is not controlled.

## Planning Considerations

Construction activities that disturb soil can be a significant source of air pollution. Large quantities of dust can be generated, especially in “heavy” construction activities such as land grading for road construction and commercial, industrial or subdivision development.

The scheduling of construction operations so that the least amount of area is disturbed at one time is important in planning for dust control.

The greatest dust problems occur during dry periods. Therefore, to the extent practicable do not expose large areas of bare soil during drought conditions.

Where wind erosion is a potential cause of dust problems, preserving vegetation should be considered as a passive measure. Leave undisturbed buffer areas between graded areas wherever possible.

Installing temporary or permanent surface stabilization measures immediately after completing land grading will minimize dust problems.

## Design Criteria

### *Permanent Methods*

*Vegetative Cover*

For disturbed areas not subject to traffic, vegetation provides the most practical method of dust control. Establish vegetative cover according to the Permanent Seeding or Temporary Seeding practice.

*Topsoiling*

This entails covering the surface with less erosive soil material. See Topsoiling practice for guidance.

*Stone*

Stone used to stabilize construction roads can also be effective for dust control. Stone should be spread a minimum of 6” thick over construction roads in the disturbed area. For heavily traveled roads or roads subjected to heavy loads the stone thickness should be 8” to 10”. A non-woven geotextile meeting the minimum requirements of AASHTO M288 for a Class 2 separation geotextile should be used under the stone.

### *Temporary Methods*

*Mulches*

Mulch offers a fast, effective means of controlling dust when properly applied. See Mulching practice for guidelines for planning and installing the practice.

*Temporary Vegetative Cover*

For disturbed areas where no activity is anticipated for 14 days or longer, temporary seeding can effectively control dust. Establish vegetative cover according to Temporary Seeding practice guidelines.

*Calcium Chloride*

Calcium chloride may be applied by mechanical spreader as loose, dry granules or flakes at a rate that keeps the surface moist but not so high as to cause water pollution or plant damage. Sites may need to be retreated because the product degrades over time.

*Spray-on Adhesives*

Spray-on adhesives may be used on mineral soils for dust control. Traffic must be kept off treated areas to prevent the product from becoming ineffective. Examples of spray-on adhesives for use in dust control are listed in Table DC-1.

Table DC-1 Spray-on Adhesives for Dust Control on Mineral Soil

| Material | Water Dilution | Type of Nozzle | Apply Gal/Ac |
|---|---|---|---|
| **Anionic Asphalt Emulsion** | 7:1 | Coarse Spray | 1,200 |
| **Latex Emulsion** | 12.5:1 | Fine Spray | 235 |
| **Resin in Water** | 4:1 | Fine Spray | 300 |

*Chemical Stabilization (CHS)*

Chemical products are available for use on mineral soils for dust control. Traffic must be often kept off treated areas to prevent the product from becoming ineffective. The manufacturer or supplier shall provide written application methods. The application method shall ensure uniform coverage to the target and avoid drift to non-target areas including waters of the State. The manufacturer or supplier shall also provide written instructions to ensure proper safety, storage, and mixing of the product. Refer to the Planning Considerations for the Chemical Stabilization practice for planning consideration before deciding to use these type products.

*Sprinkling or Irrigation*

Sprinkling is especially effective for dust control on haul roads and other traffic routes. Sprinkle the site until the surface is wet. Repeat as needed. Also, bare areas may be kept wet with irrigation to control dust as an emergency treatment.

*Tillage*

Tillage is used to roughen the site and bring clods and moist soil to the surface. This is a temporary emergency measure that can be used on large open disturbed areas as soon as soil blowing starts. Begin tilling on the windward edge of the site. The depth of tillage is determined by the depth to moist soil and the amount of moist soil desired at the surface. In sandy soils, the depth to moist soil may make tillage impractical.

*Barriers*

A board fence, wind fence, sediment fence, hay bales, or similar barriers can control air currents and blowing soil. Place barriers perpendicular to prevailing air currents at intervals about 15 times the barrier height.

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# Erosion Control Blanket (ECB)

Photo courtesy of Sunshine Supplies, Inc.

## Practice Description

To aid in controlling erosion on critical areas by providing a protective cover made of straw, jute, wood or other plant fibers; plastic, nylon, paper or cotton. This practice is best utilized on slopes and channels where the erosion hazard is high, and plant growth is likely to be too slow to provide adequate protective cover. Erosion control blankets are typically used as an alternative to mulching but can also be used to provide structural erosion protection. Some important factors in the choice of a blanket are: soil conditions, steepness of slope, length of slope, type and duration of protection required to establish desired vegetation, and probable sheer stress.

## Planning Considerations

Care must be taken to choose the type of blanket that is most appropriate for the specific project needs. Eighteen types of erosion control blankets are included in this practice and the type names and related information are from the materials developed by the Erosion Control Technology Council (ECTC). Manufacturer's instructions and recommendations, as well as a site visit by the qualified design professional and site plan reviewer are highly recommended to determine a product's appropriateness.

*Note: The Alabama Department of Transportation (ALDOT) identifies Rolled and Hydraulic Erosion Control Products based on performance. Description of ALDOT types can be found in Section 659 of their Standard Specifications for Highway Construction. ALDOT recognizes some Hydraulic Erosion Control Products equal in performance to Rolled Products.*

### *Temporary Erosion Control Blankets*

Benefits of using temporary erosion control blankets include the following:

- Protection of the seed and soil from raindrop impact and subsequent displacement.
- Thermal consistency and moisture retention for the seedbed area.
- Stronger and faster germination of grasses and legumes.
- Spreading stormwater runoff to prevent rill erosion of slopes.
- Prevention of sloughing of topsoil added to steeper slopes.

Because temporary blankets will deteriorate in a short period of time, they provide no enduring reduction in erosion potential.

### *Permanent Erosion Control Blankets*

Permanent erosion control blankets are also known as permanent soil reinforcing mats or turf reinforcement mats (TRMs). Roots penetrate and become entangled in the matrix, forming a continuous anchorage for surface growth and promoting enhanced energy dissipation.

Benefits of using permanent erosion control blankets, in addition to the benefits gained from using a temporary blanket include the following:

- Sediment from stormwater flows is deposited in the matrix providing a fine soil growth medium for the development of roots.
- In stormwater channels, blankets and the vegetative root system form an erosion resistant cover which resists hydraulic uplift and shear forces of channel flows.

## Design Criteria

### *General*

All blankets shall be nontoxic to vegetation and to the germination of seed and shall not be injurious to the unprotected skin of humans. Erosion control products shall be of sufficient strength to hold the prepared ground and, if applicable, cover material (mulch, sod, etc.) in place until an acceptable growth of natural or planted material is established. Erosion control products shall be identified by a type designation (Type 1.A, 2.B, 3.A, etc.) where the type is based on the functional longevity and physical properties of the product. Type 1 products have a 3-month functional longevity, Type 2 a 12-month, Type 3 a 24-month, Type 4 a 36-month, and Type 5 are Turf Reinforcement Mats for long-term erosion protection.

Tables ECB-1 and ECB-2 give typical applications of the different types of erosion control blankets. ECTC's recommended installation guide and standard specifications can be found on their website and at the following link:

https://www.ectc.org/assets/docs/ectc_july2017_recpspecification%20final.pdf

Table ECB-1 Temporary Erosion Control Blanket Types and Applications

| Functional Longevity | Type | Application |
|---|---|---|
| 3-Month | 1.A | A Netting / Open Weave Textile for use on a maximum slope steepness of 5:1 and provides a shear stress of at least 1.0 lbs/ft$^2$. |
| 3-Month | 1.B | A Netless Rolled Erosion Control Blanket for use on a maximum slope steepness of 3:1 and provides a shear stress of at least 1.0 lbs/ft$^2$. |
| 3-Month | 1.C | A Single-Net Erosion Control Blanket for use on a maximum slope steepness of 3:1 and provides a shear stress of at least 1.5 lbs/ft$^2$. |
| 3-Month | 1.D | A Double-Net Erosion Control Blanket for use on a maximum slope steepness of 2:1 and provides a shear stress of at least 1.75 lbs/ft$^2$. |
| 12-Month | 2.A | A Netting / Open Weave Textile for use on a maximum slope steepness of 5:1 and provides a shear stress of at least 1.0 lbs/ft$^2$. |
| 12-Month | 2.B | A Netless Rolled Erosion Control Blanket for use on a maximum slope steepness of 3:1 and provides a shear stress of at least 1.0 lbs/ft$^2$. |
| 12-Month | 2.C | A Single-Net Erosion Control Blanket for use on a maximum slope steepness of 3:1 and provides a shear stress of at least 1.5 lbs/ft$^2$. |
| 12-Month | 2.D | A Double-Net Erosion Control Blanket for use on a maximum slope steepness of 2:1 and provides a shear stress of at least 1.75 lbs/ft$^2$. |
| 24-Month | 3.A | An Open Weave Textile for use on a maximum slope steepness of 2:1 and provides a shear stress of at least 2.0 lbs/ft$^2$. |
| 24-Month | 3.B | An Erosion Control Blanket for use on a maximum slope steepness of 1.5:1 and provides a shear stress of at least 2.0 lbs/ft$^2$. |
| 36-Month | 4.A | An Open Weave Textile for use on a maximum slope steepness of 1:1 and provides a shear stress of at least 2.25 lbs/ft$^2$. |
| 36-Month | 4.B | An Erosion Control Blanket for use on a maximum slope steepness of 1:1 and provides a shear stress of at least 2.25 lbs/ft$^2$. |

Table ECB-2 Turf Reinforcement Mats (TRMs) Types and Applications

| Type | Application |
|---|---|
| 5.A | A TRM designed for use on geotechnically stable slopes up to 1:1, provide an unvegetated shear stress of at least 2.0 lbs/ft$^2$, and a vegetated shear stress of at least 6.0 lbs/ft$^2$. |
| 5.B | A TRM designed for use on geotechnically stable slopes up to 1:1, provide an unvegetated shear stress of at least 2.0 lbs/ft$^2$, and a vegetated shear stress of at least 8.0 lbs/ft$^2$. |
| 5.C | A TRM designed for use on geotechnically stable slopes up to 0.5:1, provide an unvegetated shear stress of at least 2.0 lbs/ft$^2$, and a vegetated shear stress of at least 10.0 lbs/ft$^2$. |
| 5.D | A TRM designed for use on geotechnically stable slopes up to 0.5:1, provide an unvegetated shear stress of at least 2.0 lbs/ft$^2$, and a vegetated shear stress of at least 12.0 lbs/ft$^2$. |
| 5.E | A TRM designed for use on geotechnically stable slopes up to 0.5:1, provide an unvegetated shear stress of at least 2.0 lbs/ft$^2$, and a vegetated shear stress of at least 12.0 lbs/ft$^2$. |
| 5.F | A High Performance TRM designed for use on geotechnically stable slopes up to 1:1, provide an unvegetated shear stress of at least 2.0 lbs/ft$^2$, and a vegetated shear stress of at least 14.0 lbs/ft$^2$. |

*Type Designations and Materials*

Erosion control products shall be composed of the materials shown in Tables ECB-3 and ECB-4.

Table ECB-3 Material Composition of Temporary Erosion Control Blankets

| Type | Material Composition |
|---|---|
| 1.A | A photodegradable synthetic mesh or woven biodegradable natural fiber netting. |
| 1.B | Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form an RECP. |
| 1.C | Processed degradable natural and/or polymer fibers mechanically bound together by a single rapidly degrading, synthetic or natural fiber netting. |
| 1.D | Processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings. |
| 2.A | A photodegradable synthetic mesh or woven biodegradable natural fiber netting. |
| 2.B | Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form an RECP. |
| 2.C | Processed degradable natural and/or polymer fibers mechanically bound together by a single degrading, synthetic or natural fiber netting. |
| 2.D | Processed degradable natural and/or polymer fibers mechanically bound together between two degradable, synthetic or natural fiber nettings. |
| 3.A | An open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix. |
| 3.B | An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix. |
| 4.A | An open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix. |
| 4.B | An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix. |

Table ECB-4 Material Composition of Turf Reinforcement Mats

| Type | Material Composition |
|---|---|
| 5.A<br>5.B<br>5.C<br>5.D<br>5.E | A product composed of UV-stabilized non-degradable synthetic fibers, filaments, nets, wire mesh and/or other elements, processed into a permanent, three- dimensional matrix which may be supplemented with degradable components. |
| 5.F | A product composed of UV-stabilized, non-degradable, synthetic fibers, filaments, nets, wire mesh and/or other elements, processed into a permanent, three- dimensional matrix for highest performance. |

### *Materials Physical Requirements*

A properly designed erosion control blanket installation requires selection of a product manufactured with physical properties to withstand the stresses the product will be subjected to for the design life of the product. Refer to the ECTC standard specifications for the minimum physical requirements for each type of blanket.

### *Product Placement*

General. Refer to the ECTC Installation Guide for the general guidelines for the installation of rolled erosion control products (RECPs); however, the ECTC guidelines do not supersede the manufacturer's installation guidelines.

Prior to installation of a RECP, the surface on which it is to be placed must be properly prepared. The surface should be stable and firm, the top soil should be evenly spread if specified, and the soil amendments added. The soil pH in the root zone and soil compaction MUST be addressed for long-term vegetal success. Fertilizer and lime applications per soil test recommendations should always be incorporated into the soil surface whenever possible. Some RECPs may require an application of mulch prior to placement of the blanket. Some TRMs may require soil or hydraulically-applied matrix in-filling after placement of the blanket. For soil in-filling, some of the soil amendment and the seed should be applied to the soil in-fill and lightly brushed or raked in to cover the seed.

Blankets shall be rolled out in the direction of flow to reduce rill erosion. The RECP should always have intimate contact with the soil surface over the entire installation. Do not stretch the RECP over surface irregularities.

For temporary blankets, staples should be U-shaped wire with an 11-gauge thickness or greater. Staples should be of sufficient thickness for soil penetration without undue distortion. The legs of the staples shall be at least 6" long with a crown of 1". Appropriate biodegradable staples can be used in lieu of wire staples.

Permanent blankets shall be anchored in one of two ways. Blankets can be anchored using sound wood stakes, 1" by 3" stock sawn in a triangular shape. The length of the stakes shall be from 12" to 18" depending upon the soil compaction at the site. Stakes shall be installed on 4 feet centers along each edge of the blanket. Blankets can also be anchored using U shaped staples of 11-gauge steel or greater with a minimum leg length of 8" and a 2" crown.

Upslope Anchor. The upslope portion of the RECP should be properly anchored. There are several different techniques that can be used. Always refer to the manufacturer's or the ECTC installation guidelines for the proper technique.

Seams. Edges of the RECP should be properly secured to adjacent blankets. There are several different techniques used to prevent seam or abutted rolls from separating. Always refer to the manufacturer's or the ECTC installation guidelines for the proper technique.

Terminal Ends. RECP should be securely fastened at the terminal end of the blanket. Always refer to the manufacturer's or the ECTC installation guidelines for the proper technique

Slopes. RECP should be securely fastened to the soil by installing stakes/staples at a minimum rate of 1.3/yd$^2$ within the body of the blanket. Always refer to the manufacturer's or the ECTC installation guidelines for the proper technique

Channels. Always follow manufacturer's or ECTC guidelines for anchor trenches or stake/staple check slots, seaming, and terminal end anchoring. Unroll RECPs down the center of the channel in the primary water flow direction. Securely fasten all RECPs to the soil by installing stakes/stapes at a minimum rate of 1.7/yd$^2$. Significantly higher anchor rates and longer stakes/stapes may be necessary in sandy, loose, or wet soil and in severe applications. Always refer to the manufacturer's or the ECTC installation guidelines for the proper technique for staking/stapling.

Photo courtesy of John Slupecki.

Figure ECB-1 RECP Slope Installation.


Figure ECB-2 Topsoil “In-Fill” Being Placed in TRM.


Figure ECB-3 TRM in the Middle of a Swale.

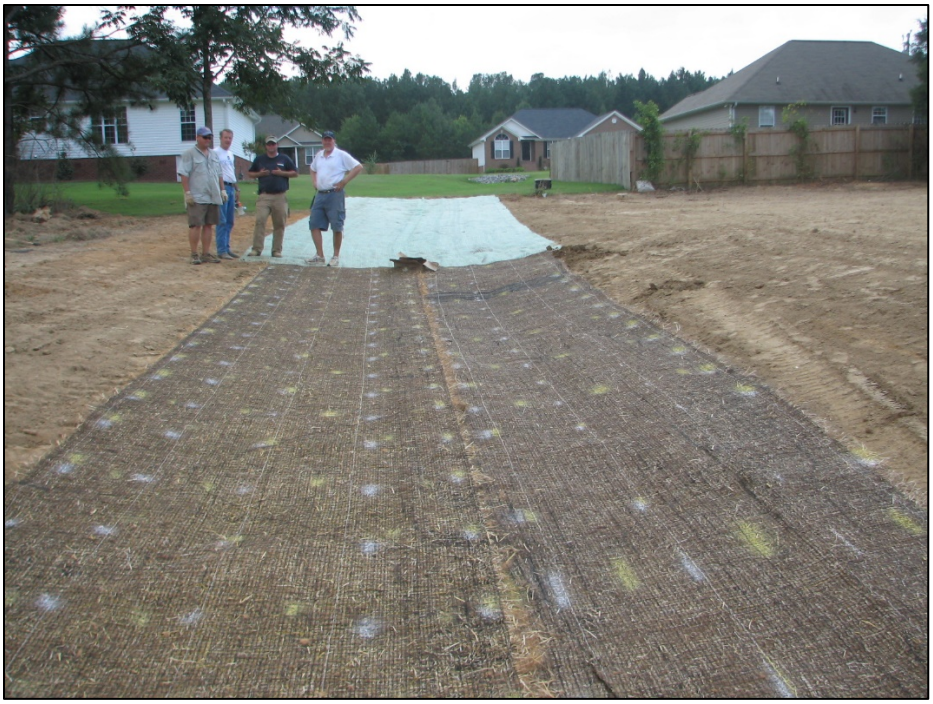

Figure ECB-4 TRM with Pre-Marked Stapling Pattern.

# Mulching (MU)

## Practice Description

Mulching is the application of plant residues such as straw or other suitable fibrous materials to the soil surface. Mulch protects the soil surface from the erosive force of raindrop impact and reduces the velocity of overland flow. It helps seedlings germinate and grow by conserving moisture, protecting against temperature extremes and controlling weeds. Mulch also maintains the infiltration capacity of the soil. Mulch can be applied to seeded areas to help establish plant cover. It can also be used in unseeded areas to protect against erosion over the winter or until final grading and shaping can be accomplished except in areas with concentrated flow.

## Planning Considerations

Surface mulch is the most effective, practical means of controlling runoff and erosion on disturbed land prior to vegetation establishment. Mulch absorbs the energy associated with raindrops and thereby minimizes soil particle detachment, which is the initiation step of erosion.

Mulch also reduces soil moisture loss by evaporation, prevents crusting and sealing of the soil surface, moderates soil temperatures, and provides a suitable microclimate for seed germination.

Organic mulches such as straw, wood chips and shredded bark have been found to be very effective mulch materials. Materials containing weed and grass seeds which may compete with establishing vegetation should not be used. Also, decomposition of some wood products can tie up significant amounts of soil nitrogen, making it necessary to modify fertilization rates or add fertilizer with the mulch.

Hydraulic Erosion Control Products (HECPs) as defined by the Erosion Control Technology Council (ECTC) can also be used as effective mulch applications. HECPs are designated as 5 different types based on product characteristics and performance. Information from the ECTC table dated April 2014 is provided as Table MU-1. To ensure that you use the most valid information refer to the latest HECP specifications provided by the ECTC or the manufacturer's recommendation. The Alabama Department of Transportation (ALDOT) characterizes mulches based on performance levels identified in Sections 656 and 659 of their Standard Specifications for Highway Construction.

The choice of materials for mulching should be based on soil conditions, season, type of vegetation to establish, and size of the area. Properly applied and tacked mulch is always beneficial. Mulching is especially important when conditions of germination are not optimum, such as midsummer and early winter, and on difficult sites such as cut slopes, fill slopes and droughty soils.

Straw has traditionally been the most commonly used mulching material in conjunction with seeding. Wheat straw is the mostly commonly used straw, and can be spread by hand or with a mulch blower. If the site is susceptible to blowing wind, the straw should be tacked down with a tackifier, or a crimper to prevent loss.

Wood chips are suitable for areas that will not be closely mowed, and around ornamental plantings. Chips do not require tacking. Because they decompose slowly they must be treated with 12 pounds of nitrogen per ton to prevent nutrient deficiency in plants. They can be an inexpensive mulch if the chips are obtained from trees cleared on the site.

Compost, peanut hulls, and pine straw are organic materials that potentially make excellent mulches but may only be available locally or seasonally. Creative use of these materials may reduce costs.

Jute mesh or the various types of netting is very effective in holding mulch in place on waterways and slopes before grasses become established.

Erosion control blankets promote seedling growth in the same way as organic mulches and are suited for use in areas with concentrated flows (see Erosion Control Blanket practice).

Table MU-1 Hydraulic Erosion Control Products (HECP) Specification Chart [1]

| Hydraulic Erosion Control | | | | | | | |
|---|---|---|---|---|---|---|---|
| Type HECP[2] | Term | Functional Longevity[3] | Typical Application Rates Lbs/acre (kg/ha) | Typical Maximum Slope Gradient (H:V) | Maximum Uninterrupted Slope Length (ft) | Maximum C Factor[4, 5] (3:1 test) | Minimum Vegetation Establishment[6] |
| **1** | Ultra Short Term | 1 month | 1500—2500 (1700—2800) | ≤ 5:1 | 20 | 0.3 | 150 % |
| **2** | Short Term | 2 month | 2000—3000 (2250—3400) | ≤ 4:1 | 25 | 0.2 | 150 % |
| **3** | Moderate Term | 3 month | 2000—3500 (2250—3900) | ≤ 3:1 | 50 | 0.1 | 200 % |
| **4** | Extended Term | 6 month | 2500—4000 (2800—4500) | ≤ 2:1 | 75 | 0.05 | 300 % |
| **5** | Long Term | 12 month | 3000—4500 (3400—5100) | ≤ 2:1 | 100 | 0.02 | 300 % |

[1] This table is for general guidelines only. Refer to manufacturer for application rates, instructions, gradients, maximum continuous slope lengths and other site-specific recommendations.

[2] These categories are independent of rolled erosion control products (RECPs) categories, despite the identical names.

[3] A manufacturer's estimated time period, based upon field observations, that a material can be anticipated to provide erosion control as influenced by it composition and site-specific conditions.

[4] "C" Factor calculated as ratio of soil loss from HECP protected slope (tested at specified or greater gradient, h:v) to ratio of soil loss from unprotected (control) plot based on large-scale testing.

[5] Acceptable large-scale test methods may include ASTM D 6459, or other independent testing deemed acceptable by the engineer.

[6] Minimum vegetation establishment is calculated as outlined in ASTM D 7322 being a percentage by dividing the plant mass per area of the protected plot by the plant mass per area of the control plot.

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(Source: Erosion Control Technology Council, April 2014)

## Design Criteria

*Site Preparation*

Before mulching, complete the required site preparation. Site preparation includes grading, if needed, and seedbed preparation and fertilizing, liming and seeding if a planting is being made by means other than hydroseeding.

*Spreading the Mulch*

Select a mulch material based on the site and practice requirements, availability of material, and availability of labor and equipment. Table MU-2 lists commonly used mulches.

Table MU-2 Mulching Materials and Application Rates

| Material | Rate Per Acre and (Per 1000 ft.$^2$) | Notes |
|---|---|---|
| **Straw with Seed** | 1 ½-2 tons (70 lbs-90 lbs) | Spread by hand or machine to attain 75% groundcover; anchor when subject to blowing. |
| **Straw Alone (no seed)** | 2 ½-3 tons (115 lbs-160 lbs) | Spread by hand or machine; anchor when subject to blowing. |
| **Wood Chips** | 5-6 tons (225 lbs-270 lbs) | Treat with 12 lbs. nitrogen/ton. |
| **Bark** | 35 cubic yards (0.8 cubic yard) | Can apply with mulch blower. |
| **Pine Straw** | 1-2 tons (45 lbs-90 lbs) | Spread by hand or machine; will not blow like straw. |
| **Peanut Hulls** | 10-20 tons (450 lbs-900 lbs) | Will wash off slopes. Treat with 12 lbs. nitrogen/ton. |
| **HECPs** | 0.75 – 2.25 tons (35 lbs – 103 lbs) | Refer to ECTC or Manufacturer's Specifications. |

Uniformly spread organic mulches by hand or with a mulch blower at a rate which provides about 75% ground cover. Spread HECPs utilizing appropriate equipment and at rates as specified When spreading straw mulch by hand, divide the area to be mulched into sections of approximately 1000 sq. ft. and place 70-90 pounds of straw (1 ½ to 2 bales) in each section to facilitate uniform distribution. Caution, an over-application of wheat straw will reduce stand success – do not over-apply wheat straw when mulching a seeding!

When straw mulch is subject to be blown away by wind, it must be anchored immediately after spreading. It is best anchored with a mulch anchoring tool.

Application of a commercial tackifier through a hydroseeder is often practical for steep slopes and can be effective on most sites. Binders (tackifiers) may be applied after mulch is spread or may be sprayed into the mulch as it is being blown onto the soil. Applying straw and binder together is the most effective

method. Liquid binders include an array of commercially available synthetic binders and organic tackifiers.

In high wind situations like roadways, crimping the mulch is the best alternative as the use of mulch binders may still result in the mulch being rolled up on the edge.

Straw mulch may also be anchored with lightweight plastic, cotton, jute, wire or paper netting which is stapled over the mulch. The manufacturer's recommendations on stapling netting should be followed.

### *Maintenance*

Inspect all mulches periodically, and after rainstorms to check for rill erosion, dislocation, or failure. Where erosion is observed, apply additional mulch or if washout has occurred, repair the slope grade, reseed, and reinstall mulch. Continue inspections until vegetation is firmly established.

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# Permanent Seeding (PS)

## Practice Description

Permanent seeding is the establishment of perennial vegetation on disturbed areas from seed. Permanent vegetation provides economical long-term erosion control and helps prevent sediment from leaving the site. This practice is used when vegetation is desired and appropriate to permanently stabilize the soil.

## Planning Considerations

The advantages of seeding over other means of establishing plants include the smaller initial cost, lower labor input, and greater flexibility of method.

Disadvantages of seeding include potential for erosion during the establishment stage, seasonal limitations on suitable seeding dates, and weather-related problems such as droughts.

The probability of successful plant establishment can be maximized through good planning. The selection of plants for permanent vegetation must be site specific. Factors that should be considered are type of soils, climate, establishment rate, and management requirements of the vegetation. Other factors that may be important are wear, mowing tolerance, and salt tolerance of vegetation.

Plant selection for permanent vegetation should be based on plant characteristics, site and soil conditions, time of year of planting, method of planting, and the intended use of the vegetated area. Climate factors can vary widely in Alabama. Important plant attributes are discussed in Vegetation Establishment for Erosion and Sediment Control in Chapter 2.

Plant selection may include companion plants to provide quick cover on difficult sites, late seedings, or where the desired permanent cover may be slow to establish. Annuals are usually used for companion plants and should be selected carefully to prevent using a species that provide so much competition that it prevents the establishment of the desired species.

Seeding properly carried out within the optimum dates has a higher probability of success. It is also possible to have satisfactory establishment when seeding outside these dates. However, as plantings are deviated from the optimum dates, the probability of failure increases rapidly. Seeding dates should be taken into account in scheduling land-disturbing activities.

Site quality impacts both short-term and long-term plant success. Sites that have compacted soils, soils that are shallow to rock or have textures that are too clayey or too sandy should be modified whenever practical to improve the potential for plant growth and long-term cover success.

The operation of equipment is restricted on slopes steeper than 3:1, severely limiting the quality of the seedbed that can be prepared. Provisions for establishment of vegetation on steep slopes can be made during final grading. In construction of fill slopes, for example, the last 4-6” might not be compacted. A loose, rough seedbed with irregularities that hold seeds and lime and fertilizer is essential for hydroseeding. Cut slopes should be roughened (see Land Grading practice).

Proper mulching is critical to protect against erosion on steep slopes. When using straw, anchor with netting or asphalt. On slopes steeper than 2:1, jute, excelsior, or synthetic matting may be required.

The use of irrigation (temporary or permanent) will greatly improve the success of vegetation establishment.

## Design Criteria

### *Plant Selection*

Select plants that can be expected to meet planting objectives. To simplify plant selection, use Figure PS-1 Geographical Areas for Species Adaptation and Seeding Dates and Table PS-1, Commonly Used Plants for Permanent Cover. Mixtures commonly specified by the Alabama Department of Transportation are an appropriate alternative for plantings on rights-of-ways. Additional information related to plants commonly used in Alabama is found in Chapter 2 under the section Vegetation for Erosion and Sediment Control.

The plants used for temporary vegetation may be used for companion plants provided the seeding rate of the annual species is reduced by one half. See the Temporary Seeding practice for additional information on establishing temporary vegetation. **Ryegrass or other highly competitive plants should not be used as a companion plant with a permanent seeding**.


Figure PS-1 Geographical Areas for Species Adaptation and Seeding Dates

*Note: Site conditions related to soils and aspect in counties adjacent to or close to county boundaries may justify adjustments in planting dates by qualified design professionals.*

Table PS-1 Commonly Used Plants for Permanent Cover with Seeding Rates and Dates

| Species | Seeding Rates/Ac PLS | North | Central | South |
|---|---|---|---|---|
| | | Seeding Dates | | |
| **Bahiagrass, Pensacola** | 40 lbs | -- | Mar 1-July 1 | Feb 1-Nov 1 |
| **Bermudagrass, Common** | 10 lbs | Apr 1-July 1 | Mar 15-July 15 | Mar 1-July 15 |
| **Bahiagrass, Pensacola Bermudagrass, Common** | 30 lbs 5 lbs | -- | Mar 1-July 1 | Mar 1-July 15 |
| **Bermudagrass, Hybrid (Lawn Types)** | Solid Sod | Anytime | Anytime | Anytime |
| **Bermudagrass, Hybrid (Lawn Types)** | Sprigs 1/sq ft | Mar 1-Aug 1 | Mar 1-Aug 1 | Feb 15-Sep 1 |
| **Fescue, Tall** | 40-50 lbs | Sep 1-Nov 1 | Sep 1-Nov 1 | -- |
| **Sericea** | 40-60 lbs | Mar 15-July 15 | Mar 1-July 15 | Feb 15-July 15 |
| **Sericea & Common Bermudagrass** | 40lbs 10 lbs | Mar 15-July 15 | Mar 1-July 15 | Feb 15-July 15 |
| **Switchgrass, Alamo** | 4 Lbs | Apr 1-Jun 15 | Mar 15-Jun 15 | Mar 15-Jun15 |

PLS means pure live seed and is used to adjust seeding rates. For example, to plant 10 lbs PLS of a species with germination of 80% and purity of 90%, PLS= 0.8X 0.9 = 72%. 10 lbs PLS = 10/0.72 = 13.9 lbs of the species to be planted.

### *Seedbed Requirements*

Establishment of vegetation should not be attempted on sites that are unsuitable due to compaction or inappropriate soil texture, poor drainage, concentrated overland flow, or steepness of slope until measures have been completed to correct these problems. To maintain a good stand of vegetation, the soil must meet certain minimum requirements as a growth medium. A good growth medium should have these attributes:

- Sufficient pore space to permit root penetration.
- Enough fine-grained soil material (silt and clay) to maintain adequate moisture and nutrient supply.
- Sufficient depth of soil to provide an adequate root zone. The depth to rock or impermeable layers such as hardpans should be 12” or more, except on slopes steeper than 2:1 where topsoiling is not feasible.
- A favorable pH range for plant growth, usually 6.0-6.5.

- Sufficient nutrients (nitrogen, phosphorus and potassium) for initial plant establishment.

- Freedom from large roots, branches, stones, or large clods. Clods and stones may be left on slopes steeper than 3:1 if they are to be hydroseeded.

If any of the above attributes are not met: i.e., if the existing soil is too dense, coarse, shallow or acidic to foster vegetation – chiseling, topsoil, or special amendments should be used to improve soil conditions. The soil conditioners described below may be beneficial or topsoil may be applied (for guidance on topsoiling see Topsoiling practice). These amendments should only be necessary where soils have limitations that make them poor for plant growth or for turf establishment.

- Peat-appropriate types are sphagnum moss peat, reed-sedge peat, or peat humus, all from fresh-water sources. Peat should be shredded and conditioned in storage piles for at least 6 months after excavation.

- Sand-should be clean and free of toxic materials.

- Vermiculite-use horticultural grade.

- Rotted manure-use stable or cattle manure not containing undue amounts of straw or other bedding materials.

- Thoroughly rotted sawdust-should be free of stones and debris. Add 6 lbs of nitrogen to each cubic yard.

### *Soil Amendments*

*Liming Materials*

Lime (Agricultural limestone) should have a neutralizing value of not less than 90 percent calcium carbonate equivalent and 90 percent will pass through a 10-mesh sieve and 50 percent will pass through a 60-mesh sieve.

Selma chalk should have a neutralizing value of not less than 80 percent calcium carbonate equivalent and 90 percent will pass through a 10-mesh sieve.

Other liming materials that may be selected should be provided in amounts that provide equal value to the criteria listed for agricultural lime or be used in combination with agricultural limestone or Selma chalk to provide equivalent values to agricultural limestone.

*Plant Nutrients*

Commercial grade fertilizers that comply with current Alabama Fertilizer Laws should be used to supply nutrients required to establish vegetation.

Lime and fertilizer needs should be determined by soil tests. Soil testing is performed by the Auburn University Soil Testing Laboratory and provides recommendations based on field tests on Alabama soils. The local county Cooperative Extension Service can provide information on obtaining soil tests. Commercial laboratories that make recommendations based on soil analysis may be used.

When soil tests are not available, use the following rates for application of soil amendments.

Sandy soils: Use 1 ton/acre (exception on sandy soils – if the cover will be tall fescue and clover) use 2 tons/acre.
Clayey soils: 2 tons/acre.
(Do not apply lime to alkaline soils).

Grasses alone: Use 400 lbs/acre of 8-24-24 or the equivalent. Apply 30 lbs of additional nitrogen when grass has emerged and begun growth (approximately 0.8lbs/1000 $ft^2$).
Grass-legume mixtures: Use 800 to 1200 lbs/acre of 5-10-10 or the equivalent.
Legumes Alone: Use 400 to 600 lbs/acre of 0-20-20 or the equivalent.

*Note: Fertilizer can be blended to meet exact fertilizer recommendations. Take soil test recommendations to local fertilizer dealer for bulk fertilizer blends. This may be more economical than bagged fertilizer.*

### *Application of Soil Amendments*

Apply lime and fertilizer evenly and incorporate into the top 6” of soil by disking, chiseling or other suitable means during seedbed preparation. Operate machinery on the contour. On sites too steep for seedbed preparation, fertilizer and lime can be applied with a hydroseeder.

### *Seedbed Preparation*

If needed, grade and shape to provide a surface on which equipment can safely and efficiently be used for seedbed preparation and seeding.

Install necessary sediment control practices before seedbed preparation and complete grading according to the approved plan.

Prepare a friable seedbed with tillage to a depth of at least 6”. Break up large clods, alleviate compaction, and smooth and firm the soil into a uniform surface. Fill in or level depressions that can collect water.

### *Planting Methods*

#### *Seeding*

Use certified seed for permanent seeding whenever possible. Certified seed is inspected by the Alabama Crop Improvement Association to meet high quality standards and will be tagged with a “Certified Seed” tag. (Note: all seed sold in

Alabama is required by law to be tagged to identify seed purity, germination, and presence of weed seeds. Seed must meet state standards for content of noxious weeds.)

Seeding dates are determined using Figure PS-1 and Table PS-1.

Inoculate legume seed with the Rhizobium bacteria appropriate to the species of legume. Details of legume inoculation are located in Chapter 2 in the part on Vegetation for Erosion and Sediment Control under Inoculation of Legumes.

Plant seed uniformly with a cyclone seeder, a drill seeder, a cultipacker seeder, or by hand on a fresh, firm, friable seedbed. If the seedbed has been sealed by rainfall, it should be disked so the seed will be sown into a freshly prepared seedbed.

When using broadcast-seeding methods, subdivide the area into workable sections and determine the amount of seed needed for each section. Apply one-half the seed while moving back and forth across the area, making a uniform pattern; then apply the second half in the same way, but moving at right angles to the first pass.

Cover broadcast seed by raking or chain dragging; then firm the surface with a roller or cultipacker to provide good seed contact. Small grains should be planted no more than 1" deep and grasses and legume seed no more than ½" deep.

*Hydroseeding*

Surface roughening is particularly important when hydroseeding, as a roughened slope will provide some natural coverage for lime, fertilizer, and seed. The surface should not be compacted or smooth. Fine seedbed preparation is not necessary for hydroseeding operations; large clods, stones, and irregularities provide cavities in which seeds can lodge.

Mix seed, inoculant if required, and a seed carrier with water and apply as a slurry uniformly over the area to be treated. The seed carrier should be a cellulose fiber, natural wood fiber or other approved fiber mulch material which is dyed an appropriate color to facilitate uniform application of seed. Use the correct legume inoculant at 4 times the recommended rate when adding inoculant to a hydroseeder slurry. The mixture should be applied within one hour after mixing to reduce damage to seed.

Fertilizer should not be mixed with the seed-inoculant mixture because fertilizer salts may damage seed and reduce germination and seedling vigor.

Fertilizer may be applied with a hydroseeder as a separate operation after seedlings are established.

Lime is not normally applied with a hydraulic seeder because it is abrasive but if necessary it can be added to the seed slurry and applied at seeding or it may be applied with the fertilizer mixture. Also, lime can be blown onto steeper slopes in dry form.

*Sprigging*

Hybrid bermudagrass cannot be grown from seed and must be planted vegetatively. Vegetative methods of establishing common and hybrid bermudagrass, centipedegrass and zoysia include sodding, plugging and sprigging (see Sodding practice).

When sprigs are planted with a sprigging machine, furrows should be 4-6" deep and 2 feet apart. Place sprigs no farther than 2 feet apart in the row and so that at least one rooting node is in the furrow.

When broadcasting is used for sprig planting, broadcast sprigs at the specified rate (Table PS-1). Press into the top ½" to 2" of soil with a cultipacker or with a disk set nearly straight so that the sprigs are not brought back to the surface. A mulch tacking machine may be used to press sprigs into the soil.

### *Mulching*

The use of mulch provides instant cover and helps ensure establishment of vegetation under normal conditions and is essential to seeding success under harsh site conditions (see Mulching practice). Harsh site conditions include: slopes steeper than 3:1 and adverse soils (shallow, rocky, or high in clay or sand). Areas with concentrated flow should be treated differently and require sod, a hydromulch formulated for channels or an appropriate erosion control blanket.

### *Irrigation*

Moisture is essential for seed germination and vegetation establishment. Supplemental irrigation can be very helpful in assuring adequate stands in dry seasons or to speed development of full cover. It is a requirement for establishment of vegetation from sod and sprigs and should be used elsewhere when feasible. However, irrigation is rarely critical for low-maintenance vegetation planted at the appropriate time of the year.

Water application rates must be carefully controlled to prevent runoff. Inadequate or excessive amounts of water can be more harmful than no supplemental water.

### *Maintenance*

Generally, a stand of vegetation cannot be determined to be fully established until soil cover has been maintained for 1 full year from planting. Inspect vegetated areas for failure and make necessary repairs and vegetate as soon as possible.

If a stand has inadequate cover, reevaluate choice of plant materials and quantities of lime and fertilizer. Re-establish the stand after seedbed preparation or over-seed the stand. Consider a temporary seeding if the time of year is not appropriate for establishment of permanent vegetation (see Temporary Seeding practice).

If vegetation fails to grow, a soil test should be made to determine if soil acidity or nutrient imbalance is responsible.

To attain complete establishment, fertilization is usually required in the second growing season. Turf grasses require annual maintenance fertilization. Use soil tests if possible or follow the guidelines given for the specific seeding mixtures.

Protect vegetation during its establishing period from traffic that will be harmful. If appropriate, use either temporary fences or barriers to protect areas that may be damaged by excessive traffic.

# Preservation of Vegetation (PV)

## Practice Description

Preservation of vegetation is the avoidance of an area during land disturbing and construction activity to prevent mechanical and other injury to desirable plants in the planned landscape. The practice provides erosion and sediment control and is applicable where vegetative cover is desired and the existing plant community is compatible with the planned landscape.

## Planning Considerations

Preservation of vegetation requires good site management to minimize the impact of construction activities on existing vegetation.

Plants to save should be identified prior to any construction activity.

Proper maintenance, especially during construction, is important to ensure healthy vegetation that can control erosion.

Different species, soil types, and climatic conditions will require different maintenance activities.

## Design Criteria

*Mark Plant Area for Retention*

Groups of plants and individual trees to be retained should be located on a plan map. Limits of clearing should be planned outside the drip line of groups or individual trees to be saved. The clearing should never be closer than 5 feet to the trunk of a tree.

Flagging or other appropriate means of marking the site of the groups of plants and individual trees to be retained should be required before construction begins Individual trees to be retained should be marked with a highly visible paint or surveyor's ribbon in a band circling the tree at a height visible to equipment operators.

### *Plant Protection*

Restrict construction equipment, vehicular traffic, stockpiles of construction materials, topsoil etc., from the areas where plants are retained and restrict these activities from occurring within the drip line of any tree to be retained. Trees being removed shall not be pushed into trees to be retained. Equipment operators shall not clean any of their equipment by slamming it against trees to be retained.

Restrict burning of debris within 100 feet of the plants being preserved. Fires shall be limited in size to prevent damage to any nearby trees.

Toxic material shall not be stored any closer than 100 feet to the drip line of any trees to be retained. Toxic materials shall be managed and disposed of according to state laws.

### *Fencing and Armoring*

Groups of plants and trees should be protected by fencing or armoring where necessary (See Figure PV-l). The following types of fencing or armoring may be used:

- Board Fence-Board fence may be constructed with 4" square posts set securely in the ground and protruding at least 4 feet above the ground. A minimum of 2 horizontal boards should be placed between the posts. The fence should be placed at the limits of the clearing around the drip line of the tree. If it is not practical to erect a fence at the drip line, construct a triangular fence near the trunk. The limits of clearing will still be the drip line as the root zone within the drip line will still require protection.

- Cord Fence-Posts at least 2" square or 2" in diameter set securely in the ground and protruding at least 4 feet above the ground shall be placed at the limits of clearing with 2 rows of cord ¼" or thicker at least 2 feet apart running between posts with strips of surveyor's tape tied securely to the string at intervals of 3 feet or less.

- Earth Berms-Temporary earth berms may be constructed. The base of the berm on the tree side should be located along the limits of clearing. Earth berms may not be used for this purpose if their presence will create drainage patterns that cause erosion.

- Additional Trees-Additional trees may be left standing as protection between the trees to be retained and the limits of clearing. However, for this alternative to be used, trees in the buffer must be no more than 6 feet apart to prevent passage of equipment and material through the buffer.

- Plan for these additional trees to be evaluated prior to the completion of construction and either given sufficient treatment to ensure survival or be removed.

- Trunk Armoring-As a last resort, a tree may be armored with burlap wrapping and 2” studs wired vertically no more than 2” apart to a height of 5 feet. The armoring should encircle the tree trunk. Nothing should ever be nailed to a tree. The root zone within the drip line will still require protection.

- Fencing and armoring devices should be in place before any construction work is done and should be kept in good condition for the duration of construction activities. Fencing and armoring should not be removed until the completion of the construction project.

*Raising the Grade*

When the ground level must be raised around an existing tree or group of trees several methods may be used to insure survival.

A well may be created around a group of trees or an individual tree slightly beyond the drip line to retain the natural soil around the feeder roots (see Figure PV-2). When the well alternative is not practical or desirable, remove vegetation and organic matter from beneath the tree or trees for 3 feet beyond the drip line and loosen the surface soil to a depth of approximately 3” without damaging the roots.

Apply fertilizer in the root area of the tree to be retained. A soil test is the best way to determine what type of fertilizer to use. In the absence of a soil test, fertilizer should be applied at the rate of 1 to 2 pounds of 10-8-6 or 10-6-4 per inch of diameter at breast height (dbh) for trees under 6” dbh and at the rate of 2 to 4 pounds of 10-8-6 or 10-6-4 per inch of dbh for trees over 6” dbh.

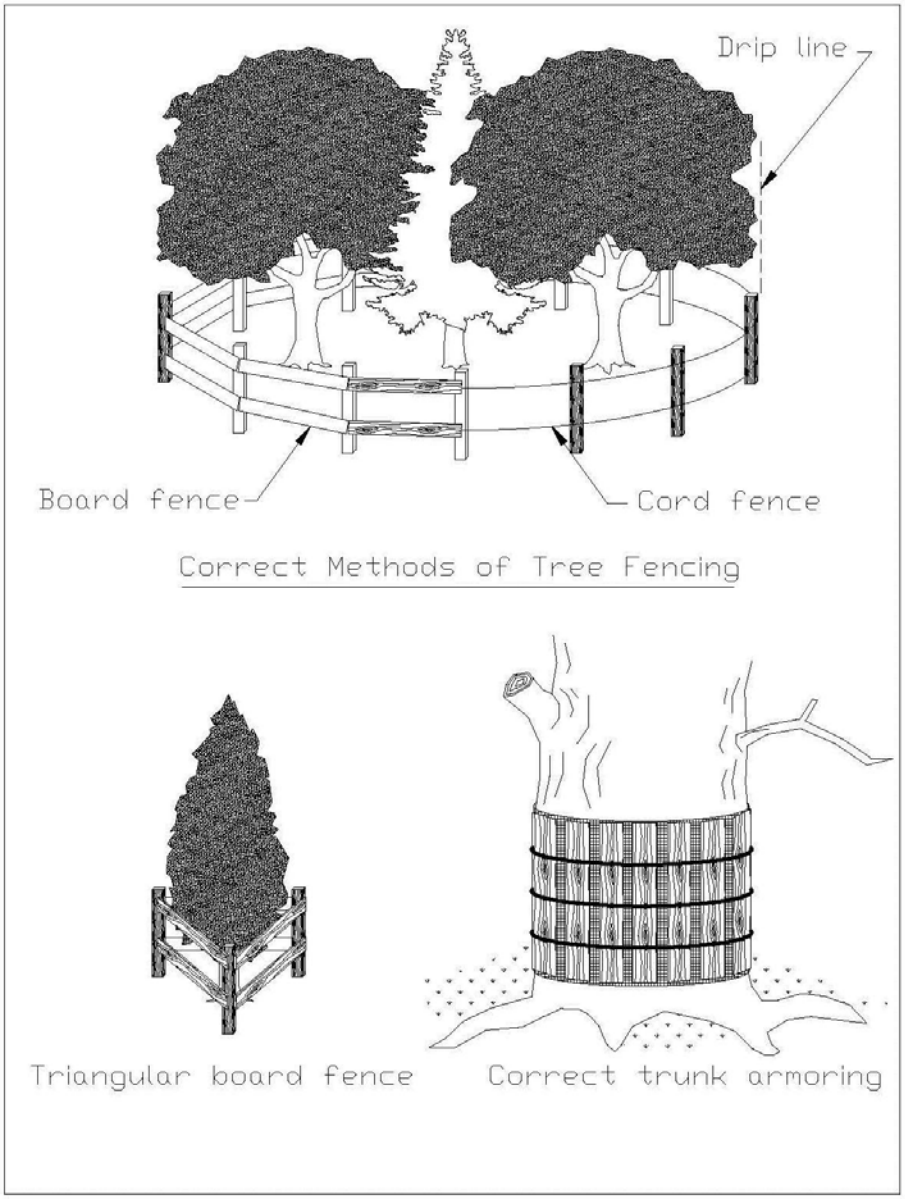



Figure PV-1 Fencing and Armoring

A dry well shall be constructed to allow for tree trunk diameter growth (see Figure PV-3). A space of at least 1 foot between the tree trunk and the well wall is adequate for old, slow growing trees. Clearance for younger trees shall be at least 2 feet. The well shall be high enough to bring the top just above the level of the proposed fill. The well wall shall taper slightly away from the tree trunk at a rate of 1” per foot of wall height.

The well wall shall be constructed of large stones, brick, building tile, concrete blocks, or cinder blocks. Openings should be left through the wall of the well to allow for free movement of air and water. Mortar shall only be used near the top of the well and only above the porous fill.

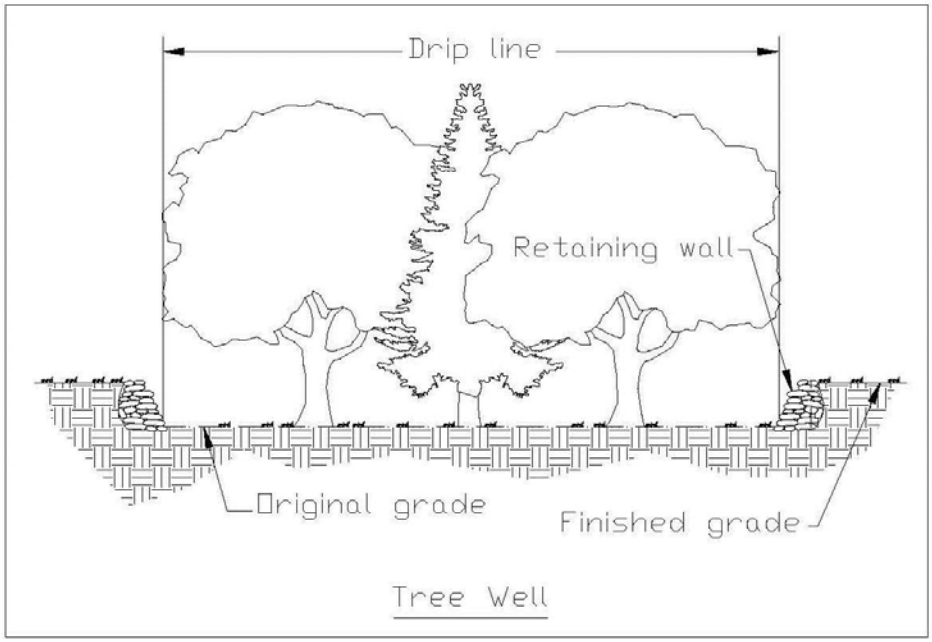



Figure PV-2 Tree Well

Drain lines composed of 4" high quality drain tiles shall begin at the lowest point inside the well and extend outward from the tree trunk in a wheel and spoke pattern with the trunk as the hub. Radial drain lines shall slope away from the well at a rate of ⅛" per foot. The circumference line of tiles should be located beneath the drip line of the trees. Vertical tiles or pipes shall be placed over the intersections of the two tile systems if a fill of more than 2 feet is contemplated. Vertical tiles shall be held in place with stone fill. Tile joints shall be tight. A few radial tiles shall extend beyond each intersection and shall slope sharply downward to insure good drainage. Tar paper or its approved equivalent shall be placed over the tile and/or pipe joints to prevent clogging and large stone shall be placed around and over drain tiles and/or pipes for protection.

A layer of 2" to 6" of stone shall be placed over the entire area under the tree from the well outward at least as far as the drip line. For fills up to 2 feet deep, a layer of stone 8" to 12" thick should be adequate.

A thick layer of this stone not to exceed 30" will be needed for deeper fills. A layer of ¾" to 1" stone covered by straw, fiberglass mat or a manufactured filter fabric shall be used to prevent soil from clogging the space between stones. Cinders shall not be used as fill material. Filling shall be completed with porous soil such as topsoil until the desired grade is reached. This soil shall be suitable to sustain specified vegetation.

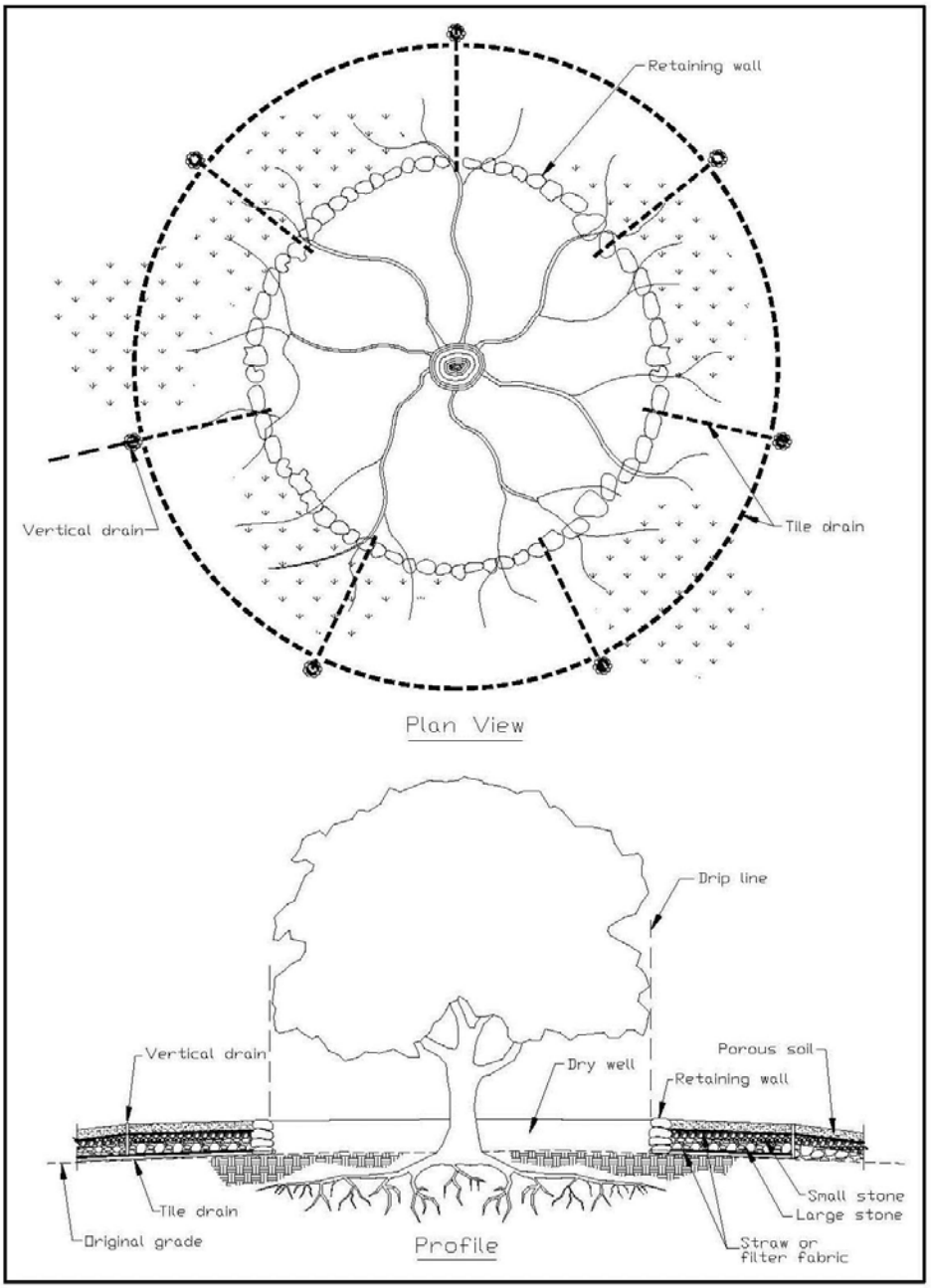



Figure PV-3 Tree Well Detail

Crushed stone shall be placed inside the dry well over the openings of the radial tiles to prevent clogging. The area between the trunk and the well wall shall either be covered by an iron grate or filled with a 50-50 mixture of crushed charcoal and sand to prevent anyone from falling into the dry well.

Where water drainage through the soil is not a problem, coarse gravel in the fill may be substituted for the tile. This material has sufficient porosity to ensure air drainage. Instead of the vertical tiles or pipes in the system, stones, crushed rock and gravel may be added so that the upper level of these porous materials slants toward the surface in the vicinity below the drip line.

Raising the grade on only one side of a tree or group of trees may be accomplished by constructing only half of one of these systems.

### *Lowering the Grade*

Shrubs and trees shall be protected from the harmful grade cuts by the construction of a tree wall (see Figure PV-4). Following excavation, all tree roots that are exposed and/or damaged shall be trimmed cleanly and covered with moist peat moss, burlap or other suitable material to keep them from drying out.

The wall shall be constructed of large stones, brick, building tile, concrete block or cinder block. The wall should be backfilled with topsoil, peat moss, or other organic matter to retain moisture and aid in root development. Apply fertilizer and water thoroughly. The tree plants should be pruned to reduce the leaf surface in proportion to the amount of root loss. Drainage should be provided through the wall so water will not accumulate behind the wall. Lowering the grade on one side of the tree or group of trees can be accomplished by constructing only half of this system.

### *Trenching and Tunneling*

Trenching should be done as far away from the trunks of trees as possible, preferably outside the branches or crown spreads of trees, to reduce the amount of root area damaged or killed by trenching activities. When possible, trenches should avoid large roots or root concentrations. This can be accomplished by curving the trench or by tunneling under large roots and areas of heavy root concentration. Tunneling under a species that does not have a large tap root may be preferable to trenching beside it as it has less impact on root systems (see Figure PV-5).

Roots should not be left exposed to the air but should be covered with soil as soon as possible or protected and kept moist with burlap or peat moss until the trench or tunnel can be filled. The ends of damaged and cut roots shall be cut off smoothly and moist peat moss, burlap or topsoil should be placed over the exposed area.

Trenches and tunnels shall be filled as soon as possible. Care should be taken to ensure that air spaces are not left in the soil. Peat moss or other organic matter shall be added to the fill material as an aid to inducing and developing root growth. The tree should be fertilized and mulched to stimulate new root growth and enhance general tree vigor. If a large part of the root system has been damaged the crown leaf surface area should be reduced in proportion to the root damage. This may be accomplished by pruning 20-30 percent of the crown foliage. If the roots are damaged during the winter the crown should be pruned before the next growing season. If roots are cut during the growing season, pruning should be done immediately.

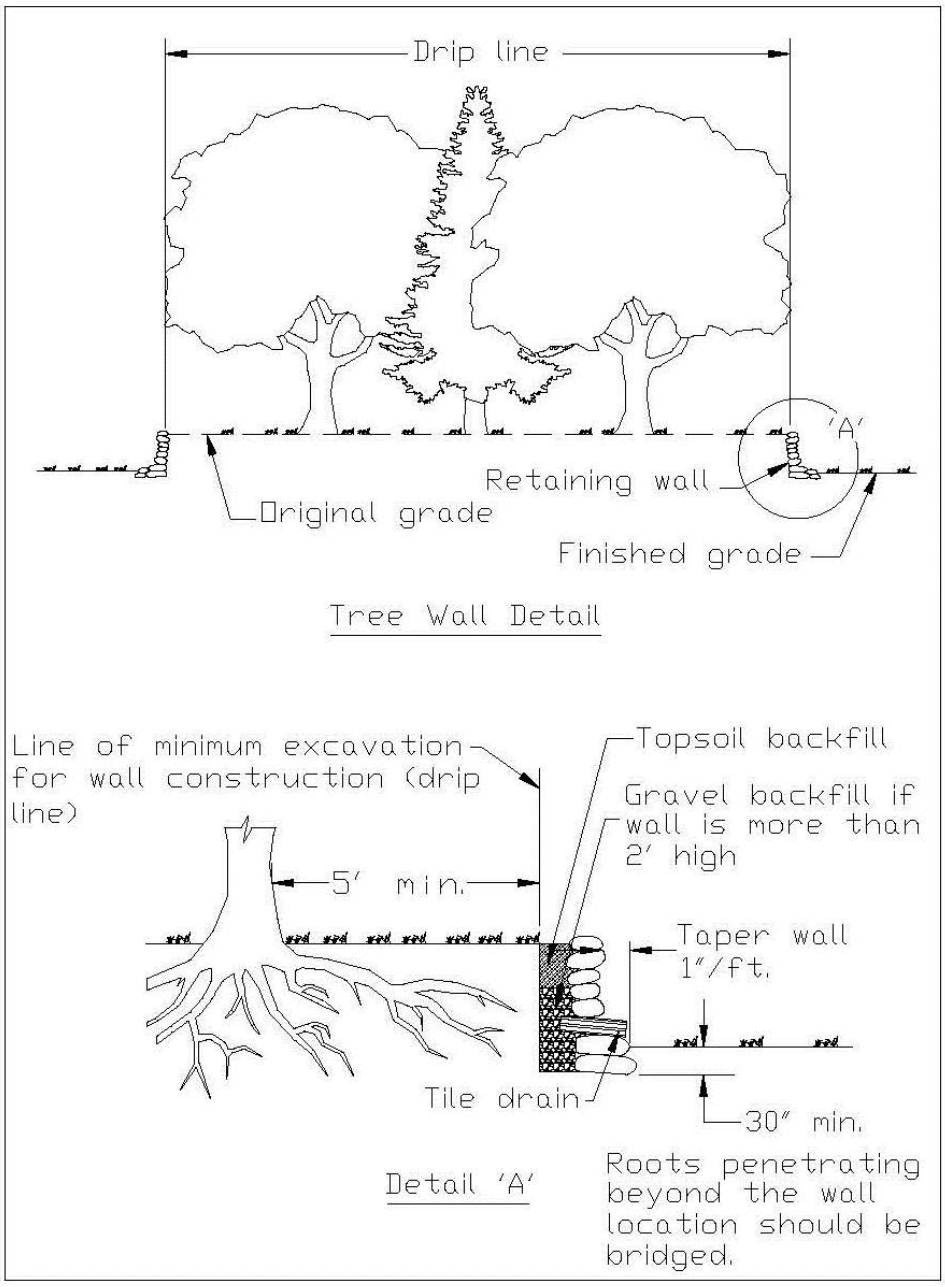



Figure PV-4 Tree Wall Detail

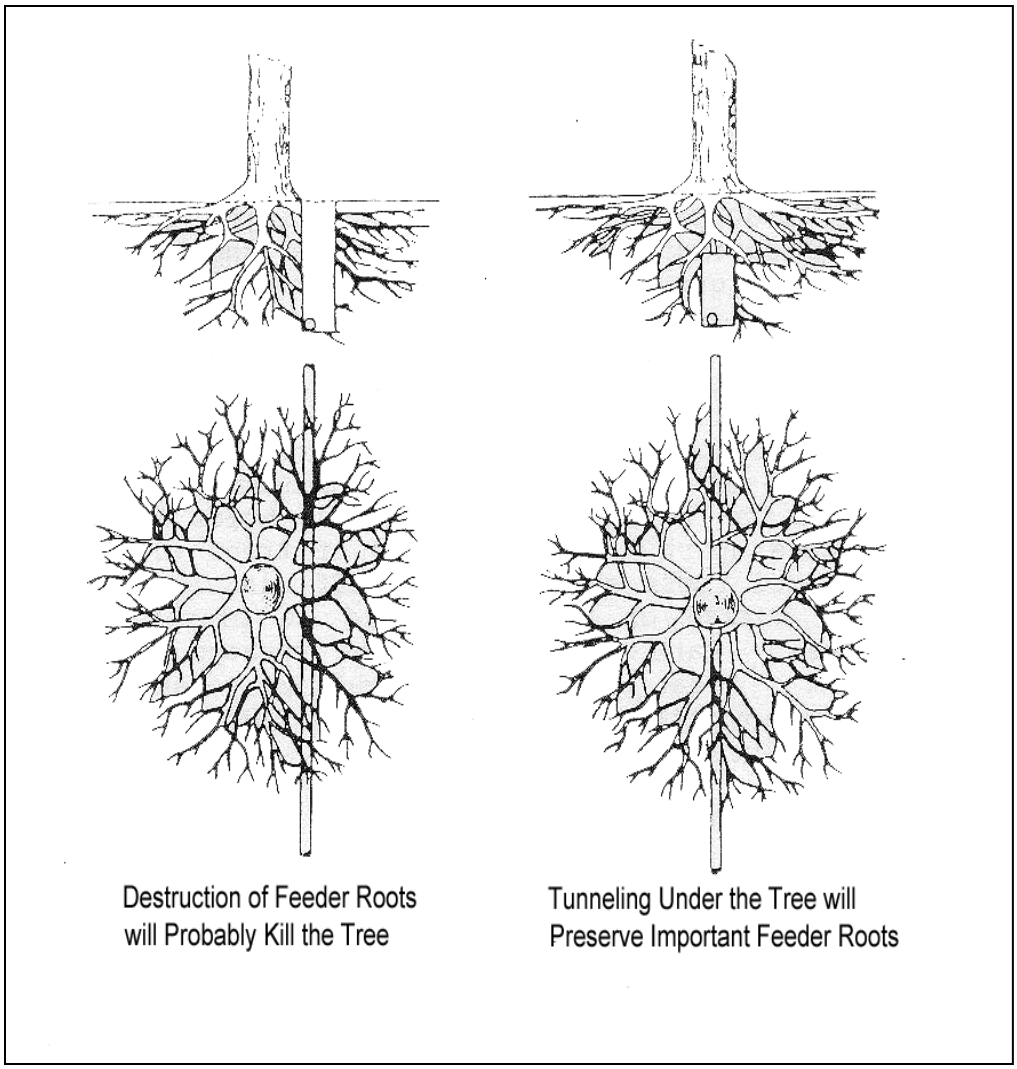



Figure PV-5 Trenching vs Tunneling

*Treating Damaged Trees*

When trees are damaged during construction activities certain maintenance practices can be applied to protect the health of the tree.

Soil aeration may be needed if the soil has been compacted. The soil around trees can be aerated by punching holes 1 foot deep and 18" apart under the crown of trees with an iron pipe.

Damaged roots should be cut off cleanly and moist peat moss, burlap or topsoil should be placed over the exposed area. Bark damage should be treated by removing loose bark.

Tree limbs damaged during construction or removed for any other reason shall be cut off above the collar at the branch junction.

Trees that have been stressed or damaged should be fertilized to aid their recovery.

Trees should be fertilized in the spring or fall. Fall applications are preferred.

Fertilizer should be applied to the soil over the feeder roots. In no case should it be applied closer than 3 feet to the trunk. Root systems of trees extend some distance beyond the drip line. The area to be fertilized should be increased by ¼ the area of the crown. A soil test is the best way to determine what type of fertilizer to use. In the absence of a soil test, fertilizer should be applied at the rate of 1 to 2 pounds of 10-8-6 or 10-6-4 per inch of dbh for trees under 6” dbh and at the rate of 2 to 4 pounds of 10-8-6 or 10-6-4 per inch of dbh for trees over 6” dbh.

A ground cover or organic mulch layer should be maintained around trees to prevent erosion, protect roots and to conserve water.

# Temporary Seeding (TS)

## Practice Description

Temporary seeding is the establishment of fast-growing annual vegetation from seed on disturbed areas. Temporary vegetation provides economical erosion control for up to a year and reduces the amount of sediment moving off the site.

This practice applies where short-lived vegetation can be established before final grading or in a season not suitable for planting the desired permanent species. It helps prevent costly maintenance operations on other practices such as sediment basins and sediment barriers. In addition, it reduces problems of mud and dust production from bare soil surfaces during construction. Temporary or permanent seeding is necessary to protect earthen structures such as dikes, diversions, grass-lined channels and the banks and dams of sediment basins.

## Planning Considerations

Temporary vegetative cover can provide significant short-term erosion and sediment reduction before establishing perennial vegetation.

Temporary vegetation will reduce the amount of maintenance associated with sediment basins.

Temporary vegetation is used to provide cover for no more than 1 year. Permanent vegetation should be established at the proper planting time for permanent vegetative cover.

Certain plants species used for temporary vegetation will produce large quantities of residue which can provide mulch for establishment of the permanent vegetation.

Proper seedbed preparation and selection of appropriate species are important with this practice. Failure to follow establishment guidelines and recommendations carefully may result in an inadequate or short-lived stand of vegetation that will not control erosion.

The selection of plants for temporary vegetation must be site specific. Factors that should be considered are type of soils, climate, establishment rate, and management requirements of the vegetation. Other factors that may be important are wear, mowing tolerance, and salt tolerance of vegetation.

Seeding properly carried out within the optimum dates has a higher probability of success. It is also possible to have satisfactory establishment when seeding outside these dates. However, as plantings are deviated from the optimum dates, the probability of failure increases rapidly. Seeding dates should be taken into account in scheduling land-disturbing activities.

Site quality impacts both short-term and long-term plant success. Sites that have compacted soils should be modified whenever practical to improve the potential for plant growth.

The operation of equipment is restricted on slopes steeper than 3:1, severely limiting the quality of the seedbed that can be prepared. Provisions for establishment of vegetation on steep slopes can be made during final grading. In construction of fill slopes, for example, the last 4-6” might not be compacted. A loose, rough seedbed with irregularities that hold seeds and fertilizer is essential for hydroseeding. Cut slopes should be roughened (see practice Land Grading).

Good mulching practices are critical to protect against erosion on steep slopes. When using straw, anchor with netting or asphalt. On slopes steeper than 2:1, either hydraulic mulch or erosion control blanket is more appropriate than straw to protect the slope.

The use of irrigation (temporary or permanent) will greatly improve the success of vegetation establishment.

## Design Criteria

### *Plant Selection*

Select plants that can be expected to meet planting objectives. To simplify plant selection, use Table TS-1, Commonly Used Plants for Temporary Cover and Figure TS-1, Geographical Areas for Species Adaptation and Seeding Dates. Seeding mixtures commonly specified by the Alabama Department of Transportation are an appropriate alternative for plantings on rights-of-ways. Additional information related to plantings in Alabama is found in Chapter 2 in the section Non-Woody Vegetation for Erosion and Sediment Control.


Figure TS-1 Geographical Areas for Species Adaptation and Seeding Dates

*Note: Site conditions related to soils and aspect in counties adjacent to or close to county boundaries may justify adjustments in planting dates by qualified design professionals.*

Table TS-l Commonly Used Plants for Temporary Cover

| Species | Seeding Rate/AC PLS | North | Central | South |
|---|---|---|---|---|
| | | Seeding Dates | | |
| **Millet, Browntop or German** | 40 lbs | Apr1-Aug 1 | Apr1- Aug 15 | Apr 1-Aug 15 |
| **Rye** | 3 bu | Sep I-Nov 15 | Sep 15-Nov 15 | Sep 15-Nov 15 |
| **Ryegrass** | 30 lbs | Aug l-Sep 15 | Sep l-Oct 15 | Sep 1-Oct 15 |
| **Sorghum-Sudan Hybrids** | 40 lbs | May l-Aug 1 | Apr 15-Aug 1 | Apr l-Aug 15 |
| **Sudangrass** | 40 lbs | May l-Aug I | Apr 15-Aug | Apr l-Aug 15 |
| **Wheat** | 3 bu | Sep I-Nov 1 | Sep 15-Nov 15 | Sep 15-Nov 15 |
| **Common Bermudagrass** | 10 lbs | Apr 1-July 1 | Mar 15-July 15 | Mar 1-July 15 |
| **Crimson Clover** | 10lbs | Sept 1-Nov 1 | Sept 1-Nov 1 | Sept 1-Nov 1 |

PLS means pure live seed and is used to adjust seeding rates. For example, to plant 10 lbs PLS of a species with germination of 80% and purity of 90%, PLS= 0.8X 0.9 = 72%. 10 lbs PLS = 10/0.72 = 13.9 lbs of the species to be planted.

### *Site Preparation and Soil Amendments*

Complete grading and shaping before applying soil amendments if needed to provide a surface on which equipment can safely and efficiently be used to apply soil amendments and accomplish seedbed preparation and seeding.

*Lime*

Apply lime according to soil test recommendations. If a soil test is not available, use 1 ton of agricultural limestone or equivalent per acre on coarse textured soils and 2 tons per acre on fine textured soils. Do not apply lime to alkaline soils or to areas which have been limed during the preceding 2 years. Other liming materials that may be selected should be provided in amounts that provide equal value to the criteria listed for agricultural lime or be used in combination with agricultural limestone or Selma chalk to provide equivalent values to agricultural limestone.

*Fertilizer*

Apply fertilizer according to soil test results. If a soil test is not available, apply 8-24-24 fertilizer.

When vegetation has emerged to a stand and is growing, 30 to 40 lbs/acre (approximately 0.8 lbs/1000 $ft^2$) of additional nitrogen fertilizer should be applied.

*Note: Fertilizer can be blended to meet exact fertilizer recommendations. Take soil test recommendations to local fertilizer dealer for bulk fertilizer blends. This may be more economical than bagged fertilizer.*

### *Application of Soil Amendments*

Incorporate lime and fertilizer into the top 6” of soil during seedbed preparation.

### *Seedbed Preparation*

Good seedbed preparation is essential to successful plant establishment. A good seedbed is well pulverized, loose, and smooth. If soils become compacted during grading, loosen them to a depth of 6” to 8” using a ripper or chisel plow.

If rainfall has caused the surface to become sealed or crusted, loosen it just prior to seeding by disking, raking, harrowing, or other suitable methods. When hydroseeding methods are used, the surface should be left with a more irregular surface of clods.

### *Planting Methods*

#### *Seeding*

Evenly apply seed using a cyclone seeder (broadcast), drill seeder, cultipacker seeder, or hydroseeder. Broadcast seeding and hydroseeding are appropriate for steep slopes where equipment cannot operate safely. Small grains should be planted no more than 1” deep, and grasses and legumes no more than ½” deep. Seed that are broadcast must be covered by raking or chain dragging, and then lightly firmed with a roller or cultipacker.

#### *Hydroseeding*

Surface roughening is particularly important when hydroseeding, as a roughened slope will provide some natural coverage for lime, fertilizer, and seed. The surface should not be compacted or smooth. Fine seedbed preparation is not necessary for hydroseeding operations; large clods, stones, and irregularities provide cavities in which seeds can lodge.

Mix seed, inoculant if required, and a seed carrier with water and apply as slurry uniformly over the area to be treated. The seed carrier should be a cellulose fiber, natural wood fiber or other approved fiber mulch material which is dyed an appropriate color to facilitate uniform application of seed. Use the correct legume inoculant at 4 times the recommended rate when adding inoculant to hydroseeder slurry. The mixture should be applied within one hour after mixing to reduce damage to seed.

Fertilizer should not be mixed with the seed-inoculant mixture because fertilizer salts may damage seed and reduce germination and seedling vigor. Fertilizer may be applied with a hydro seeder as a separate operation after seedlings are established.

### *Mulching*

The use of appropriate mulch provides instant cover and helps ensure establishment of vegetative cover under normal conditions and is essential to seeding success

under harsh site conditions (see the Mulching practice for guidance). Harsh site conditions include the following: slopes steeper than 3:1 and adverse soils (soils that are shallow to rock, rocky, or high in clay or sand). Areas with concentrated flow should be treated differently and require a practice appropriate for channel flow. (refer to Chapter 5 Runoff Conveyance for guidance).

# Check Dam (CD)

## Practice Description

A check dam (also referred to as a “ditch check”) is a small barrier or dam constructed across a swale, drainage ditch or other area of concentrated flow for the purpose of reducing channel erosion. Channel erosion is reduced because check dams flatten the gradient of the flow channel and slow the velocity of channel flow. Check dams do not reduce turbidity of runoff. Check dams can be constructed of rock, wattles (sometimes referred to as tubes or rolls), sand bags, or other materials that may be acceptable to the design professional. Unless installed correctly, check dams will not capture a significant amount of sediment. When installed correctly, most check dams can capture the coarser grained material, which can be significant for sandy soils. Sediment capture increases as velocity in the channel decreases by creating impoundments with the check dams. This impoundment pool creates the flattening of the gradient, greatly reducing channel erosion.

This practice applies in small open channels and drainageways, including temporary and permanent swales. Check dams are not to be used in a live stream. Situations of use include areas in need of protection during establishment of grass and areas that cannot receive a temporary or permanent non-erodible lining for an extended period.

## Planning Considerations

Check dams are used in concentrated flow areas to provide temporary channel stabilization with minimal sediment retention during rainfall runoff periods on construction sites. Check dams may be constructed of rock, wattles, sand bags, or other suitable material, including manufactured products. Water flowing over a check dam creates turbulent erosive forces (super critical flow) that must be addressed to prevent erosion downstream of the check dam. Inevitably water will likely flow under check dams due to limitation with ground contact. Therefore, it is of upmost importance to ensure the performance of the check dam that erosion and scour under the check dam be minimized. This is best achieved using an underlay such as an 8-oz. nonwoven filter fabric. If the underlay is extended downstream, it will also protect the channel from super critical flows from water flowing over and under the dam.

Check dams should be planned to be compatible with the other features such as streets, walkways, trails, sediment basins and rights-of-way or property lines. Check dams are installed with the center overflow area lower in elevation than the ends to ensure flow goes over the check dam and not around. Check dams are normally constructed in series and the dams should be located at a normal interval from other grade controls such as culverts or sediment basins.

Check dams are generally used as a temporary BMP that is removed following construction to allow for final long-term stabilization of the channel. Provisions should be made to establish permanent channel linings as early as possible.

Check dams can also be used for other purposes such as the capture of sediment upstream of other practices or flocculent dosing upstream of a sediment basin.

Extensive research has been conducted by The Auburn University Erosion and Sediment Control Test Facility. The research recommendations are incorporated in the following planning considerations:

Rock Check Dams

Many check dams are constructed of rock. Rock may not be acceptable in some installations and alternative types of check dams need to be considered. Rock check dams (Figures CD-1 and CD-2) are usually installed with mechanical equipment but hand labor is likely needed to complete most installations to the quality needed. The availability and cost of commercially produced rock should be considered. The use of rock should be considered carefully in areas to be mowed. Some rock may be washed downstream and should be removed before each mowing operation. The use of geotextile can be used on the upstream face of the rock check dam to increase the sediment trapping efficiency of the rock check dam. Measures must be taken to prevent undermining of the check dam and erosion below the check dam. A non-woven geotextile underlayment should be used to prevent this from happening. The geotextile meeting AASHTO M 288 requirement for separation Class II (minimum 8-oz. fabric) should extend approximately 3 ft. upstream and downstream, and pinned securely with the upstream edge buried.

Measures to prevent downstream erosion associated with a rock check dam include placing larger rock on the downstream face of a rock dam, and providing erosion protection material just downstream of the dam.

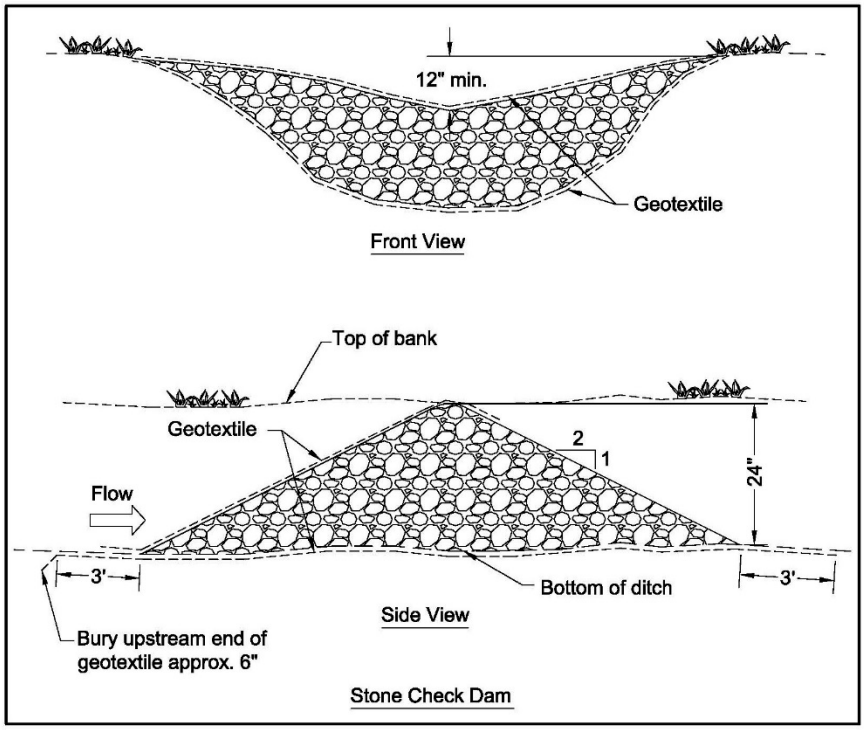



Figure CD-1 Profile and Cross-Section of Typical Rock Check Dams

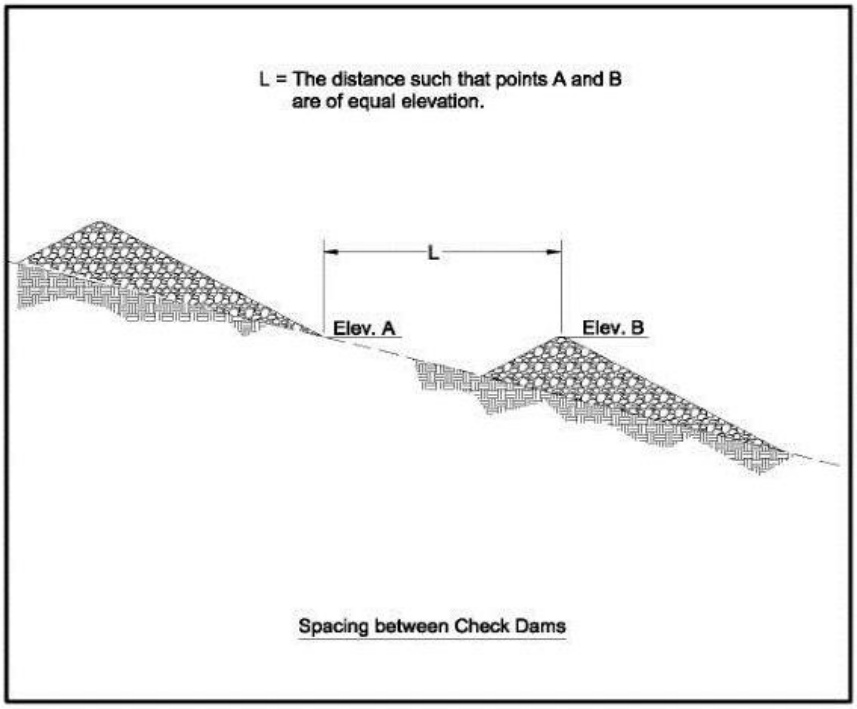



Figure CD-2 Profile of Typical Rock Check Dams

Wattle Check Dams

Wattles have been found to be best installed without trenching and on top of stapled geotextile underlayment that extends a minimum 3 ft. up and downstream from the wattle. Wattles must be properly stapled with sod staples on 10-inch centers on each side of the wattle to prevent flotation, and staked over the top using non-destructive tee-pee type staking. Wattles that provide less “flow through” create more ponding of water that increases the trapping of sediment (see Figures CD-3 and CD-4).

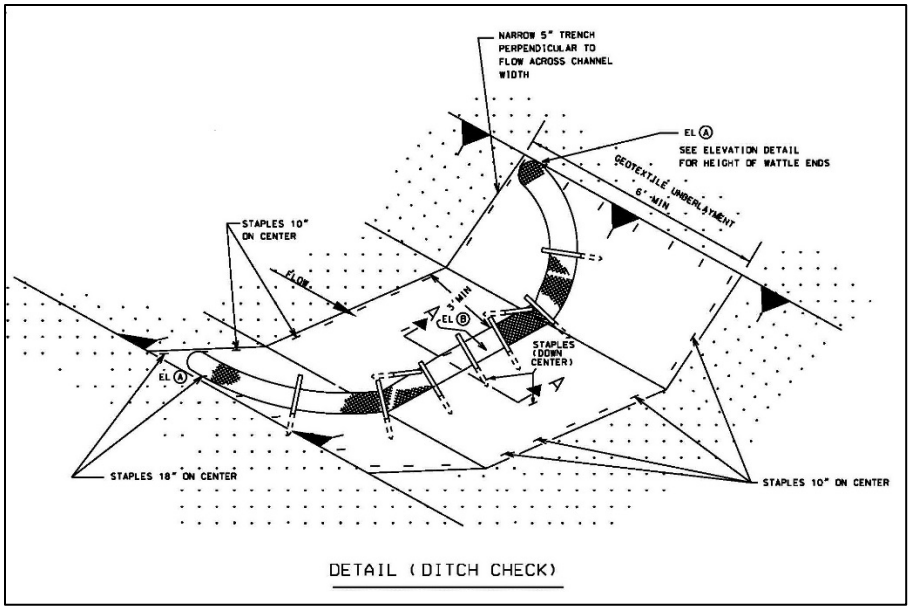



Figure CD-3 Wattle Check Dam (ditch check)

Figure CD-4 Wattle Check Dam (ditch check)
(Photo courtesy of Auburn University Erosion and Sediment Control Test Facility)

Silt Fence Check Dam

When properly designed and installed, typical silt fence materials can be utilized to construct a check dam. Geotextile underlayment should be used and the fence notched as needed to ensure the maximum depth of flow is no greater than the depth of the channel. Figures CD-5 and CD-6 show the recommended details.

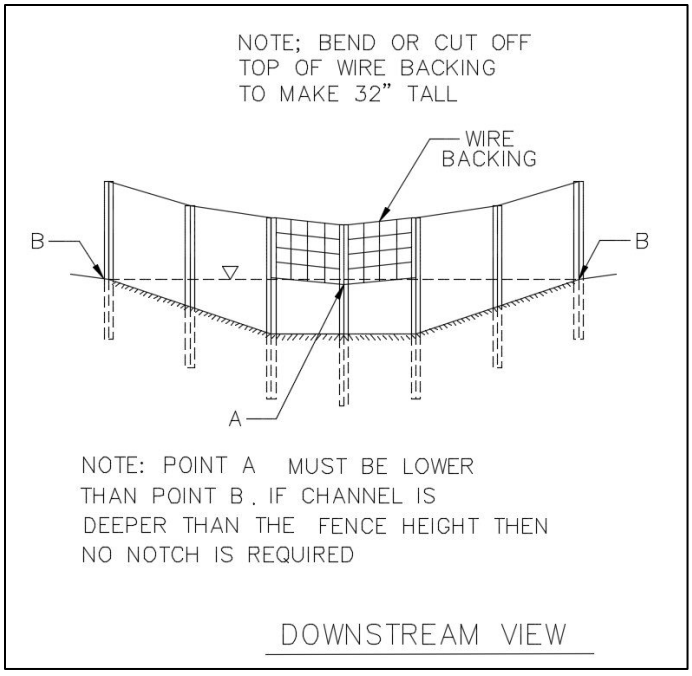



Figure CD-5 Silt Fence Check Dam Cross-Section

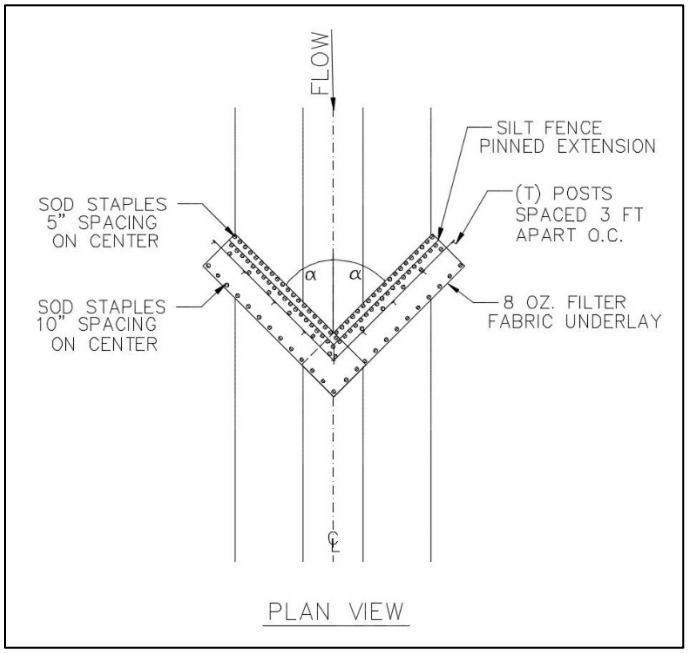



Figure CD-6 Silt Fence Check Dam Plan View

Figure CD-7 Silt Fence Check Dam
(Photo courtesy of Auburn University Erosion and Sediment Control Test Facility)

Sand Bag Check Dam

Sand bags have also been proven to be effective as check dams but only when the bags are properly oriented (See Figures CD-8 and CD-9). A geotextile underlayment that extends approximately 3 ft. upstream and downstream should also be used in earth channel situations to prevent undermining and scour.

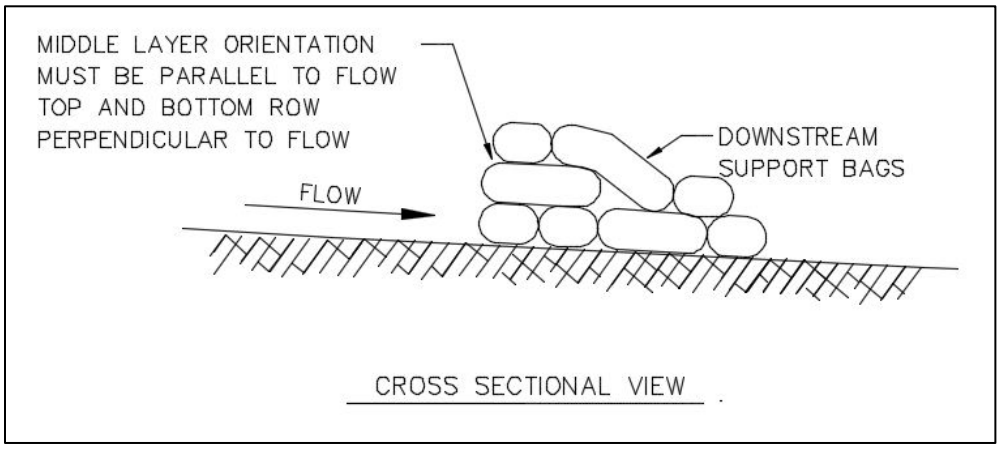



Figure CD-8 Sand Bag Check Dam Cross-Section

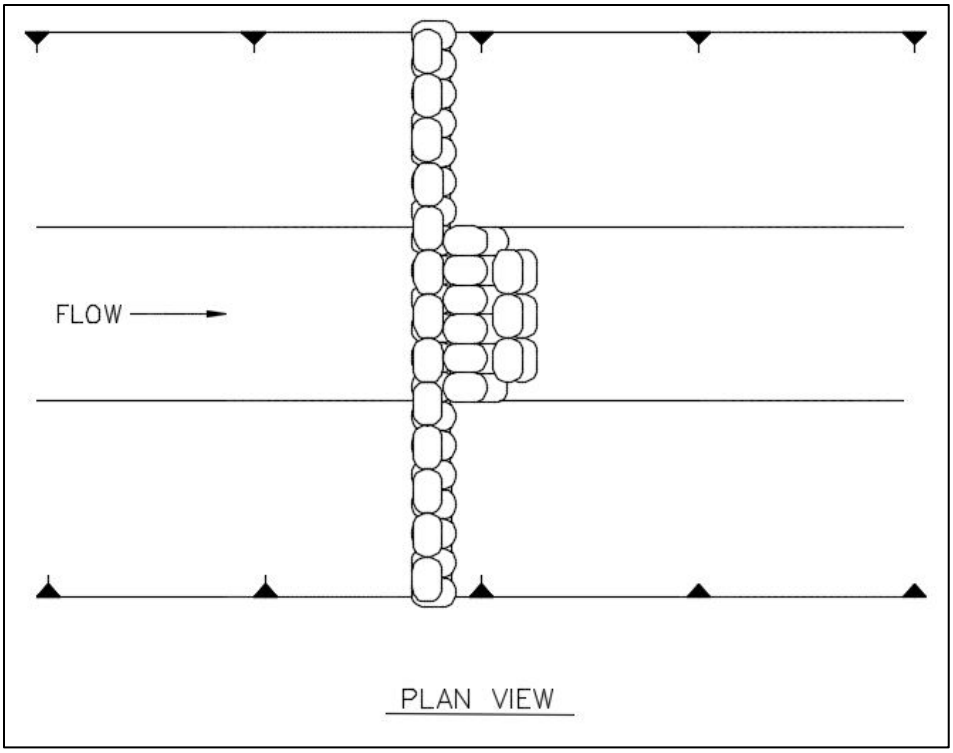



Figure CD-9 Sand Bag Check Dam Plan View

## Design Criteria

Formal design is not required. The following factors should be considered when designing check dams.

### *Drainage Area*

Generally, one acre or less.

### *Maximum Height*

Check dam height is a function of channel geometry. Most check dams are 3 feet or less in height.

### *Depth of Flow*

Depth of flow over a check dam is a function of the cross-section and porosity of the check dam. Generally, flows over a check dam are less than 1 foot.

The center of the dam should be constructed lower than the ends. The elevation of the center of the dam should be lower than the ends by the depth of design flow.

### *Side Slopes*

2:1 or flatter (rock check dam).

### *Spacing*

The elevation of the toe of the upstream dam should be at or below the elevation of crest of the downstream dam (Figure CD-2).

For example, if the channel is 3% grade, and the check dam height is 2 feet, The check dam spacing should be 67 feet:

Spacing (ft) = dam height (ft) / channel grade

Spacing = 2 ft / 0.03 = 67 feet

### *Geotextile*

Generally, the non-woven geotextile should meet the requirements found in AASHTO M 288 Class II used for separation.

# Diversion (DV)

## Practice Description

A diversion is a watercourse constructed across a slope consisting of an excavated channel, a compacted ridge or a combination of both. Most diversions are constructed by excavating a channel and using the excavated material to construct a ridge on the downslope side of the channel. Right-of-way diversions and temporary diversions are sometimes constructed by making a ridge, often called a berm, from fill material.

This practice applies to sites where stormwater runoff can be redirected to permanently protect structures or areas downslope from erosion, sediment, and excessive wetness or localized flooding. Diversions may be used to temporarily divert stormwater runoff to protect disturbed areas and slopes or to retain sediment on-site during construction.

Perimeter protection is sometimes used to describe both permanent and temporary diversions used at either the upslope or downslope side of a construction area.

Right-of-way diversions, sometimes referred to as water bars, are used to shorten the flow length on a sloping right-of-way and reduce the erosion potential of the stormwater runoff.

## Planning Considerations

Diversions are designed to intercept and carry excess water to a stable outlet.

Diversions can be useful tools for managing surface water flows and preventing soil erosion. On moderately sloping areas, they may be placed at intervals to trap and divert sheet flow before it has a chance to concentrate and cause rill and gully erosion.

Diversions may be placed at the top of cut or fill slopes to keep runoff from upgradient drainage areas off the slope. The following picture illustrates the placement of a diversion near the top of the slope. Diversions are sometimes built at the base of steeper slopes to protect flatter developed areas which cannot withstand runoff water from outside areas. Also, they can be used to protect structures, parking lots, adjacent properties, and other special areas from flooding.

Figure DV-1 Diversion near the top of a slope

Diversions are preferable to other types of man-made stormwater conveyance systems because they more closely simulate natural flow patterns and characteristics. Flow velocities are generally kept to a minimum. When properly coordinated into the landscape design of a site, diversions can he visually pleasing as well as functional.

As with any earthen structure, it is very important to establish adequate vegetation as soon as possible after installation. It is usually important to stabilize the drainage area above the diversion so that sediment will not enter and accumulate in the diversion channel.

## Design Criteria

### *Location*

Diversion location should be determined by considering outlet conditions, topography, land use, soil type, length of slope, seepage (where seepage is a problem) and the development layout. Outlets must be stable after the diversion empties stormwater flow into it; therefore, care should be exercised in selecting the location of the diversion and its outlet.

### *Capacity*

The diversion channel must have a minimum capacity to carry the runoff expected from a storm frequency meeting the requirements of Table DV-l with a freeboard of at least 0.3 foot (Figure DV-1).

The storm frequency should be used to determine the required channel capacity, Q (peak rate of runoff). The peak rate of runoff should be determined using the Natural Resources Conservation Service runoff curve no. (RCN) method or other equivalent methods.

Table DV-1 Design Frequency

| Diversion Type | Typical Area of Protection | 24-Hour Design Storm Frequency |
|---|---|---|
| Temporary | Construction Areas | 2-year |
| | Building Sites | 5-year |
| Permanent | Agricultural Land | 10-year |
| | Mined Reclamation Area | 10-year |
| | Recreation Areas | 10-year |
| | Isolated Buildings | 25-year |
| | Urban areas, Residential, School, Industrial Areas, etc. | 50-year |

Diversions designed to protect homes, schools, industrial buildings, roads, parking lots, and comparable high-risk areas, and those designed to function in connection with other structures, should have sufficient capacity to carry peak runoff expected from a storm frequency consistent with the hazard involved.

### *Velocities*

Diversions should be designed so that the design velocities will be safe for the planned type of protective vegetation and the expected maintenance. Maximum permissible velocities are dependent upon the erosion resistance of the soil (Table DV-2) and the quality of the vegetation maintained.

Table DV-2 Permissible Velocities

| Soil Texture | Velocity in Feet/Second | | |
|---|---|---|---|
| | Conditions of Vegetation | | |
| | Poor | Fair | Good |
| Sand, Silt, Sandy Loam, Silt Loam | 1.5 | 2.0 | 3.0 |
| Silty Clay Loam, Sandy Clay Loam | 2.5 | 3.0 | 4.0 |
| Clay | 3.0 | 4.0 | 5.0 |

### *Channel Design*

The diversion channel may be parabolic, trapezoidal or v-shaped as shown in Figure DV-2 and should be designed in accordance with the procedure provided in the Diversion Design section. Land slope must be considered when choosing channel dimensions. On steeper slopes, narrow and deep channels may be required. On more gentle slopes, broad, shallow channels can be used to facilitate maintenance.

### *Ridge Design*

The supporting ridge cross section should meet the configuration and requirements of Figure DV-2.

The side slopes should be no steeper than 2:1. Side slopes should be flatter, 5:1 to 10:1, when the diversion is to be permanent with mowing and other maintenance activities performed on or around it.

The width of the ridge at the design water elevation should be a minimum of 4 feet.

The minimum freeboard should be 0.3 foot.

The design should include a 10% settlement factor.

### *Outlet*

Diversions should have adequate outlets which will convey concentrated runoff without erosion. Acceptable outlets include practices such as Grassed Swale, Lined Swale, Drop Structure, Sediment Basin, and Stormwater Detention Basins.

### *Stabilization*

Unless otherwise stabilized, the ridge and channel should be seeded within 13 days of installation in accordance with the applicable seeding practice, Permanent Seeding or Temporary Seeding.

Disturbed areas draining into the diversion should be seeded and mulched prior to or at the time the diversion is constructed in accordance with the Permanent Seeding or Temporary Seeding (whichever is applicable) practices.

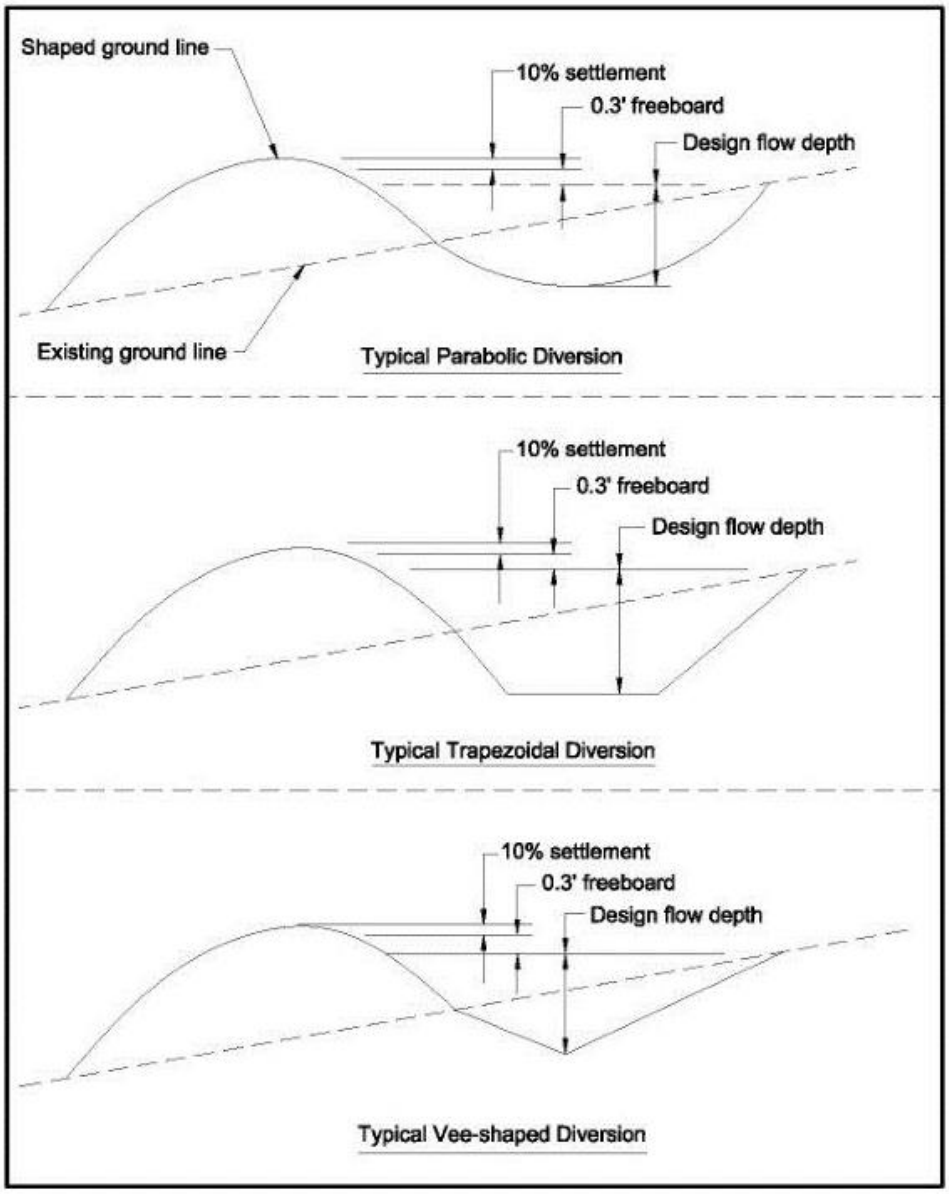



Figure DV-2 Typical Diversions Detail

# Diversion Design

*Note: This design example uses the Permissible Velocity approach. Diversion design using the Tractive Stress approach can also be used but is not discussed in this document.*

Table DV-l through DV-16 may be used to facilitate the design of grass-lined diversions with parabolic cross sections. These tables are based on a retardance of "D" (vegetation newly cut) to determine V1 for stability considerations. To determine channel capacity, choose a retardance of "C" when proper maintenance is expected; otherwise, design channel capacity based on retardance "B". Refer to Table DV-2 for maximum permissible velocities. The permissible velocities guide the selection of V1 and should not be exceeded. It is good practice to use a value for V1 that is significantly less than the maximum allowable when choosing a design cross section. When velocities approach the maximum allowable, flatter grades should be evaluated or a more erosion resistant liner such as erosion control blanket or riprap should be considered. After the diversion dimensions are selected in the design tables, the top width should be increased by 4 feet. and the depth by 0.3 foot. for freeboard.

## *Example Problem*

*Given*

Q: 30 cfs
Grade: 1%
Soil: Sandy clay loam
Condition of vegetation expected: fair
Maintenance: low; will be cut only twice a year.
Site will allow a top width of 26 feet.

*Find*

Diversion top width and depth that will be stable and fit site conditions.

*Solution*

From Table DV-2 use maximum permissible velocity of 3.0 ft./sec.

Since maintenance will be low use "B" retardance for capacity.

From Table DV-4 use retardance "D" and "B";
Grade 1.00 Percent. Top width = 21.0 feet + 4 feet = 25.0 feet.

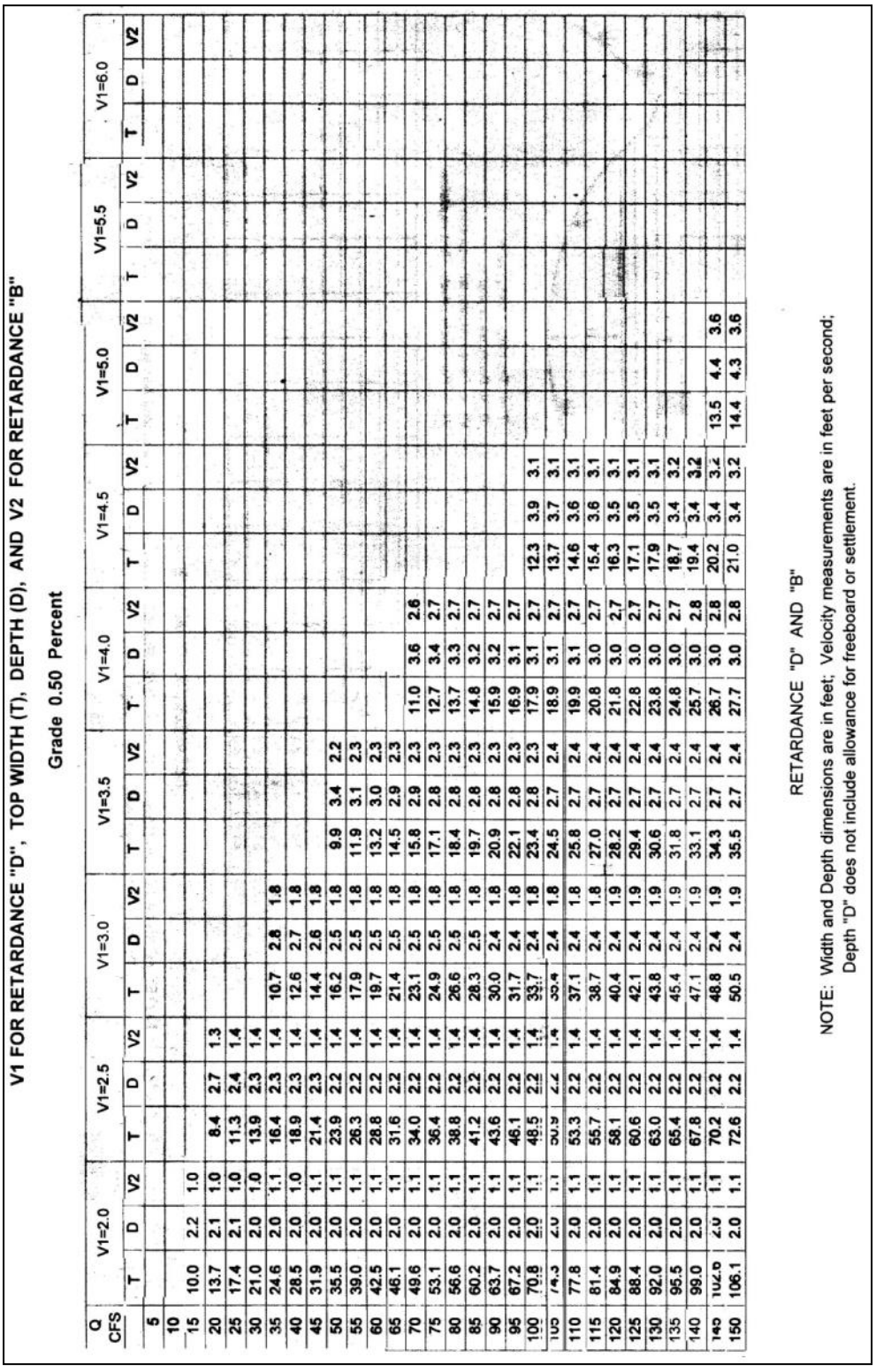
Depth = 1.6 feet + 0.3 foot = 1.9 feet.

$V_2$ = 1.3 ft./sec.

Note: $V_1$ < 3.0 ft./sec.; Top width < 26 feet, design O.K.

*Note: It is good practice to select a cross section that will give a velocity, $V_1$, well below the maximum allowable whenever site conditions permit. Wide, shallow cross sections are more stable and require less maintenance. It is always prudent to evaluate flatter design grades to best fit diversions to the site and keep velocities well below maximum allowable.*

Table DV-3 Parabolic Diversion Design Chart (Retardance “D” and “B”, Grade 0.50%)



**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "B"**

**Grade 0.50 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | 10.0 | 2.2 | 1.0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | 13.7 | 2.1 | 1.0 | 8.4 | 2.7 | 1.3 | | | | | | | | | | | | | | | | | | | | | |
| 25 | 17.4 | 2.1 | 1.0 | 11.3 | 2.4 | 1.4 | | | | | | | | | | | | | | | | | | | | | |
| 30 | 21.0 | 2.0 | 1.0 | 13.9 | 2.3 | 1.4 | | | | | | | | | | | | | | | | | | | | | |
| 35 | 24.6 | 2.0 | 1.1 | 16.4 | 2.3 | 1.4 | 10.7 | 2.8 | 1.8 | | | | | | | | | | | | | | | | | | |
| 40 | 28.5 | 2.0 | 1.0 | 18.9 | 2.3 | 1.4 | 12.6 | 2.7 | 1.8 | | | | | | | | | | | | | | | | | | |
| 45 | 31.9 | 2.0 | 1.1 | 21.4 | 2.3 | 1.4 | 14.4 | 2.6 | 1.8 | | | | | | | | | | | | | | | | | | |
| 50 | 35.5 | 2.0 | 1.1 | 23.9 | 2.2 | 1.4 | 16.2 | 2.5 | 1.8 | 9.9 | 3.4 | 2.2 | | | | | | | | | | | | | | | |
| 55 | 39.0 | 2.0 | 1.1 | 26.3 | 2.2 | 1.4 | 17.9 | 2.5 | 1.8 | 11.9 | 3.1 | 2.3 | | | | | | | | | | | | | | | |
| 60 | 42.5 | 2.0 | 1.1 | 28.8 | 2.2 | 1.4 | 19.7 | 2.5 | 1.8 | 13.2 | 3.0 | 2.3 | | | | | | | | | | | | | | | |
| 65 | 46.1 | 2.0 | 1.1 | 31.6 | 2.2 | 1.4 | 21.4 | 2.5 | 1.8 | 14.5 | 2.9 | 2.3 | | | | | | | | | | | | | | | |
| 70 | 49.6 | 2.0 | 1.1 | 34.0 | 2.2 | 1.4 | 23.1 | 2.5 | 1.8 | 15.8 | 2.9 | 2.3 | 11.0 | 3.6 | 2.6 | | | | | | | | | | | | |
| 75 | 53.1 | 2.0 | 1.1 | 36.4 | 2.2 | 1.4 | 24.9 | 2.5 | 1.8 | 17.1 | 2.8 | 2.3 | 12.7 | 3.4 | 2.7 | | | | | | | | | | | | |
| 80 | 56.6 | 2.0 | 1.1 | 38.8 | 2.2 | 1.4 | 26.6 | 2.5 | 1.8 | 18.4 | 2.8 | 2.3 | 13.7 | 3.3 | 2.7 | | | | | | | | | | | | |
| 85 | 60.2 | 2.0 | 1.1 | 41.2 | 2.2 | 1.4 | 28.3 | 2.5 | 1.8 | 19.7 | 2.8 | 2.3 | 14.8 | 3.2 | 2.7 | | | | | | | | | | | | |
| 90 | 63.7 | 2.0 | 1.1 | 43.6 | 2.2 | 1.4 | 30.0 | 2.4 | 1.8 | 20.9 | 2.8 | 2.3 | 15.9 | 3.2 | 2.7 | | | | | | | | | | | | |
| 95 | 67.2 | 2.0 | 1.1 | 46.1 | 2.2 | 1.4 | 31.7 | 2.4 | 1.8 | 22.1 | 2.8 | 2.3 | 16.9 | 3.1 | 2.7 | | | | | | | | | | | | |
| 100 | 70.8 | 2.0 | 1.1 | 48.5 | 2.2 | 1.4 | 33.7 | 2.4 | 1.8 | 23.4 | 2.8 | 2.3 | 17.9 | 3.1 | 2.7 | 12.3 | 3.9 | 3.1 | | | | | | | | | |
| 105 | 74.3 | 2.0 | 1.1 | 50.9 | 2.2 | 1.4 | 35.4 | 2.4 | 1.8 | 24.5 | 2.7 | 2.4 | 18.9 | 3.1 | 2.7 | 13.7 | 3.7 | 3.1 | | | | | | | | | |
| 110 | 77.8 | 2.0 | 1.1 | 53.3 | 2.2 | 1.4 | 37.1 | 2.4 | 1.8 | 25.8 | 2.7 | 2.4 | 19.9 | 3.1 | 2.7 | 14.6 | 3.6 | 3.1 | | | | | | | | | |
| 115 | 81.4 | 2.0 | 1.1 | 55.7 | 2.2 | 1.4 | 38.7 | 2.4 | 1.8 | 27.0 | 2.7 | 2.4 | 20.8 | 3.0 | 2.7 | 15.4 | 3.6 | 3.1 | | | | | | | | | |
| 120 | 84.9 | 2.0 | 1.1 | 58.1 | 2.2 | 1.4 | 40.4 | 2.4 | 1.9 | 28.2 | 2.7 | 2.4 | 21.8 | 3.0 | 2.7 | 16.3 | 3.5 | 3.1 | | | | | | | | | |
| 125 | 88.4 | 2.0 | 1.1 | 60.6 | 2.2 | 1.4 | 42.1 | 2.4 | 1.9 | 29.4 | 2.7 | 2.4 | 22.8 | 3.0 | 2.7 | 17.1 | 3.5 | 3.1 | | | | | | | | | |
| 130 | 92.0 | 2.0 | 1.1 | 63.0 | 2.2 | 1.4 | 43.8 | 2.4 | 1.9 | 30.6 | 2.7 | 2.4 | 23.8 | 3.0 | 2.7 | 17.9 | 3.5 | 3.1 | | | | | | | | | |
| 135 | 95.5 | 2.0 | 1.1 | 65.4 | 2.2 | 1.4 | 45.4 | 2.4 | 1.9 | 31.8 | 2.7 | 2.4 | 24.8 | 3.0 | 2.7 | 18.7 | 3.4 | 3.2 | | | | | | | | | |
| 140 | 99.0 | 2.0 | 1.1 | 67.8 | 2.2 | 1.4 | 47.1 | 2.4 | 1.9 | 33.1 | 2.7 | 2.4 | 25.7 | 3.0 | 2.8 | 19.4 | 3.4 | 3.2 | | | | | | | | | |
| 145 | 102.6 | 2.0 | 1.1 | 70.2 | 2.2 | 1.4 | 48.8 | 2.4 | 1.9 | 34.3 | 2.7 | 2.4 | 26.7 | 3.0 | 2.8 | 20.2 | 3.4 | 3.2 | 13.5 | 4.4 | 3.6 | | | | | | |
| 150 | 106.1 | 2.0 | 1.1 | 72.6 | 2.2 | 1.4 | 50.5 | 2.4 | 1.9 | 35.5 | 2.7 | 2.4 | 27.7 | 3.0 | 2.8 | 21.0 | 3.4 | 3.2 | 14.4 | 4.3 | 3.6 | | | | | | |

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table DV-4 Parabolic Diversion Design Chart (Retardance “D” and “B”, Grade 1.00%)

**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "B"**

**Grade 1.00 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | 9.7 | 1.6 | 1.0 | 6.2 | 2.0 | 1.2 | | | | | | | | | | | | | | | | | | | | | |
| 15 | 14.8 | 1.5 | 1.0 | 10.2 | 1.7 | 1.3 | 6.5 | 2.2 | 1.5 | | | | | | | | | | | | | | | | | | |
| 20 | 20.2 | 1.5 | 1.0 | 13.8 | 1.7 | 1.3 | 9.6 | 1.9 | 1.6 | | | | | | | | | | | | | | | | | | |
| 25 | 25.1 | 1.5 | 1.0 | 17.4 | 1.7 | 1.3 | 12.2 | 1.9 | 1.6 | 8.5 | 2.2 | 2.0 | | | | | | | | | | | | | | | |
| 30 | 30.1 | 1.5 | 1.0 | 21.0 | 1.6 | 1.3 | 14.9 | 1.8 | 1.7 | 10.6 | 2.1 | 2.1 | | | | | | | | | | | | | | | |
| 35 | 35.1 | 1.5 | 1.0 | 24.7 | 1.6 | 1.3 | 17.5 | 1.8 | 1.7 | 12.6 | 2.0 | 2.1 | 8.9 | 2.4 | 2.5 | | | | | | | | | | | | |
| 40 | 40.1 | 1.5 | 1.0 | 28.2 | 1.6 | 1.3 | 20.0 | 1.8 | 1.7 | 14.5 | 2.0 | 2.1 | 10.5 | 2.3 | 2.5 | | | | | | | | | | | | |
| 45 | 45.1 | 1.5 | 1.0 | 31.7 | 1.6 | 1.3 | 22.5 | 1.8 | 1.7 | 16.4 | 2.0 | 2.1 | 12.1 | 2.2 | 2.5 | 8.2 | 2.8 | 2.9 | | | | | | | | | |
| 50 | 50.2 | 1.5 | 1.0 | 35.2 | 1.6 | 1.3 | 25.4 | 1.8 | 1.7 | 18.3 | 2.0 | 2.1 | 13.6 | 2.2 | 2.5 | 10.0 | 2.6 | 2.9 | | | | | | | | | |
| 55 | 55.2 | 1.5 | 1.0 | 38.8 | 1.6 | 1.3 | 27.9 | 1.8 | 1.7 | 20.3 | 1.9 | 2.1 | 15.1 | 2.2 | 2.5 | 11.2 | 2.5 | 3.0 | | | | | | | | | |
| 60 | 60.2 | 1.5 | 1.0 | 42.3 | 1.6 | 1.3 | 30.4 | 1.8 | 1.7 | 22.2 | 1.9 | 2.1 | 16.6 | 2.1 | 2.5 | 12.4 | 2.4 | 3.0 | | | | | | | | | |
| 65 | 65.2 | 1.5 | 1.0 | 45.8 | 1.6 | 1.3 | 32.9 | 1.8 | 1.7 | 24.0 | 1.9 | 2.1 | 18.0 | 2.1 | 2.5 | 13.6 | 2.4 | 3.0 | 8.9 | 3.1 | 3.5 | | | | | | |
| 70 | 70.2 | 1.5 | 1.0 | 49.3 | 1.6 | 1.3 | 35.5 | 1.8 | 1.7 | 25.9 | 1.9 | 2.1 | 19.5 | 2.1 | 2.6 | 14.8 | 2.4 | 3.0 | 10.6 | 2.8 | 3.5 | | | | | | |
| 75 | 75.2 | 1.5 | 1.0 | 52.8 | 1.6 | 1.3 | 38.0 | 1.8 | 1.7 | 28.2 | 1.9 | 2.1 | 20.9 | 2.1 | 2.6 | 16.0 | 2.3 | 3.0 | 11.5 | 2.8 | 3.5 | | | | | | |
| 80 | 80.2 | 1.5 | 1.0 | 56.3 | 1.6 | 1.3 | 40.5 | 1.8 | 1.7 | 30.0 | 1.9 | 2.1 | 22.3 | 2.1 | 2.6 | 17.1 | 2.3 | 3.0 | 12.5 | 2.7 | 3.5 | | | | | | |
| 85 | 85.2 | 1.5 | 1.0 | 59.8 | 1.6 | 1.3 | 43.0 | 1.8 | 1.7 | 31.9 | 1.9 | 2.1 | 23.7 | 2.1 | 2.6 | 18.3 | 2.3 | 3.0 | 13.5 | 2.7 | 3.6 | 9.8 | 3.3 | 3.9 | | | |
| 90 | 90.2 | 1.5 | 1.0 | 63.3 | 1.6 | 1.3 | 45.6 | 1.8 | 1.7 | 33.6 | 1.9 | 2.1 | 25.2 | 2.1 | 2.6 | 19.4 | 2.3 | 3.1 | 14.4 | 2.6 | 3.6 | 10.9 | 3.1 | 3.9 | | | |
| 95 | 95.2 | 1.5 | 1.0 | 66.9 | 1.6 | 1.3 | 48.1 | 1.8 | 1.7 | 35.5 | 1.9 | 2.1 | 26.6 | 2.1 | 2.6 | 20.5 | 2.3 | 3.1 | 15.3 | 2.6 | 3.6 | 12.0 | 3.0 | 3.9 | | | |
| 100 | 100.2 | 1.5 | 1.0 | 70.4 | 1.6 | 1.3 | 50.6 | 1.8 | 1.7 | 37.4 | 1.9 | 2.1 | 28.0 | 2.1 | 2.6 | 21.6 | 2.3 | 3.1 | 16.2 | 2.6 | 3.6 | 12.9 | 2.9 | 4.0 | | | |
| 105 | 105.3 | 1.5 | 1.0 | 73.9 | 1.6 | 1.3 | 53.1 | 1.8 | 1.7 | 39.2 | 1.9 | 2.1 | 29.8 | 2.1 | 2.6 | 22.8 | 2.3 | 3.1 | 17.1 | 2.6 | 3.6 | 13.7 | 2.9 | 4.0 | 10.8 | 3.4 | 4.3 |
| 110 | 110.3 | 1.5 | 1.0 | 77.4 | 1.6 | 1.3 | 55.7 | 1.8 | 1.7 | 41.1 | 1.9 | 2.1 | 31.3 | 2.1 | 2.6 | 23.9 | 2.3 | 3.1 | 18.0 | 2.6 | 3.6 | 14.4 | 2.9 | 4.0 | 12.0 | 3.2 | 4.3 |
| 115 | 115.3 | 1.5 | 1.0 | 80.9 | 1.6 | 1.3 | 58.2 | 1.8 | 1.7 | 42.9 | 1.9 | 2.1 | 32.7 | 2.1 | 2.6 | 25.0 | 2.3 | 3.1 | 18.9 | 2.5 | 3.6 | 15.2 | 2.8 | 4.0 | 12.7 | 3.2 | 4.3 |
| 120 | 120.3 | 1.5 | 1.0 | 84.4 | 1.6 | 1.3 | 60.7 | 1.8 | 1.7 | 44.8 | 1.9 | 2.1 | 34.1 | 2.1 | 2.6 | 26.1 | 2.2 | 3.1 | 19.7 | 2.5 | 3.6 | 16.0 | 2.8 | 4.0 | 13.4 | 3.1 | 4.3 |
| 125 | 125.3 | 1.5 | 1.0 | 88.0 | 1.6 | 1.3 | 63.2 | 1.8 | 1.7 | 46.7 | 1.9 | 2.1 | 35.5 | 2.1 | 2.6 | 27.2 | 2.2 | 3.1 | 20.6 | 2.5 | 3.6 | 16.8 | 2.8 | 4.0 | 14.1 | 3.1 | 4.3 |
| 130 | 130.3 | 1.5 | 1.0 | 91.5 | 1.6 | 1.3 | 65.8 | 1.8 | 1.7 | 48.5 | 1.9 | 2.1 | 36.9 | 2.1 | 2.6 | 28.4 | 2.2 | 3.1 | 21.5 | 2.5 | 3.6 | 17.4 | 2.8 | 4.0 | 14.8 | 3.1 | 4.3 |
| 135 | 135.3 | 1.5 | 1.0 | 95.0 | 1.6 | 1.3 | 68.3 | 1.8 | 1.7 | 50.4 | 1.9 | 2.1 | 38.3 | 2.1 | 2.6 | 29.5 | 2.2 | 3.1 | 22.4 | 2.5 | 3.6 | 18.2 | 2.8 | 4.0 | 15.5 | 3.0 | 4.3 |
| 140 | 140.3 | 1.5 | 1.0 | 98.5 | 1.6 | 1.3 | 70.8 | 1.8 | 1.7 | 52.2 | 1.9 | 2.1 | 39.7 | 2.0 | 2.6 | 30.6 | 2.2 | 3.1 | 23.2 | 2.5 | 3.6 | 18.9 | 2.7 | 4.0 | 16.1 | 3.0 | 4.4 |
| 145 | 145.3 | 1.5 | 1.0 | 102.0 | 1.6 | 1.3 | 73.3 | 1.8 | 1.7 | 54.1 | 1.9 | 2.1 | 41.1 | 2.0 | 2.6 | 32.1 | 2.2 | 3.0 | 24.1 | 2.5 | 3.6 | 19.7 | 2.7 | 4.0 | 16.8 | 3.0 | 4.4 |
| 150 | 150.3 | 1.5 | 1.0 | 105.5 | 1.6 | 1.3 | 75.9 | 1.8 | 1.7 | 56.0 | 1.9 | 2.1 | 42.5 | 2.0 | 2.6 | 33.2 | 2.2 | 3.0 | 25.0 | 2.5 | 3.6 | 20.4 | 2.7 | 4.1 | 17.5 | 2.9 | 4.4 |

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table DV-5 Parabolic Diversion Design Chart (Retardance “D” and “B”, Grade 2.00%)

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "B"

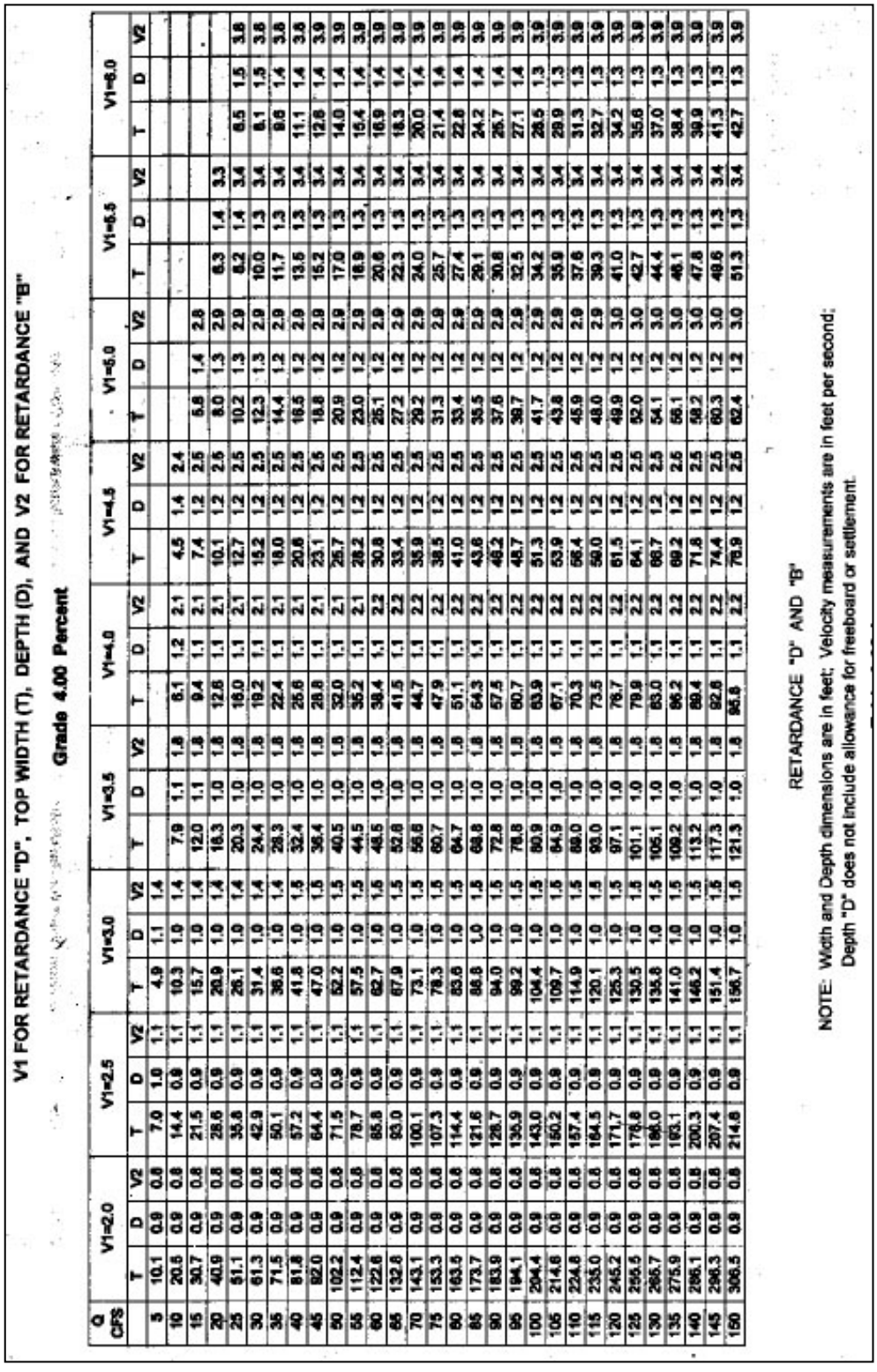
Grade 2.00 Percent

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 7.1 | 1.2 | 0.9 | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | 14.7 | 1.2 | 0.9 | 9.5 | 1.3 | 1.2 | 7.0 | 1.4 | 1.5 | | | | | | | | | | | | | | | | | | |
| 15 | 22.0 | 1.2 | 0.9 | 14.5 | 1.3 | 1.2 | 10.8 | 1.4 | 1.5 | 8.0 | 1.5 | 1.9 | 5.5 | 1.9 | 2.1 | | | | | | | | | | | | |
| 20 | 29.3 | 1.2 | 0.9 | 19.6 | 1.2 | 1.2 | 14.6 | 1.3 | 1.5 | 10.9 | 1.5 | 1.9 | 8.1 | 1.8 | 2.3 | 5.5 | 2.1 | 2.6 | | | | | | | | | |
| 25 | 36.6 | 1.2 | 0.9 | 24.4 | 1.2 | 1.2 | 18.5 | 1.3 | 1.5 | 13.6 | 1.4 | 1.9 | 10.4 | 1.8 | 2.3 | 7.9 | 1.8 | 2.7 | | | | | | | | | |
| 30 | 43.9 | 1.2 | 0.9 | 29.3 | 1.2 | 1.2 | 22.2 | 1.3 | 1.6 | 16.6 | 1.4 | 1.9 | 12.7 | 1.5 | 2.3 | 9.7 | 1.7 | 2.7 | 7.3 | 2.0 | 3.1 | | | | | | |
| 35 | 51.2 | 1.2 | 0.9 | 34.2 | 1.2 | 1.2 | 25.8 | 1.3 | 1.6 | 19.6 | 1.4 | 1.9 | 14.9 | 1.5 | 2.3 | 11.5 | 1.7 | 2.7 | 8.9 | 1.8 | 3.2 | | | | | | |
| 40 | 58.5 | 1.2 | 0.9 | 39.0 | 1.2 | 1.2 | 29.5 | 1.3 | 1.6 | 22.4 | 1.4 | 1.9 | 17.1 | 1.5 | 2.3 | 13.3 | 1.6 | 2.8 | 10.4 | 1.8 | 3.2 | 8.0 | 2.1 | 3.6 | | | |
| 45 | 65.8 | 1.2 | 0.9 | 43.9 | 1.2 | 1.2 | 33.2 | 1.3 | 1.6 | 25.2 | 1.4 | 1.9 | 19.3 | 1.5 | 2.3 | 15.0 | 1.6 | 2.8 | 11.8 | 1.8 | 3.2 | 9.2 | 2.0 | 3.7 | | | |
| 50 | 73.1 | 1.2 | 0.9 | 48.8 | 1.2 | 1.2 | 36.8 | 1.3 | 1.6 | 28.0 | 1.4 | 1.9 | 21.7 | 1.5 | 2.3 | 16.7 | 1.6 | 2.8 | 13.2 | 1.8 | 3.2 | 10.5 | 1.9 | 3.7 | 7.9 | 2.3 | 4.1 |
| 55 | 80.4 | 1.2 | 0.9 | 53.6 | 1.2 | 1.2 | 40.5 | 1.3 | 1.6 | 30.7 | 1.4 | 1.9 | 23.9 | 1.5 | 2.3 | 18.5 | 1.6 | 2.8 | 14.6 | 1.7 | 3.2 | 11.7 | 1.9 | 3.7 | 9.2 | 2.2 | 4.1 |
| 60 | 87.7 | 1.2 | 0.9 | 58.5 | 1.2 | 1.2 | 44.2 | 1.3 | 1.6 | 33.5 | 1.4 | 1.9 | 26.0 | 1.5 | 2.3 | 20.2 | 1.6 | 2.8 | 16.0 | 1.7 | 3.2 | 12.8 | 1.9 | 3.7 | 10.2 | 2.1 | 4.1 |
| 65 | 95.0 | 1.2 | 0.9 | 63.4 | 1.2 | 1.2 | 47.9 | 1.3 | 1.6 | 36.3 | 1.4 | 1.9 | 28.2 | 1.5 | 2.3 | 22.1 | 1.6 | 2.8 | 17.4 | 1.7 | 3.3 | 14.0 | 1.9 | 3.7 | 11.3 | 2.1 | 4.2 |
| 70 | 102.3 | 1.2 | 0.9 | 68.2 | 1.2 | 1.2 | 51.6 | 1.3 | 1.6 | 39.1 | 1.4 | 1.9 | 30.3 | 1.5 | 2.3 | 23.8 | 1.6 | 2.8 | 18.8 | 1.7 | 3.3 | 15.2 | 1.9 | 3.7 | 12.3 | 2.1 | 4.2 |
| 75 | 109.6 | 1.2 | 0.9 | 73.1 | 1.2 | 1.2 | 55.2 | 1.3 | 1.6 | 41.9 | 1.4 | 1.9 | 32.5 | 1.5 | 2.3 | 25.5 | 1.6 | 2.8 | 20.1 | 1.7 | 3.3 | 16.2 | 1.8 | 3.7 | 13.2 | 2.0 | 4.2 |
| 80 | 116.9 | 1.2 | 0.9 | 78.0 | 1.2 | 1.2 | 58.9 | 1.3 | 1.6 | 44.7 | 1.4 | 1.9 | 34.6 | 1.5 | 2.3 | 27.2 | 1.6 | 2.8 | 21.5 | 1.7 | 3.3 | 17.4 | 1.8 | 3.6 | 14.2 | 2.0 | 4.2 |
| 85 | 124.2 | 1.2 | 0.9 | 82.9 | 1.2 | 1.2 | 62.6 | 1.3 | 1.6 | 47.4 | 1.4 | 1.9 | 36.8 | 1.5 | 2.3 | 28.9 | 1.6 | 2.8 | 22.9 | 1.7 | 3.3 | 18.5 | 1.8 | 3.8 | 16.1 | 2.0 | 4.2 |
| 90 | 131.5 | 1.2 | 0.9 | 87.7 | 1.2 | 1.2 | 66.3 | 1.3 | 1.6 | 50.2 | 1.4 | 1.9 | 39.0 | 1.5 | 2.3 | 30.6 | 1.6 | 2.8 | 24.6 | 1.7 | 3.2 | 19.6 | 1.8 | 3.8 | 18.1 | 2.0 | 4.2 |
| 95 | 138.8 | 1.2 | 0.9 | 92.6 | 1.2 | 1.2 | 69.9 | 1.3 | 1.6 | 53.0 | 1.4 | 1.9 | 41.1 | 1.5 | 2.3 | 32.3 | 1.6 | 2.8 | 25.9 | 1.7 | 3.3 | 20.8 | 1.8 | 3.8 | 17.0 | 2.0 | 4.2 |
| 100 | 146.1 | 1.2 | 0.9 | 97.5 | 1.2 | 1.2 | 73.6 | 1.3 | 1.6 | 55.8 | 1.4 | 1.9 | 43.3 | 1.5 | 2.3 | 34.0 | 1.6 | 2.8 | 27.3 | 1.7 | 3.3 | 21.9 | 1.8 | 3.8 | 18.0 | 2.0 | 4.2 |
| 105 | 153.4 | 1.2 | 0.9 | 102.3 | 1.2 | 1.2 | 77.3 | 1.3 | 1.6 | 58.6 | 1.4 | 1.9 | 45.4 | 1.5 | 2.3 | 35.7 | 1.6 | 2.8 | 28.6 | 1.7 | 3.3 | 23.0 | 1.8 | 3.8 | 18.9 | 2.0 | 4.2 |
| 110 | 160.7 | 1.2 | 0.9 | 107.2 | 1.2 | 1.2 | 81.0 | 1.3 | 1.6 | 61.4 | 1.4 | 1.9 | 47.6 | 1.5 | 2.3 | 37.3 | 1.6 | 2.8 | 30.0 | 1.7 | 3.3 | 24.1 | 1.8 | 3.8 | 19.8 | 2.0 | 4.2 |
| 115 | 168.0 | 1.2 | 0.9 | 112.1 | 1.2 | 1.2 | 84.7 | 1.3 | 1.6 | 64.2 | 1.4 | 1.9 | 49.8 | 1.5 | 2.3 | 39.0 | 1.6 | 2.8 | 31.3 | 1.7 | 3.3 | 25.3 | 1.8 | 3.8 | 20.8 | 2.0 | 4.2 |
| 120 | 175.3 | 1.2 | 0.9 | 117.0 | 1.2 | 1.2 | 88.3 | 1.3 | 1.6 | 67.0 | 1.4 | 1.9 | 51.9 | 1.5 | 2.3 | 40.7 | 1.6 | 2.8 | 32.7 | 1.7 | 3.3 | 26.7 | 1.8 | 3.7 | 21.7 | 2.0 | 4.2 |
| 125 | 182.6 | 1.2 | 0.9 | 121.8 | 1.2 | 1.2 | 92.0 | 1.3 | 1.6 | 69.7 | 1.4 | 1.9 | 54.1 | 1.5 | 2.3 | 42.4 | 1.6 | 2.8 | 34.1 | 1.7 | 3.3 | 27.8 | 1.8 | 3.7 | 22.6 | 1.9 | 4.3 |
| 130 | 189.9 | 1.2 | 0.9 | 126.7 | 1.2 | 1.2 | 95.7 | 1.3 | 1.6 | 72.5 | 1.4 | 1.9 | 56.2 | 1.5 | 2.3 | 44.1 | 1.6 | 2.8 | 35.4 | 1.7 | 3.3 | 28.9 | 1.8 | 3.7 | 23.6 | 1.9 | 4.3 |
| 135 | 197.3 | 1.2 | 0.9 | 131.6 | 1.2 | 1.2 | 99.4 | 1.3 | 1.6 | 75.3 | 1.4 | 1.9 | 58.4 | 1.5 | 2.3 | 45.8 | 1.6 | 2.8 | 36.8 | 1.7 | 3.3 | 30.0 | 1.8 | 3.7 | 24.5 | 1.9 | 4.3 |
| 140 | 204.6 | 1.2 | 0.9 | 136.5 | 1.2 | 1.2 | 103.1 | 1.3 | 1.6 | 78.1 | 1.4 | 1.9 | 60.6 | 1.5 | 2.3 | 47.5 | 1.6 | 2.8 | 38.1 | 1.7 | 3.3 | 31.1 | 1.8 | 3.7 | 25.4 | 1.9 | 4.3 |
| 145 | 211.9 | 1.2 | 0.9 | 141.3 | 1.2 | 1.2 | 106.7 | 1.3 | 1.6 | 80.9 | 1.4 | 1.9 | 62.7 | 1.5 | 2.3 | 49.2 | 1.6 | 2.8 | 39.5 | 1.7 | 3.3 | 32.3 | 1.8 | 3.7 | 26.4 | 1.9 | 4.3 |
| 150 | 219.2 | 1.2 | 0.9 | 146.2 | 1.2 | 1.2 | 110.4 | 1.3 | 1.6 | 83.7 | 1.4 | 1.9 | 64.9 | 1.5 | 2.3 | 50.9 | 1.6 | 2.8 | 40.8 | 1.7 | 3.3 | 33.4 | 1.8 | 3.7 | 27.3 | 1.9 | 4.3 |

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table DV-6 Parabolic Diversion Design Chart (Retardance “D” and “B”, Grade 4.00%)



**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "B"**

**Grade 4.00 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 10.1 | 0.9 | 0.8 | 7.0 | 1.0 | 1.1 | 4.9 | 1.1 | 1.4 | | | | | | | | | | | | | | | | | | |
| 10 | 20.5 | 0.9 | 0.8 | 14.4 | 0.8 | 1.1 | 10.3 | 1.0 | 1.4 | 7.9 | 1.1 | 1.8 | 6.1 | 1.2 | 2.1 | 4.5 | 1.4 | 2.4 | | | | | | | | | |
| 15 | 30.7 | 0.9 | 0.8 | 21.5 | 0.9 | 1.1 | 15.7 | 1.0 | 1.4 | 12.0 | 1.1 | 1.8 | 9.4 | 1.1 | 2.1 | 7.4 | 1.2 | 2.5 | 5.8 | 1.4 | 2.8 | | | | | | |
| 20 | 40.9 | 0.9 | 0.8 | 28.6 | 0.9 | 1.1 | 20.9 | 1.0 | 1.4 | 16.3 | 1.0 | 1.8 | 12.6 | 1.1 | 2.1 | 10.1 | 1.2 | 2.5 | 8.0 | 1.3 | 2.9 | 6.3 | 1.4 | 3.3 | | | |
| 25 | 51.1 | 0.9 | 0.8 | 35.8 | 0.9 | 1.1 | 26.1 | 1.0 | 1.4 | 20.3 | 1.0 | 1.8 | 16.0 | 1.1 | 2.1 | 12.7 | 1.2 | 2.5 | 10.2 | 1.3 | 2.9 | 8.2 | 1.4 | 3.4 | 6.5 | 1.5 | 3.8 |
| 30 | 61.3 | 0.9 | 0.8 | 42.9 | 0.9 | 1.1 | 31.4 | 1.0 | 1.4 | 24.4 | 1.0 | 1.8 | 19.2 | 1.1 | 2.1 | 15.2 | 1.2 | 2.5 | 12.3 | 1.3 | 2.9 | 10.0 | 1.3 | 3.4 | 8.1 | 1.5 | 3.8 |
| 35 | 71.5 | 0.9 | 0.8 | 50.1 | 0.9 | 1.1 | 36.6 | 1.0 | 1.4 | 28.3 | 1.0 | 1.8 | 22.4 | 1.1 | 2.1 | 18.0 | 1.2 | 2.5 | 14.4 | 1.2 | 2.9 | 11.7 | 1.3 | 3.4 | 9.6 | 1.4 | 3.8 |
| 40 | 81.8 | 0.9 | 0.8 | 57.2 | 0.9 | 1.1 | 41.8 | 1.0 | 1.5 | 32.4 | 1.0 | 1.8 | 25.6 | 1.1 | 2.1 | 20.6 | 1.2 | 2.5 | 16.5 | 1.2 | 2.9 | 13.5 | 1.3 | 3.4 | 11.1 | 1.4 | 3.8 |
| 45 | 92.0 | 0.9 | 0.8 | 64.4 | 0.9 | 1.1 | 47.0 | 1.0 | 1.5 | 36.4 | 1.0 | 1.8 | 28.8 | 1.1 | 2.1 | 23.1 | 1.2 | 2.5 | 18.6 | 1.2 | 2.9 | 15.2 | 1.3 | 3.4 | 12.6 | 1.4 | 3.9 |
| 50 | 102.2 | 0.9 | 0.8 | 71.5 | 0.9 | 1.1 | 52.2 | 1.0 | 1.5 | 40.5 | 1.0 | 1.8 | 32.0 | 1.1 | 2.1 | 25.7 | 1.2 | 2.5 | 20.9 | 1.2 | 2.9 | 17.0 | 1.3 | 3.4 | 14.0 | 1.4 | 3.9 |
| 55 | 112.4 | 0.9 | 0.8 | 78.7 | 0.9 | 1.1 | 57.5 | 1.0 | 1.5 | 44.5 | 1.0 | 1.8 | 35.2 | 1.1 | 2.1 | 28.2 | 1.2 | 2.5 | 23.0 | 1.2 | 2.9 | 18.9 | 1.3 | 3.4 | 15.4 | 1.4 | 3.9 |
| 60 | 122.6 | 0.9 | 0.8 | 85.8 | 0.9 | 1.1 | 62.7 | 1.0 | 1.5 | 48.5 | 1.0 | 1.8 | 38.4 | 1.1 | 2.2 | 30.8 | 1.2 | 2.5 | 25.1 | 1.2 | 2.9 | 20.6 | 1.3 | 3.4 | 16.9 | 1.4 | 3.9 |
| 65 | 132.8 | 0.9 | 0.8 | 93.0 | 0.9 | 1.1 | 67.9 | 1.0 | 1.5 | 52.8 | 1.0 | 1.8 | 41.5 | 1.1 | 2.2 | 33.4 | 1.2 | 2.5 | 27.2 | 1.2 | 2.9 | 22.3 | 1.3 | 3.4 | 18.3 | 1.4 | 3.9 |
| 70 | 143.1 | 0.9 | 0.8 | 100.1 | 0.9 | 1.1 | 73.1 | 1.0 | 1.5 | 56.8 | 1.0 | 1.8 | 44.7 | 1.1 | 2.2 | 35.9 | 1.2 | 2.5 | 29.2 | 1.2 | 2.9 | 24.0 | 1.3 | 3.4 | 20.0 | 1.4 | 3.9 |
| 75 | 153.3 | 0.8 | 0.8 | 107.3 | 0.9 | 1.1 | 78.3 | 1.0 | 1.5 | 60.7 | 1.0 | 1.8 | 47.9 | 1.1 | 2.2 | 38.5 | 1.2 | 2.5 | 31.3 | 1.2 | 2.9 | 25.7 | 1.3 | 3.4 | 21.4 | 1.4 | 3.9 |
| 80 | 163.6 | 0.9 | 0.8 | 114.4 | 0.9 | 1.1 | 83.6 | 1.0 | 1.5 | 64.7 | 1.0 | 1.8 | 51.1 | 1.1 | 2.2 | 41.0 | 1.2 | 2.5 | 33.4 | 1.2 | 2.9 | 27.4 | 1.3 | 3.4 | 22.8 | 1.4 | 3.9 |
| 85 | 173.7 | 0.9 | 0.8 | 121.6 | 0.9 | 1.1 | 88.8 | 1.0 | 1.5 | 68.8 | 1.0 | 1.8 | 54.3 | 1.1 | 2.2 | 43.6 | 1.2 | 2.5 | 35.5 | 1.2 | 2.9 | 29.1 | 1.3 | 3.4 | 24.2 | 1.4 | 3.9 |
| 90 | 183.9 | 0.9 | 0.8 | 128.7 | 0.9 | 1.1 | 94.0 | 1.0 | 1.5 | 72.8 | 1.0 | 1.8 | 57.5 | 1.1 | 2.2 | 46.2 | 1.2 | 2.5 | 37.6 | 1.2 | 2.9 | 30.8 | 1.3 | 3.4 | 25.7 | 1.4 | 3.9 |
| 95 | 194.1 | 0.9 | 0.8 | 135.9 | 0.9 | 1.1 | 99.2 | 1.0 | 1.5 | 76.8 | 1.0 | 1.8 | 60.7 | 1.1 | 2.2 | 48.7 | 1.2 | 2.5 | 39.7 | 1.2 | 2.9 | 32.5 | 1.3 | 3.4 | 27.1 | 1.4 | 3.9 |
| 100 | 204.4 | 0.9 | 0.8 | 143.0 | 0.9 | 1.1 | 104.4 | 1.0 | 1.5 | 80.9 | 1.0 | 1.8 | 63.9 | 1.1 | 2.2 | 51.3 | 1.2 | 2.5 | 41.7 | 1.2 | 2.9 | 34.2 | 1.3 | 3.4 | 28.5 | 1.3 | 3.9 |
| 105 | 214.6 | 0.9 | 0.8 | 150.2 | 0.9 | 1.1 | 109.7 | 1.0 | 1.5 | 84.9 | 1.0 | 1.8 | 67.1 | 1.1 | 2.2 | 53.9 | 1.2 | 2.5 | 43.8 | 1.2 | 2.9 | 35.9 | 1.3 | 3.4 | 29.9 | 1.3 | 3.9 |
| 110 | 224.8 | 0.9 | 0.8 | 157.4 | 0.9 | 1.1 | 114.9 | 1.0 | 1.5 | 88.9 | 1.0 | 1.8 | 70.3 | 1.1 | 2.2 | 56.4 | 1.2 | 2.5 | 45.9 | 1.2 | 2.9 | 37.6 | 1.3 | 3.4 | 31.3 | 1.3 | 3.9 |
| 115 | 235.0 | 0.9 | 0.8 | 164.5 | 0.9 | 1.1 | 120.1 | 1.0 | 1.5 | 93.0 | 1.0 | 1.8 | 73.5 | 1.1 | 2.2 | 59.0 | 1.2 | 2.5 | 48.0 | 1.2 | 2.9 | 39.3 | 1.3 | 3.4 | 32.7 | 1.3 | 3.9 |
| 120 | 245.2 | 0.9 | 0.8 | 171.7 | 0.9 | 1.1 | 125.3 | 1.0 | 1.5 | 97.1 | 1.0 | 1.8 | 76.7 | 1.1 | 2.2 | 61.5 | 1.2 | 2.5 | 49.9 | 1.2 | 3.0 | 41.0 | 1.3 | 3.4 | 34.2 | 1.3 | 3.9 |
| 125 | 255.5 | 0.9 | 0.8 | 178.8 | 0.9 | 1.1 | 130.5 | 1.0 | 1.5 | 101.1 | 1.0 | 1.8 | 79.9 | 1.1 | 2.2 | 64.1 | 1.2 | 2.5 | 52.0 | 1.2 | 3.0 | 42.7 | 1.3 | 3.4 | 35.6 | 1.3 | 3.9 |
| 130 | 265.7 | 0.9 | 0.8 | 186.0 | 0.9 | 1.1 | 135.8 | 1.0 | 1.5 | 105.1 | 1.0 | 1.8 | 83.0 | 1.1 | 2.2 | 66.7 | 1.2 | 2.5 | 54.1 | 1.2 | 3.0 | 44.4 | 1.3 | 3.4 | 37.0 | 1.3 | 3.9 |
| 135 | 275.9 | 0.9 | 0.8 | 193.1 | 0.9 | 1.1 | 141.0 | 1.0 | 1.5 | 109.2 | 1.0 | 1.8 | 86.2 | 1.1 | 2.2 | 69.2 | 1.2 | 2.5 | 56.1 | 1.2 | 3.0 | 46.1 | 1.3 | 3.4 | 38.4 | 1.3 | 3.9 |
| 140 | 286.1 | 0.9 | 0.8 | 200.3 | 0.9 | 1.1 | 146.2 | 1.0 | 1.5 | 113.2 | 1.0 | 1.8 | 89.4 | 1.1 | 2.2 | 71.8 | 1.2 | 2.5 | 58.2 | 1.2 | 3.0 | 47.8 | 1.3 | 3.4 | 39.9 | 1.3 | 3.9 |
| 145 | 296.3 | 0.9 | 0.8 | 207.4 | 0.9 | 1.1 | 151.4 | 1.0 | 1.5 | 117.3 | 1.0 | 1.8 | 92.6 | 1.1 | 2.2 | 74.4 | 1.2 | 2.5 | 60.3 | 1.2 | 3.0 | 49.6 | 1.3 | 3.4 | 41.3 | 1.3 | 3.9 |
| 150 | 306.5 | 0.9 | 0.8 | 214.6 | 0.9 | 1.1 | 156.7 | 1.0 | 1.5 | 121.3 | 1.0 | 1.8 | 95.8 | 1.1 | 2.2 | 76.9 | 1.2 | 2.5 | 62.4 | 1.2 | 3.0 | 51.3 | 1.3 | 3.4 | 42.7 | 1.3 | 3.9 |

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table DV-7 Parabolic Diversion Design Chart (Retardance “D” and “B”, Grade 6.00%)

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "B"

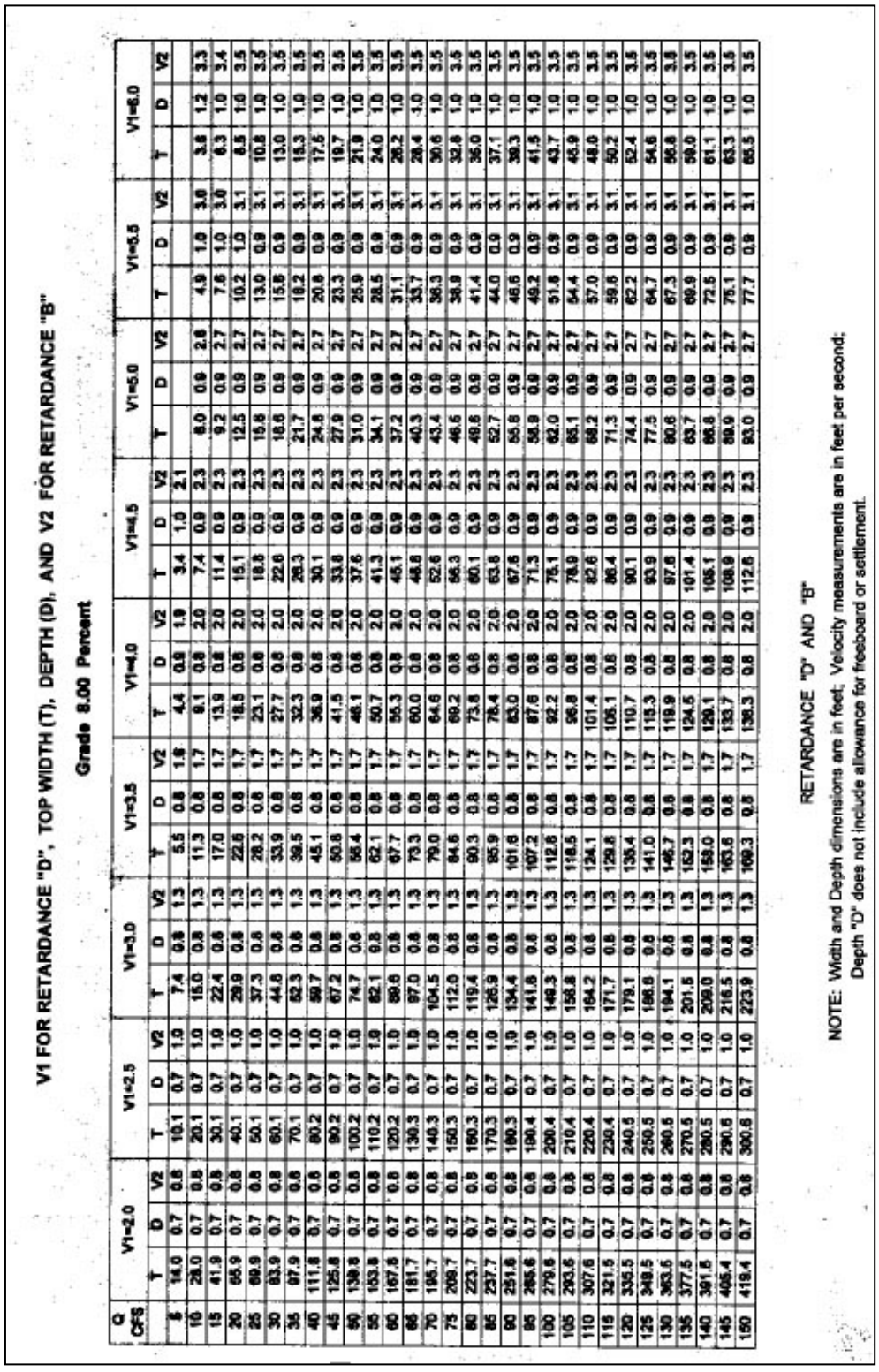
Grade 6.00 Percent

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 12.4 | 0.7 | 0.8 | 8.7 | 0.8 | 1.0 | 6.2 | 0.9 | 1.4 | 4.7 | 1.0 | 1.8 | 3.5 | 1.2 | 1.9 | | | | | | | | | | | | |
| 10 | 24.7 | 0.7 | 0.8 | 17.6 | 0.8 | 1.0 | 12.6 | 0.9 | 1.4 | 9.8 | 0.9 | 1.7 | 7.8 | 1.0 | 2.0 | 6.2 | 1.0 | 2.3 | 4.8 | 1.1 | 2.7 | | | | | | |
| 15 | 37.1 | 0.7 | 0.8 | 26.4 | 0.8 | 1.1 | 19.2 | 0.8 | 1.4 | 15.0 | 0.9 | 1.7 | 11.8 | 0.9 | 2.0 | 9.5 | 1.0 | 2.4 | 7.7 | 1.1 | 2.7 | 6.2 | 1.2 | 3.1 | 5.0 | 1.3 | 3.5 |
| 20 | 49.4 | 0.7 | 0.8 | 35.1 | 0.8 | 1.1 | 25.6 | 0.8 | 1.4 | 19.9 | 0.9 | 1.7 | 16.0 | 0.9 | 2.0 | 12.9 | 1.0 | 2.4 | 10.4 | 1.0 | 2.8 | 8.5 | 1.1 | 3.2 | 7.0 | 1.2 | 3.6 |
| 25 | 61.8 | 0.7 | 0.8 | 43.9 | 0.8 | 1.1 | 32.0 | 0.8 | 1.4 | 24.9 | 0.9 | 1.7 | 19.9 | 0.9 | 2.0 | 16.1 | 1.0 | 2.4 | 13.1 | 1.0 | 2.8 | 10.8 | 1.1 | 3.2 | 8.9 | 1.2 | 3.6 |
| 30 | 74.1 | 0.7 | 0.8 | 52.7 | 0.8 | 1.1 | 38.4 | 0.8 | 1.4 | 29.9 | 0.9 | 1.7 | 23.8 | 0.9 | 2.1 | 19.3 | 1.0 | 2.4 | 15.9 | 1.0 | 2.8 | 13.0 | 1.1 | 3.2 | 10.8 | 1.1 | 3.6 |
| 35 | 86.5 | 0.7 | 0.8 | 61.5 | 0.8 | 1.1 | 44.8 | 0.8 | 1.4 | 34.8 | 0.9 | 1.7 | 27.8 | 0.9 | 2.1 | 22.5 | 1.0 | 2.4 | 18.5 | 1.0 | 2.8 | 15.4 | 1.1 | 3.2 | 12.7 | 1.1 | 3.6 |
| 40 | 98.9 | 0.7 | 0.8 | 70.2 | 0.8 | 1.1 | 51.2 | 0.8 | 1.4 | 39.8 | 0.9 | 1.7 | 31.8 | 0.9 | 2.1 | 25.7 | 1.0 | 2.4 | 21.2 | 1.0 | 2.8 | 17.8 | 1.1 | 3.2 | 14.5 | 1.1 | 3.6 |
| 45 | 111.2 | 0.7 | 0.8 | 79.0 | 0.8 | 1.1 | 57.6 | 0.8 | 1.4 | 44.8 | 0.9 | 1.7 | 38.7 | 0.9 | 2.1 | 29.0 | 1.0 | 2.4 | 23.8 | 1.0 | 2.8 | 19.8 | 1.1 | 3.2 | 16.6 | 1.1 | 3.6 |
| 50 | 123.6 | 0.7 | 0.8 | 87.8 | 0.8 | 1.1 | 64.0 | 0.8 | 1.4 | 49.7 | 0.9 | 1.7 | 39.7 | 0.9 | 2.1 | 32.2 | 1.0 | 2.4 | 26.4 | 1.0 | 2.8 | 22.0 | 1.1 | 3.2 | 18.4 | 1.1 | 3.6 |
| 55 | 136.0 | 0.7 | 0.8 | 96.6 | 0.8 | 1.1 | 70.4 | 0.8 | 1.4 | 54.7 | 0.9 | 1.7 | 43.6 | 0.9 | 2.1 | 35.4 | 1.0 | 2.4 | 29.1 | 1.0 | 2.8 | 24.2 | 1.1 | 3.2 | 20.2 | 1.1 | 3.7 |
| 60 | 148.3 | 0.7 | 0.8 | 105.3 | 0.8 | 1.1 | 76.8 | 0.8 | 1.4 | 58.7 | 0.9 | 1.7 | 47.6 | 0.9 | 2.1 | 38.6 | 1.0 | 2.4 | 31.7 | 1.0 | 2.8 | 26.3 | 1.1 | 3.2 | 22.0 | 1.1 | 3.7 |
| 65 | 160.6 | 0.7 | 0.8 | 114.1 | 0.8 | 1.1 | 83.2 | 0.8 | 1.4 | 64.7 | 0.9 | 1.7 | 51.6 | 0.9 | 2.1 | 41.8 | 1.0 | 2.4 | 34.3 | 1.0 | 2.8 | 28.5 | 1.1 | 3.2 | 23.8 | 1.1 | 3.7 |
| 70 | 173.0 | 0.7 | 0.8 | 122.9 | 0.8 | 1.1 | 89.6 | 0.8 | 1.4 | 69.6 | 0.9 | 1.7 | 55.5 | 0.9 | 2.1 | 45.0 | 1.0 | 2.4 | 37.0 | 1.0 | 2.8 | 30.7 | 1.1 | 3.2 | 25.6 | 1.1 | 3.7 |
| 75 | 185.4 | 0.7 | 0.8 | 131.7 | 0.8 | 1.1 | 96.0 | 0.8 | 1.4 | 74.6 | 0.9 | 1.7 | 59.6 | 0.9 | 2.1 | 48.2 | 1.0 | 2.4 | 39.6 | 1.0 | 2.8 | 32.9 | 1.1 | 3.2 | 27.4 | 1.1 | 3.7 |
| 80 | 197.7 | 0.7 | 0.8 | 140.4 | 0.8 | 1.1 | 102.3 | 0.8 | 1.4 | 79.6 | 0.9 | 1.7 | 63.5 | 0.9 | 2.1 | 51.4 | 1.0 | 2.4 | 42.2 | 1.0 | 2.8 | 35.1 | 1.1 | 3.2 | 29.3 | 1.1 | 3.7 |
| 85 | 210.1 | 0.7 | 0.8 | 149.2 | 0.8 | 1.1 | 108.7 | 0.8 | 1.4 | 84.5 | 0.9 | 1.7 | 67.4 | 0.9 | 2.1 | 54.7 | 1.0 | 2.4 | 44.9 | 1.0 | 2.8 | 37.3 | 1.1 | 3.2 | 31.1 | 1.1 | 3.7 |
| 90 | 222.4 | 0.7 | 0.8 | 158.0 | 0.8 | 1.1 | 115.1 | 0.8 | 1.4 | 89.5 | 0.9 | 1.7 | 71.4 | 0.9 | 2.1 | 57.9 | 1.0 | 2.4 | 47.5 | 1.0 | 2.8 | 39.5 | 1.1 | 3.2 | 32.9 | 1.1 | 3.7 |
| 95 | 234.8 | 0.7 | 0.8 | 166.8 | 0.8 | 1.1 | 121.5 | 0.8 | 1.4 | 94.5 | 0.9 | 1.7 | 75.4 | 0.9 | 2.1 | 61.1 | 1.0 | 2.4 | 50.2 | 1.0 | 2.8 | 41.7 | 1.1 | 3.2 | 34.7 | 1.1 | 3.7 |
| 100 | 247.1 | 0.7 | 0.8 | 175.5 | 0.8 | 1.1 | 127.9 | 0.8 | 1.4 | 99.5 | 0.9 | 1.7 | 79.3 | 0.9 | 2.1 | 64.3 | 1.0 | 2.4 | 52.8 | 1.0 | 2.8 | 43.9 | 1.1 | 3.2 | 36.6 | 1.1 | 3.7 |
| 105 | 259.5 | 0.7 | 0.8 | 184.3 | 0.8 | 1.1 | 134.3 | 0.8 | 1.4 | 104.4 | 0.9 | 1.7 | 83.3 | 0.9 | 2.1 | 67.5 | 1.0 | 2.4 | 55.4 | 1.0 | 2.8 | 46.1 | 1.1 | 3.2 | 38.4 | 1.1 | 3.7 |
| 110 | 271.8 | 0.7 | 0.8 | 193.1 | 0.8 | 1.1 | 140.7 | 0.8 | 1.4 | 109.4 | 0.9 | 1.7 | 87.3 | 0.9 | 2.1 | 70.7 | 1.0 | 2.4 | 58.1 | 1.0 | 2.8 | 48.2 | 1.1 | 3.2 | 40.2 | 1.1 | 3.7 |
| 115 | 284.2 | 0.7 | 0.8 | 201.9 | 0.8 | 1.1 | 147.1 | 0.8 | 1.4 | 114.4 | 0.9 | 1.7 | 91.2 | 0.9 | 2.1 | 73.9 | 1.0 | 2.4 | 60.7 | 1.0 | 2.8 | 50.4 | 1.1 | 3.2 | 42.0 | 1.1 | 3.7 |
| 120 | 296.6 | 0.7 | 0.8 | 210.7 | 0.8 | 1.1 | 153.5 | 0.8 | 1.4 | 119.3 | 0.9 | 1.7 | 95.2 | 0.9 | 2.1 | 77.2 | 1.0 | 2.4 | 63.3 | 1.0 | 2.8 | 52.6 | 1.1 | 3.2 | 43.9 | 1.1 | 3.7 |
| 125 | 308.9 | 0.7 | 0.8 | 219.4 | 0.8 | 1.1 | 159.8 | 0.8 | 1.4 | 124.3 | 0.9 | 1.7 | 99.2 | 0.9 | 2.1 | 80.4 | 1.0 | 2.4 | 66.0 | 1.0 | 2.8 | 54.8 | 1.1 | 3.2 | 45.7 | 1.1 | 3.7 |
| 130 | 321.3 | 0.7 | 0.8 | 228.2 | 0.8 | 1.1 | 166.3 | 0.8 | 1.4 | 129.3 | 0.9 | 1.7 | 103.1 | 0.9 | 2.1 | 83.6 | 1.0 | 2.4 | 68.6 | 1.0 | 2.8 | 57.0 | 1.1 | 3.2 | 47.5 | 1.1 | 3.7 |
| 135 | 333.6 | 0.7 | 0.8 | 237.0 | 0.8 | 1.1 | 172.7 | 0.8 | 1.4 | 134.3 | 0.9 | 1.7 | 107.1 | 0.9 | 2.1 | 86.8 | 1.0 | 2.4 | 71.3 | 1.0 | 2.8 | 59.2 | 1.1 | 3.2 | 49.3 | 1.1 | 3.7 |
| 140 | 346.0 | 0.7 | 0.8 | 245.8 | 0.8 | 1.1 | 179.1 | 0.8 | 1.4 | 139.2 | 0.9 | 1.7 | 111.0 | 0.9 | 2.1 | 90.0 | 1.0 | 2.4 | 73.9 | 1.0 | 2.8 | 61.4 | 1.1 | 3.2 | 51.2 | 1.1 | 3.7 |
| 145 | 358.3 | 0.7 | 0.8 | 254.5 | 0.8 | 1.1 | 185.5 | 0.8 | 1.4 | 144.2 | 0.9 | 1.7 | 115.0 | 0.9 | 2.1 | 93.2 | 1.0 | 2.4 | 76.5 | 1.0 | 2.8 | 63.6 | 1.1 | 3.2 | 53.0 | 1.1 | 3.7 |
| 150 | 370.7 | 0.7 | 0.8 | 263.3 | 0.8 | 1.1 | 191.9 | 0.8 | 1.4 | 149.2 | 0.9 | 1.7 | 119.0 | 0.9 | 2.1 | 96.4 | 1.0 | 2.4 | 79.2 | 1.0 | 2.8 | 66.8 | 1.1 | 3.2 | 54.8 | 1.1 | 3.7 |

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table DV-8 Parabolic Diversion Design Chart (Retardance “D” and “B”, Grade 8.00%)



**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "B"**

**Grade 8.00 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 14.0 | 0.7 | 0.8 | 10.1 | 0.7 | 1.0 | 7.4 | 0.8 | 1.3 | 5.5 | 0.8 | 1.6 | 4.4 | 0.8 | 1.9 | 3.4 | 1.0 | 2.1 | | | | | | | | | |
| 10 | 28.0 | 0.7 | 0.8 | 20.1 | 0.7 | 1.0 | 15.0 | 0.8 | 1.3 | 11.3 | 0.8 | 1.7 | 9.1 | 0.8 | 2.0 | 7.4 | 0.9 | 2.3 | 8.0 | 0.9 | 2.6 | 4.9 | 1.0 | 3.0 | 3.6 | 1.2 | 3.3 |
| 15 | 41.9 | 0.7 | 0.8 | 30.1 | 0.7 | 1.0 | 22.4 | 0.8 | 1.3 | 17.0 | 0.8 | 1.7 | 13.9 | 0.8 | 2.0 | 11.4 | 0.9 | 2.3 | 9.2 | 0.9 | 2.7 | 7.6 | 1.0 | 3.0 | 6.3 | 1.0 | 3.4 |
| 20 | 55.9 | 0.7 | 0.8 | 40.1 | 0.7 | 1.0 | 29.9 | 0.8 | 1.3 | 22.6 | 0.8 | 1.7 | 18.5 | 0.8 | 2.0 | 15.1 | 0.9 | 2.3 | 12.5 | 0.9 | 2.7 | 10.2 | 1.0 | 3.1 | 8.5 | 1.0 | 3.5 |
| 25 | 69.9 | 0.7 | 0.8 | 50.1 | 0.7 | 1.0 | 37.3 | 0.8 | 1.3 | 28.2 | 0.8 | 1.7 | 23.1 | 0.8 | 2.0 | 18.8 | 0.9 | 2.3 | 15.6 | 0.9 | 2.7 | 13.0 | 0.9 | 3.1 | 10.8 | 1.0 | 3.5 |
| 30 | 83.9 | 0.7 | 0.8 | 60.1 | 0.7 | 1.0 | 44.8 | 0.8 | 1.3 | 33.9 | 0.8 | 1.7 | 27.7 | 0.8 | 2.0 | 22.6 | 0.8 | 2.3 | 18.8 | 0.9 | 2.7 | 15.8 | 0.9 | 3.1 | 13.0 | 1.0 | 3.5 |
| 35 | 97.9 | 0.7 | 0.8 | 70.1 | 0.7 | 1.0 | 52.3 | 0.8 | 1.3 | 39.5 | 0.8 | 1.7 | 32.3 | 0.8 | 2.0 | 26.3 | 0.9 | 2.3 | 21.7 | 0.9 | 2.7 | 18.2 | 0.9 | 3.1 | 15.3 | 1.0 | 3.5 |
| 40 | 111.8 | 0.7 | 0.8 | 80.2 | 0.7 | 1.0 | 59.7 | 0.8 | 1.3 | 45.1 | 0.8 | 1.7 | 36.9 | 0.8 | 2.0 | 30.1 | 0.9 | 2.3 | 24.8 | 0.9 | 2.7 | 20.8 | 0.9 | 3.1 | 17.5 | 1.0 | 3.5 |
| 45 | 125.8 | 0.7 | 0.8 | 90.2 | 0.7 | 1.0 | 67.2 | 0.8 | 1.3 | 50.8 | 0.8 | 1.7 | 41.5 | 0.8 | 2.0 | 33.8 | 0.9 | 2.3 | 27.9 | 0.9 | 2.7 | 23.3 | 0.9 | 3.1 | 19.7 | 1.0 | 3.5 |
| 50 | 139.8 | 0.7 | 0.8 | 100.2 | 0.7 | 1.0 | 74.7 | 0.8 | 1.3 | 56.4 | 0.8 | 1.7 | 46.1 | 0.8 | 2.0 | 37.6 | 0.9 | 2.3 | 31.0 | 0.9 | 2.7 | 25.9 | 0.9 | 3.1 | 21.9 | 1.0 | 3.5 |
| 55 | 153.8 | 0.7 | 0.8 | 110.2 | 0.7 | 1.0 | 82.1 | 0.8 | 1.3 | 62.1 | 0.8 | 1.7 | 50.7 | 0.8 | 2.0 | 41.3 | 0.9 | 2.3 | 34.1 | 0.9 | 2.7 | 28.5 | 0.9 | 3.1 | 24.0 | 1.0 | 3.5 |
| 60 | 167.8 | 0.7 | 0.8 | 120.2 | 0.7 | 1.0 | 89.6 | 0.8 | 1.3 | 67.7 | 0.8 | 1.7 | 55.3 | 0.8 | 2.0 | 45.1 | 0.9 | 2.3 | 37.2 | 0.9 | 2.7 | 31.1 | 0.9 | 3.1 | 26.2 | 1.0 | 3.5 |
| 65 | 181.7 | 0.7 | 0.8 | 130.3 | 0.7 | 1.0 | 97.0 | 0.8 | 1.3 | 73.3 | 0.8 | 1.7 | 60.0 | 0.8 | 2.0 | 48.8 | 0.9 | 2.3 | 40.3 | 0.9 | 2.7 | 33.7 | 0.9 | 3.1 | 28.4 | 1.0 | 3.5 |
| 70 | 195.7 | 0.7 | 0.8 | 140.3 | 0.7 | 1.0 | 104.5 | 0.8 | 1.3 | 79.0 | 0.8 | 1.7 | 64.6 | 0.8 | 2.0 | 52.6 | 0.9 | 2.3 | 43.4 | 0.9 | 2.7 | 36.3 | 0.9 | 3.1 | 30.6 | 1.0 | 3.5 |
| 75 | 209.7 | 0.7 | 0.8 | 150.3 | 0.7 | 1.0 | 112.0 | 0.8 | 1.3 | 84.6 | 0.8 | 1.7 | 69.2 | 0.8 | 2.0 | 56.3 | 0.9 | 2.3 | 46.6 | 0.9 | 2.7 | 38.9 | 0.9 | 3.1 | 32.8 | 1.0 | 3.5 |
| 80 | 223.7 | 0.7 | 0.8 | 160.3 | 0.7 | 1.0 | 119.4 | 0.8 | 1.3 | 90.3 | 0.8 | 1.7 | 73.8 | 0.8 | 2.0 | 60.1 | 0.9 | 2.3 | 49.8 | 0.9 | 2.7 | 41.4 | 0.9 | 3.1 | 35.0 | 1.0 | 3.5 |
| 85 | 237.7 | 0.7 | 0.8 | 170.3 | 0.7 | 1.0 | 126.9 | 0.8 | 1.3 | 95.9 | 0.8 | 1.7 | 78.4 | 0.8 | 2.0 | 63.8 | 0.9 | 2.3 | 52.7 | 0.9 | 2.7 | 44.0 | 0.9 | 3.1 | 37.1 | 1.0 | 3.5 |
| 90 | 251.6 | 0.7 | 0.8 | 180.3 | 0.7 | 1.0 | 134.4 | 0.8 | 1.3 | 101.8 | 0.8 | 1.7 | 83.0 | 0.8 | 2.0 | 67.6 | 0.9 | 2.3 | 55.8 | 0.9 | 2.7 | 46.6 | 0.9 | 3.1 | 39.3 | 1.0 | 3.5 |
| 95 | 265.6 | 0.7 | 0.8 | 190.4 | 0.7 | 1.0 | 141.8 | 0.8 | 1.3 | 107.2 | 0.8 | 1.7 | 87.6 | 0.8 | 2.0 | 71.3 | 0.9 | 2.3 | 58.9 | 0.9 | 2.7 | 49.2 | 0.9 | 3.1 | 41.5 | 1.0 | 3.5 |
| 100 | 279.6 | 0.7 | 0.8 | 200.4 | 0.7 | 1.0 | 149.3 | 0.8 | 1.3 | 112.8 | 0.8 | 1.7 | 92.2 | 0.8 | 2.0 | 75.1 | 0.9 | 2.3 | 62.0 | 0.9 | 2.7 | 51.8 | 0.9 | 3.1 | 43.7 | 1.0 | 3.5 |
| 105 | 293.6 | 0.7 | 0.8 | 210.4 | 0.7 | 1.0 | 156.8 | 0.8 | 1.3 | 118.5 | 0.8 | 1.7 | 96.8 | 0.8 | 2.0 | 78.9 | 0.9 | 2.3 | 65.1 | 0.9 | 2.7 | 54.4 | 0.9 | 3.1 | 45.9 | 1.0 | 3.5 |
| 110 | 307.6 | 0.7 | 0.8 | 220.4 | 0.7 | 1.0 | 164.2 | 0.8 | 1.3 | 124.1 | 0.8 | 1.7 | 101.4 | 0.8 | 2.0 | 82.6 | 0.9 | 2.3 | 68.2 | 0.9 | 2.7 | 57.0 | 0.9 | 3.1 | 48.0 | 1.0 | 3.5 |
| 115 | 321.6 | 0.7 | 0.8 | 230.4 | 0.7 | 1.0 | 171.7 | 0.8 | 1.3 | 129.8 | 0.8 | 1.7 | 106.1 | 0.8 | 2.0 | 86.4 | 0.9 | 2.3 | 71.3 | 0.9 | 2.7 | 59.6 | 0.9 | 3.1 | 50.2 | 1.0 | 3.5 |
| 120 | 335.5 | 0.7 | 0.8 | 240.5 | 0.7 | 1.0 | 179.1 | 0.8 | 1.3 | 135.4 | 0.8 | 1.7 | 110.7 | 0.8 | 2.0 | 90.1 | 0.9 | 2.3 | 74.4 | 0.9 | 2.7 | 62.2 | 0.9 | 3.1 | 52.4 | 1.0 | 3.5 |
| 125 | 349.5 | 0.7 | 0.8 | 250.5 | 0.7 | 1.0 | 186.6 | 0.8 | 1.3 | 141.0 | 0.8 | 1.7 | 115.3 | 0.8 | 2.0 | 93.9 | 0.9 | 2.3 | 77.5 | 0.9 | 2.7 | 64.7 | 0.9 | 3.1 | 54.6 | 1.0 | 3.5 |
| 130 | 363.5 | 0.7 | 0.8 | 260.5 | 0.7 | 1.0 | 194.1 | 0.8 | 1.3 | 146.7 | 0.8 | 1.7 | 119.9 | 0.8 | 2.0 | 97.6 | 0.9 | 2.3 | 80.6 | 0.9 | 2.7 | 67.3 | 0.9 | 3.1 | 56.8 | 1.0 | 3.5 |
| 135 | 377.5 | 0.7 | 0.8 | 270.5 | 0.7 | 1.0 | 201.6 | 0.8 | 1.3 | 152.3 | 0.8 | 1.7 | 124.5 | 0.8 | 2.0 | 101.4 | 0.9 | 2.3 | 83.7 | 0.9 | 2.7 | 69.9 | 0.9 | 3.1 | 59.0 | 1.0 | 3.5 |
| 140 | 391.5 | 0.7 | 0.8 | 280.5 | 0.7 | 1.0 | 209.0 | 0.8 | 1.3 | 158.0 | 0.8 | 1.7 | 129.1 | 0.8 | 2.0 | 105.1 | 0.9 | 2.3 | 86.8 | 0.9 | 2.7 | 72.5 | 0.9 | 3.1 | 61.1 | 1.0 | 3.5 |
| 145 | 405.4 | 0.7 | 0.8 | 290.6 | 0.7 | 1.0 | 216.5 | 0.8 | 1.3 | 163.6 | 0.8 | 1.7 | 133.7 | 0.8 | 2.0 | 108.9 | 0.9 | 2.3 | 89.9 | 0.9 | 2.7 | 75.1 | 0.9 | 3.1 | 63.3 | 1.0 | 3.5 |
| 150 | 419.4 | 0.7 | 0.8 | 300.6 | 0.7 | 1.0 | 223.9 | 0.8 | 1.3 | 169.3 | 0.8 | 1.7 | 138.3 | 0.8 | 2.0 | 112.6 | 0.9 | 2.3 | 93.0 | 0.9 | 2.7 | 77.7 | 0.9 | 3.1 | 65.5 | 1.0 | 3.5 |

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table DV-9 Parabolic Diversion Design Chart (Retardance “D” and “B”, Grade 10.00%)

**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "B"**

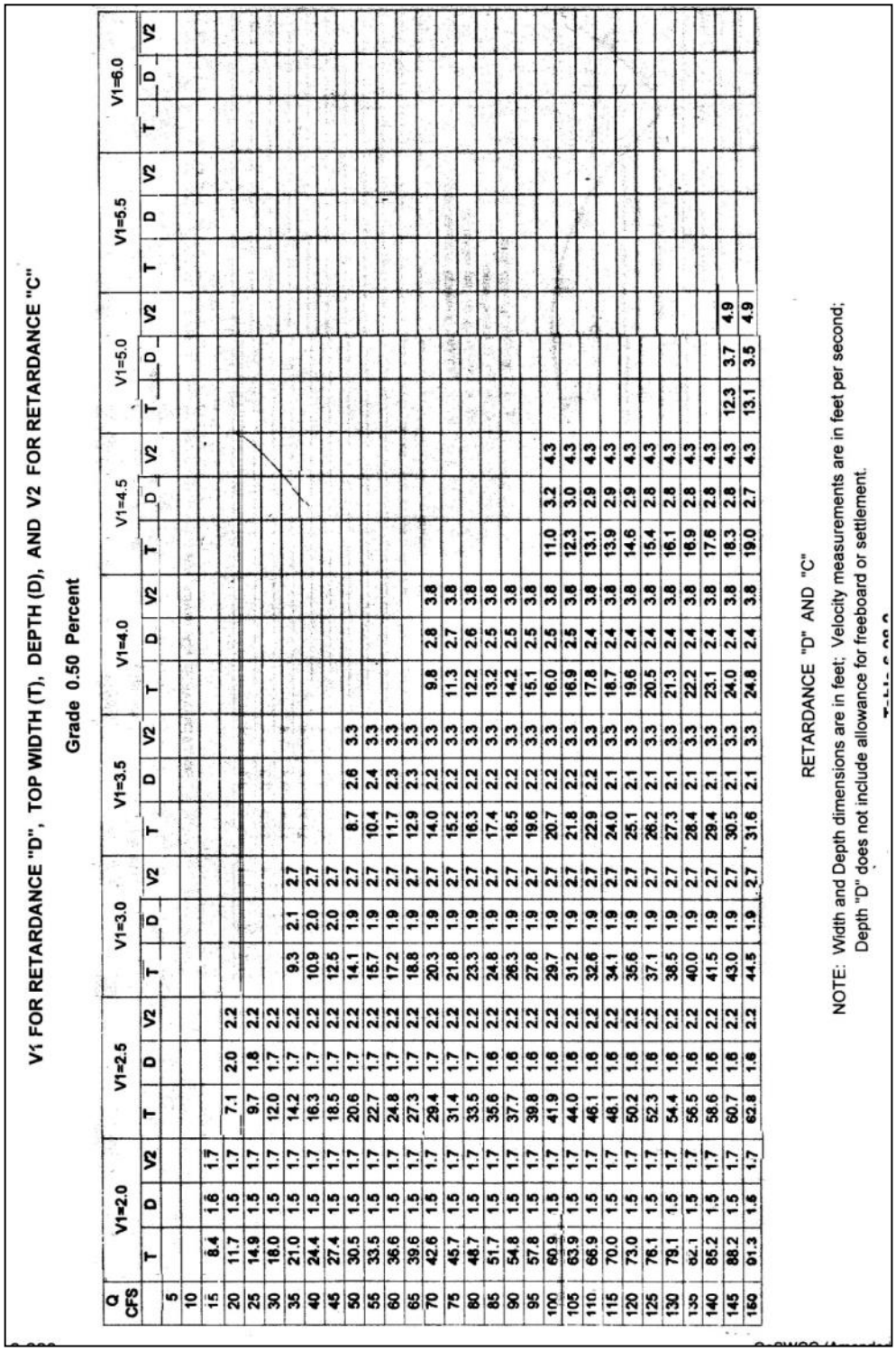
**Grade 10.00 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 15.3 | 0.6 | 0.8 | 11.1 | 0.7 | 1.0 | 8.1 | 0.7 | 1.3 | 6.3 | 0.7 | 1.6 | 4.8 | 0.8 | 1.9 | 4.0 | 0.9 | 2.2 | 3.1 | 1.0 | 2.4 | | | | | | |
| 10 | 30.6 | 0.6 | 0.8 | 22.1 | 0.7 | 1.0 | 16.5 | 0.7 | 1.3 | 12.8 | 0.7 | 1.6 | 10.0 | 0.8 | 2.0 | 8.4 | 0.8 | 2.2 | 6.9 | 0.8 | 2.6 | 5.7 | 0.9 | 2.8 | 4.7 | 1.0 | 3.3 |
| 15 | 45.9 | 0.6 | 0.8 | 33.2 | 0.7 | 1.0 | 24.7 | 0.7 | 1.3 | 19.2 | 0.7 | 1.6 | 15.0 | 0.8 | 2.0 | 12.7 | 0.8 | 2.2 | 10.5 | 0.8 | 2.6 | 8.7 | 0.9 | 3.0 | 7.3 | 0.9 | 3.3 |
| 20 | 61.2 | 0.6 | 0.8 | 44.2 | 0.7 | 1.0 | 32.9 | 0.7 | 1.3 | 25.6 | 0.7 | 1.6 | 20.0 | 0.8 | 2.0 | 17.0 | 0.8 | 2.2 | 14.1 | 0.8 | 2.6 | 11.8 | 0.9 | 3.0 | 9.8 | 0.9 | 3.4 |
| 25 | 76.5 | 0.6 | 0.8 | 55.3 | 0.7 | 1.0 | 41.1 | 0.7 | 1.3 | 32.0 | 0.7 | 1.6 | 25.0 | 0.8 | 2.0 | 21.2 | 0.8 | 2.3 | 17.6 | 0.8 | 2.6 | 14.7 | 0.9 | 3.0 | 12.5 | 0.9 | 3.4 |
| 30 | 91.8 | 0.6 | 0.8 | 66.3 | 0.7 | 1.0 | 49.3 | 0.7 | 1.3 | 38.3 | 0.7 | 1.6 | 29.9 | 0.8 | 2.0 | 25.4 | 0.8 | 2.3 | 21.1 | 0.8 | 2.6 | 17.7 | 0.8 | 3.0 | 15.0 | 0.9 | 3.3 |
| 35 | 107.1 | 0.6 | 0.8 | 77.4 | 0.7 | 1.0 | 57.5 | 0.7 | 1.3 | 44.7 | 0.7 | 1.6 | 34.8 | 0.8 | 2.0 | 29.7 | 0.8 | 2.3 | 24.6 | 0.8 | 2.6 | 20.6 | 0.8 | 3.0 | 17.5 | 0.9 | 3.4 |
| 40 | 122.4 | 0.6 | 0.8 | 88.4 | 0.7 | 1.0 | 65.7 | 0.7 | 1.3 | 51.1 | 0.7 | 1.6 | 39.9 | 0.8 | 2.0 | 33.9 | 0.8 | 2.3 | 28.1 | 0.8 | 2.6 | 23.5 | 0.8 | 3.0 | 20.0 | 0.9 | 3.4 |
| 45 | 137.8 | 0.6 | 0.8 | 99.5 | 0.7 | 1.0 | 73.9 | 0.7 | 1.3 | 57.5 | 0.7 | 1.6 | 44.9 | 0.8 | 2.0 | 38.0 | 0.8 | 2.3 | 31.6 | 0.8 | 2.6 | 26.5 | 0.8 | 3.0 | 22.5 | 0.9 | 3.4 |
| 50 | 153.1 | 0.6 | 0.8 | 110.6 | 0.7 | 1.0 | 82.1 | 0.7 | 1.3 | 63.9 | 0.7 | 1.6 | 49.9 | 0.8 | 2.0 | 42.2 | 0.8 | 2.3 | 35.1 | 0.8 | 2.6 | 29.4 | 0.8 | 3.0 | 25.0 | 0.9 | 3.4 |
| 55 | 168.4 | 0.6 | 0.8 | 121.6 | 0.7 | 1.0 | 90.3 | 0.7 | 1.3 | 70.3 | 0.7 | 1.6 | 54.9 | 0.8 | 2.0 | 46.4 | 0.8 | 2.3 | 38.6 | 0.8 | 2.6 | 32.3 | 0.8 | 3.0 | 27.5 | 0.9 | 3.4 |
| 60 | 183.7 | 0.6 | 0.8 | 132.7 | 0.7 | 1.0 | 98.6 | 0.7 | 1.3 | 76.7 | 0.7 | 1.6 | 59.9 | 0.8 | 2.0 | 50.7 | 0.8 | 2.3 | 42.1 | 0.8 | 2.6 | 35.3 | 0.8 | 3.0 | 30.0 | 0.9 | 3.4 |
| 65 | 199.0 | 0.6 | 0.8 | 143.7 | 0.7 | 1.0 | 106.7 | 0.7 | 1.3 | 83.1 | 0.7 | 1.6 | 64.8 | 0.8 | 2.0 | 54.9 | 0.8 | 2.3 | 45.6 | 0.8 | 2.6 | 38.2 | 0.8 | 3.0 | 32.5 | 0.9 | 3.4 |
| 70 | 214.3 | 0.6 | 0.8 | 154.8 | 0.7 | 1.0 | 115.0 | 0.7 | 1.3 | 89.4 | 0.7 | 1.6 | 69.8 | 0.8 | 2.0 | 59.1 | 0.8 | 2.3 | 49.1 | 0.8 | 2.6 | 41.2 | 0.8 | 3.0 | 35.0 | 0.9 | 3.4 |
| 75 | 229.6 | 0.6 | 0.8 | 165.8 | 0.7 | 1.0 | 123.2 | 0.7 | 1.3 | 95.8 | 0.7 | 1.6 | 74.8 | 0.8 | 2.0 | 63.3 | 0.8 | 2.3 | 52.6 | 0.8 | 2.6 | 44.1 | 0.8 | 3.0 | 37.4 | 0.9 | 3.4 |
| 80 | 244.9 | 0.6 | 0.8 | 176.9 | 0.7 | 1.0 | 131.4 | 0.7 | 1.3 | 102.2 | 0.7 | 1.6 | 79.8 | 0.8 | 2.0 | 67.6 | 0.8 | 2.3 | 56.1 | 0.8 | 2.6 | 47.0 | 0.8 | 3.0 | 39.8 | 0.9 | 3.4 |
| 85 | 260.2 | 0.6 | 0.8 | 187.9 | 0.7 | 1.0 | 139.6 | 0.7 | 1.3 | 108.6 | 0.7 | 1.6 | 84.8 | 0.8 | 2.0 | 71.8 | 0.8 | 2.3 | 59.6 | 0.8 | 2.6 | 50.0 | 0.8 | 3.0 | 42.3 | 0.9 | 3.4 |
| 90 | 275.5 | 0.6 | 0.8 | 199.0 | 0.7 | 1.0 | 147.8 | 0.7 | 1.3 | 115.0 | 0.7 | 1.6 | 89.8 | 0.8 | 2.0 | 76.0 | 0.8 | 2.3 | 63.1 | 0.8 | 2.6 | 52.9 | 0.8 | 3.0 | 44.6 | 0.9 | 3.4 |
| 95 | 290.8 | 0.6 | 0.8 | 210.0 | 0.7 | 1.0 | 156.0 | 0.7 | 1.3 | 121.4 | 0.7 | 1.6 | 94.8 | 0.8 | 2.0 | 80.2 | 0.8 | 2.3 | 66.6 | 0.8 | 2.6 | 55.8 | 0.8 | 3.0 | 47.3 | 0.9 | 3.4 |
| 100 | 306.1 | 0.6 | 0.8 | 221.1 | 0.7 | 1.0 | 164.2 | 0.7 | 1.3 | 127.8 | 0.7 | 1.6 | 99.8 | 0.8 | 2.0 | 84.4 | 0.8 | 2.3 | 70.1 | 0.8 | 2.6 | 58.8 | 0.8 | 3.0 | 49.7 | 0.9 | 3.4 |
| 105 | 321.4 | 0.6 | 0.8 | 232.2 | 0.7 | 1.0 | 172.4 | 0.7 | 1.3 | 134.2 | 0.7 | 1.6 | 104.7 | 0.8 | 2.0 | 88.7 | 0.8 | 2.3 | 73.6 | 0.8 | 2.6 | 61.7 | 0.8 | 3.0 | 52.2 | 0.9 | 3.4 |
| 110 | 336.7 | 0.6 | 0.8 | 243.2 | 0.7 | 1.0 | 180.6 | 0.7 | 1.3 | 140.5 | 0.7 | 1.6 | 109.7 | 0.8 | 2.0 | 92.9 | 0.8 | 2.3 | 77.1 | 0.8 | 2.6 | 64.7 | 0.8 | 3.0 | 54.7 | 0.9 | 3.4 |
| 115 | 352.0 | 0.6 | 0.8 | 254.3 | 0.7 | 1.0 | 188.8 | 0.7 | 1.3 | 146.9 | 0.7 | 1.6 | 114.7 | 0.8 | 2.0 | 97.1 | 0.8 | 2.3 | 80.6 | 0.8 | 2.6 | 67.6 | 0.8 | 3.0 | 57.2 | 0.9 | 3.4 |
| 120 | 367.3 | 0.6 | 0.8 | 265.3 | 0.7 | 1.0 | 197.1 | 0.7 | 1.3 | 153.3 | 0.7 | 1.6 | 119.7 | 0.8 | 2.0 | 101.3 | 0.8 | 2.3 | 84.1 | 0.8 | 2.6 | 70.5 | 0.8 | 3.0 | 59.7 | 0.9 | 3.4 |
| 125 | 382.6 | 0.8 | 0.8 | 276.4 | 0.7 | 1.0 | 205.3 | 0.7 | 1.3 | 159.7 | 0.7 | 1.6 | 124.7 | 0.8 | 2.0 | 105.5 | 0.8 | 2.3 | 87.6 | 0.8 | 2.6 | 73.5 | 0.8 | 3.0 | 62.2 | 0.9 | 3.4 |
| 130 | 397.9 | 0.6 | 0.8 | 287.4 | 0.7 | 1.0 | 213.5 | 0.7 | 1.3 | 166.1 | 0.7 | 1.6 | 129.7 | 0.8 | 2.0 | 109.8 | 0.8 | 2.3 | 91.1 | 0.8 | 2.6 | 76.4 | 0.8 | 3.0 | 64.7 | 0.9 | 3.4 |
| 135 | 413.2 | 0.6 | 0.8 | 298.5 | 0.7 | 1.0 | 221.7 | 0.7 | 1.3 | 172.5 | 0.7 | 1.6 | 134.7 | 0.8 | 2.0 | 114.0 | 0.8 | 2.3 | 94.6 | 0.8 | 2.6 | 79.3 | 0.8 | 3.0 | 67.2 | 0.9 | 3.4 |
| 140 | 428.6 | 0.6 | 0.8 | 309.6 | 0.7 | 1.0 | 229.9 | 0.7 | 1.3 | 178.9 | 0.7 | 1.6 | 139.7 | 0.8 | 2.0 | 118.2 | 0.8 | 2.3 | 98.1 | 0.8 | 2.6 | 82.3 | 0.8 | 3.0 | 69.6 | 0.9 | 3.4 |
| 145 | 443.9 | 0.6 | 0.8 | 320.6 | 0.7 | 1.0 | 238.1 | 0.7 | 1.3 | 185.3 | 0.7 | 1.6 | 144.6 | 0.8 | 2.0 | 122.4 | 0.8 | 2.3 | 101.7 | 0.8 | 2.6 | 85.2 | 0.8 | 3.0 | 72.1 | 0.9 | 3.4 |
| 150 | 459.2 | 0.6 | 0.8 | 331.7 | 0.7 | 1.0 | 246.3 | 0.7 | 1.3 | 191.6 | 0.7 | 1.6 | 149.6 | 0.8 | 2.0 | 126.7 | 0.8 | 2.3 | 105.2 | 0.8 | 2.6 | 88.2 | 0.9 | 3.0 | 74.6 | 0.9 | 3.4 |

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table DV-10 Parabolic Diversion Design Chart (Retardance “D” and “C”, Grade .50%)



V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"

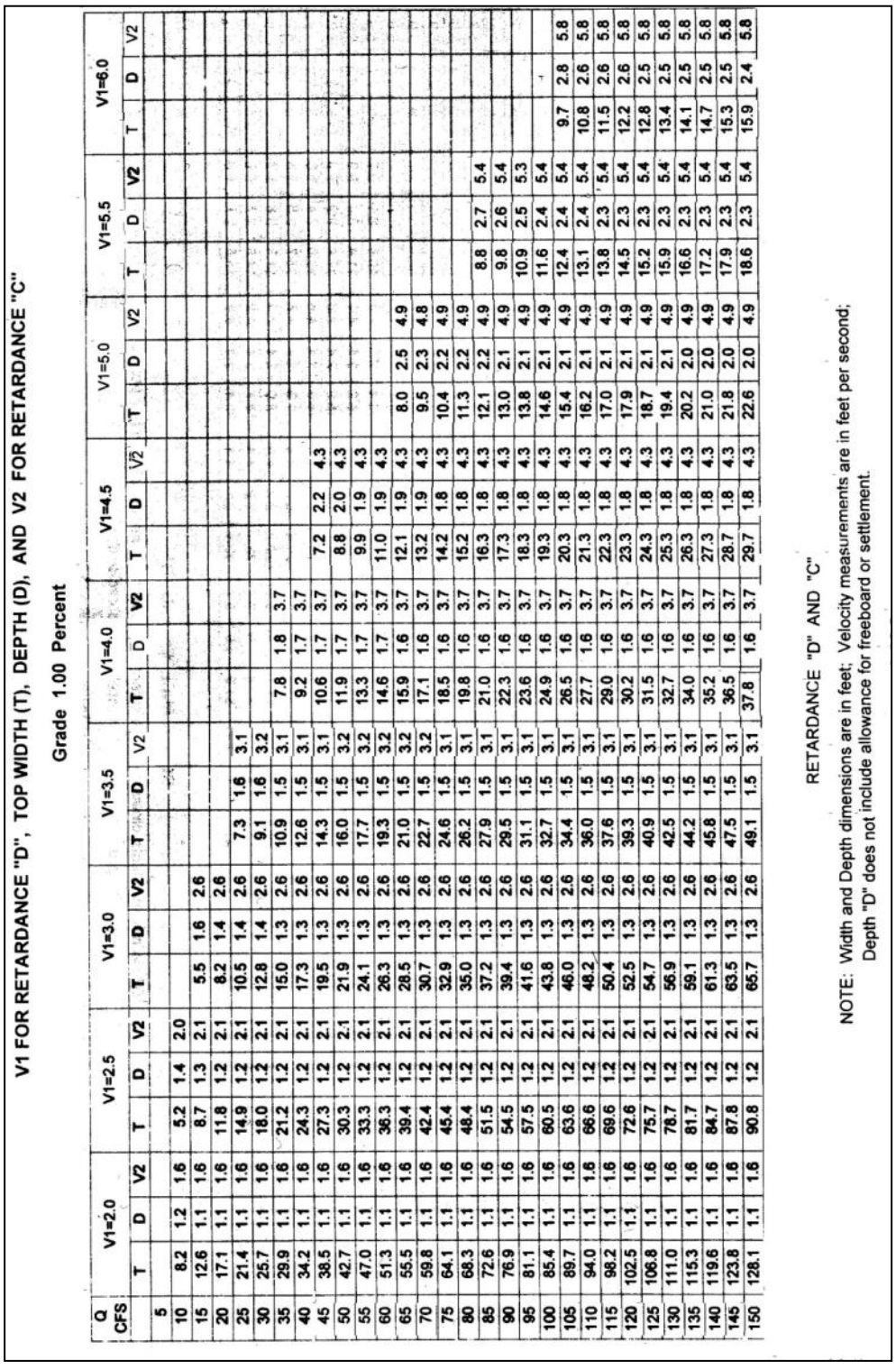
Grade 0.50 Percent

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | 8.4 | 1.6 | 1.7 | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | 11.7 | 1.5 | 1.7 | 7.1 | 2.0 | 2.2 | | | | | | | | | | | | | | | | | | | | | |
| 25 | 14.9 | 1.5 | 1.7 | 9.7 | 1.8 | 2.2 | | | | | | | | | | | | | | | | | | | | | |
| 30 | 18.0 | 1.5 | 1.7 | 12.0 | 1.7 | 2.2 | | | | | | | | | | | | | | | | | | | | | |
| 35 | 21.0 | 1.5 | 1.7 | 14.2 | 1.7 | 2.2 | 9.3 | 2.1 | 2.7 | | | | | | | | | | | | | | | | | | |
| 40 | 24.4 | 1.5 | 1.7 | 16.3 | 1.7 | 2.2 | 10.9 | 2.0 | 2.7 | | | | | | | | | | | | | | | | | | |
| 45 | 27.4 | 1.5 | 1.7 | 18.5 | 1.7 | 2.2 | 12.5 | 2.0 | 2.7 | | | | | | | | | | | | | | | | | | |
| 50 | 30.5 | 1.5 | 1.7 | 20.6 | 1.7 | 2.2 | 14.1 | 1.9 | 2.7 | 8.7 | 2.6 | 3.3 | | | | | | | | | | | | | | | |
| 55 | 33.5 | 1.5 | 1.7 | 22.7 | 1.7 | 2.2 | 15.7 | 1.9 | 2.7 | 10.4 | 2.4 | 3.3 | | | | | | | | | | | | | | | |
| 60 | 36.6 | 1.5 | 1.7 | 24.8 | 1.7 | 2.2 | 17.2 | 1.9 | 2.7 | 11.7 | 2.3 | 3.3 | | | | | | | | | | | | | | | |
| 65 | 39.6 | 1.5 | 1.7 | 27.3 | 1.7 | 2.2 | 18.8 | 1.9 | 2.7 | 12.9 | 2.3 | 3.3 | | | | | | | | | | | | | | | |
| 70 | 42.6 | 1.5 | 1.7 | 29.4 | 1.7 | 2.2 | 20.3 | 1.9 | 2.7 | 14.0 | 2.2 | 3.3 | 9.8 | 2.8 | 3.8 | | | | | | | | | | | | |
| 75 | 45.7 | 1.5 | 1.7 | 31.4 | 1.7 | 2.2 | 21.8 | 1.9 | 2.7 | 15.2 | 2.2 | 3.3 | 11.3 | 2.7 | 3.8 | | | | | | | | | | | | |
| 80 | 48.7 | 1.5 | 1.7 | 33.5 | 1.7 | 2.2 | 23.3 | 1.9 | 2.7 | 16.3 | 2.2 | 3.3 | 12.2 | 2.6 | 3.8 | | | | | | | | | | | | |
| 85 | 51.7 | 1.5 | 1.7 | 35.6 | 1.6 | 2.2 | 24.8 | 1.9 | 2.7 | 17.4 | 2.2 | 3.3 | 13.2 | 2.5 | 3.8 | | | | | | | | | | | | |
| 90 | 54.8 | 1.5 | 1.7 | 37.7 | 1.6 | 2.2 | 26.3 | 1.9 | 2.7 | 18.5 | 2.2 | 3.3 | 14.2 | 2.5 | 3.8 | | | | | | | | | | | | |
| 95 | 57.8 | 1.5 | 1.7 | 39.8 | 1.6 | 2.2 | 27.8 | 1.9 | 2.7 | 19.6 | 2.2 | 3.3 | 15.1 | 2.5 | 3.8 | | | | | | | | | | | | |
| 100 | 60.9 | 1.5 | 1.7 | 41.9 | 1.6 | 2.2 | 29.7 | 1.9 | 2.7 | 20.7 | 2.2 | 3.3 | 16.0 | 2.5 | 3.8 | 11.0 | 3.2 | 4.3 | | | | | | | | | |
| 105 | 63.9 | 1.5 | 1.7 | 44.0 | 1.6 | 2.2 | 31.2 | 1.9 | 2.7 | 21.8 | 2.2 | 3.3 | 16.9 | 2.5 | 3.8 | 12.3 | 3.0 | 4.3 | | | | | | | | | |
| 110 | 66.9 | 1.5 | 1.7 | 46.1 | 1.6 | 2.2 | 32.6 | 1.9 | 2.7 | 22.9 | 2.2 | 3.3 | 17.8 | 2.4 | 3.8 | 13.1 | 2.9 | 4.3 | | | | | | | | | |
| 115 | 70.0 | 1.5 | 1.7 | 48.1 | 1.6 | 2.2 | 34.1 | 1.9 | 2.7 | 24.0 | 2.1 | 3.3 | 18.7 | 2.4 | 3.8 | 13.9 | 2.9 | 4.3 | | | | | | | | | |
| 120 | 73.0 | 1.5 | 1.7 | 50.2 | 1.6 | 2.2 | 35.6 | 1.9 | 2.7 | 25.1 | 2.1 | 3.3 | 19.6 | 2.4 | 3.8 | 14.6 | 2.9 | 4.3 | | | | | | | | | |
| 125 | 76.1 | 1.5 | 1.7 | 52.3 | 1.6 | 2.2 | 37.1 | 1.9 | 2.7 | 26.2 | 2.1 | 3.3 | 20.5 | 2.4 | 3.8 | 15.4 | 2.8 | 4.3 | | | | | | | | | |
| 130 | 79.1 | 1.5 | 1.7 | 54.4 | 1.6 | 2.2 | 38.5 | 1.9 | 2.7 | 27.3 | 2.1 | 3.3 | 21.3 | 2.4 | 3.8 | 16.1 | 2.8 | 4.3 | | | | | | | | | |
| 135 | 82.1 | 1.5 | 1.7 | 56.5 | 1.6 | 2.2 | 40.0 | 1.9 | 2.7 | 28.4 | 2.1 | 3.3 | 22.2 | 2.4 | 3.8 | 16.9 | 2.8 | 4.3 | | | | | | | | | |
| 140 | 85.2 | 1.5 | 1.7 | 58.6 | 1.6 | 2.2 | 41.5 | 1.9 | 2.7 | 29.4 | 2.1 | 3.3 | 23.1 | 2.4 | 3.8 | 17.6 | 2.8 | 4.3 | | | | | | | | | |
| 145 | 88.2 | 1.5 | 1.7 | 60.7 | 1.6 | 2.2 | 43.0 | 1.9 | 2.7 | 30.5 | 2.1 | 3.3 | 24.0 | 2.4 | 3.8 | 18.3 | 2.8 | 4.3 | 12.3 | 3.7 | 4.9 | | | | | | |
| 150 | 91.3 | 1.6 | 1.7 | 62.8 | 1.6 | 2.2 | 44.5 | 1.9 | 2.7 | 31.6 | 2.1 | 3.3 | 24.8 | 2.4 | 3.8 | 19.0 | 2.7 | 4.3 | 13.1 | 3.5 | 4.9 | | | | | | |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table DV-11 Parabolic Diversion Design Chart (Retardance “D” and “C”, Grade 1.00%)



V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"

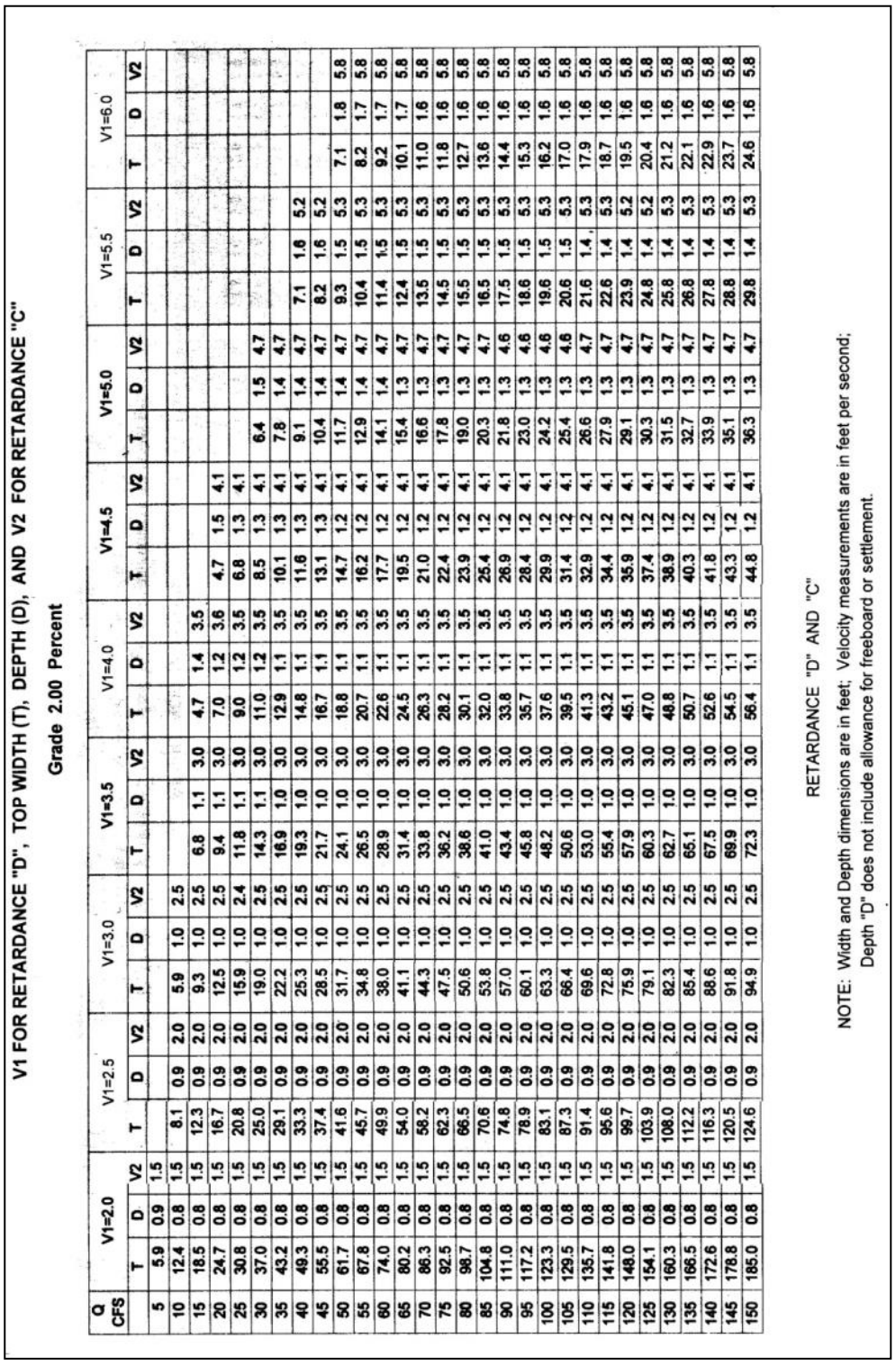
Grade 1.00 Percent

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | 8.2 | 1.2 | 1.6 | 5.2 | 1.4 | 2.0 | | | | | | | | | | | | | | | | | | | | | |
| 15 | 12.6 | 1.1 | 1.6 | 8.7 | 1.3 | 2.1 | 5.5 | 1.6 | 2.6 | | | | | | | | | | | | | | | | | | |
| 20 | 17.1 | 1.1 | 1.6 | 11.8 | 1.2 | 2.1 | 8.2 | 1.4 | 2.6 | | | | | | | | | | | | | | | | | | |
| 25 | 21.4 | 1.1 | 1.6 | 14.9 | 1.2 | 2.1 | 10.5 | 1.4 | 2.6 | 7.3 | 1.6 | 3.1 | | | | | | | | | | | | | | | |
| 30 | 25.7 | 1.1 | 1.6 | 18.0 | 1.2 | 2.1 | 12.8 | 1.4 | 2.6 | 9.1 | 1.6 | 3.2 | | | | | | | | | | | | | | | |
| 35 | 29.9 | 1.1 | 1.6 | 21.2 | 1.2 | 2.1 | 15.0 | 1.3 | 2.6 | 10.9 | 1.5 | 3.1 | 7.8 | 1.8 | 3.7 | | | | | | | | | | | | |
| 40 | 34.2 | 1.1 | 1.6 | 24.3 | 1.2 | 2.1 | 17.3 | 1.3 | 2.6 | 12.6 | 1.5 | 3.1 | 9.2 | 1.7 | 3.7 | | | | | | | | | | | | |
| 45 | 38.5 | 1.1 | 1.6 | 27.3 | 1.2 | 2.1 | 19.5 | 1.3 | 2.6 | 14.3 | 1.5 | 3.1 | 10.6 | 1.7 | 3.7 | 7.2 | 2.2 | 4.3 | | | | | | | | | |
| 50 | 42.7 | 1.1 | 1.6 | 30.3 | 1.2 | 2.1 | 21.9 | 1.3 | 2.6 | 16.0 | 1.5 | 3.2 | 11.9 | 1.7 | 3.7 | 8.8 | 2.0 | 4.3 | | | | | | | | | |
| 55 | 47.0 | 1.1 | 1.6 | 33.3 | 1.2 | 2.1 | 24.1 | 1.3 | 2.6 | 17.7 | 1.5 | 3.2 | 13.3 | 1.7 | 3.7 | 9.9 | 1.9 | 4.3 | | | | | | | | | |
| 60 | 51.3 | 1.1 | 1.6 | 36.3 | 1.2 | 2.1 | 26.3 | 1.3 | 2.6 | 19.3 | 1.5 | 3.2 | 14.6 | 1.7 | 3.7 | 11.0 | 1.9 | 4.3 | | | | | | | | | |
| 65 | 55.5 | 1.1 | 1.6 | 39.4 | 1.2 | 2.1 | 28.5 | 1.3 | 2.6 | 21.0 | 1.5 | 3.2 | 15.9 | 1.6 | 3.7 | 12.1 | 1.9 | 4.3 | 8.0 | 2.5 | 4.9 | | | | | | |
| 70 | 59.8 | 1.1 | 1.6 | 42.4 | 1.2 | 2.1 | 30.7 | 1.3 | 2.6 | 22.7 | 1.5 | 3.2 | 17.1 | 1.6 | 3.7 | 13.2 | 1.9 | 4.3 | 9.5 | 2.3 | 4.8 | | | | | | |
| 75 | 64.1 | 1.1 | 1.6 | 45.4 | 1.2 | 2.1 | 32.9 | 1.3 | 2.6 | 24.6 | 1.5 | 3.1 | 18.5 | 1.6 | 3.7 | 14.2 | 1.8 | 4.3 | 10.4 | 2.2 | 4.9 | | | | | | |
| 80 | 68.3 | 1.1 | 1.6 | 48.4 | 1.2 | 2.1 | 35.0 | 1.3 | 2.6 | 26.2 | 1.5 | 3.1 | 19.8 | 1.6 | 3.7 | 15.2 | 1.8 | 4.3 | 11.3 | 2.2 | 4.9 | | | | | | |
| 85 | 72.6 | 1.1 | 1.6 | 51.5 | 1.2 | 2.1 | 37.2 | 1.3 | 2.6 | 27.9 | 1.5 | 3.1 | 21.0 | 1.6 | 3.7 | 16.3 | 1.8 | 4.3 | 12.1 | 2.2 | 4.9 | 8.8 | 2.7 | 5.4 | | | |
| 90 | 76.9 | 1.1 | 1.6 | 54.5 | 1.2 | 2.1 | 39.4 | 1.3 | 2.6 | 29.5 | 1.5 | 3.1 | 22.3 | 1.6 | 3.7 | 17.3 | 1.8 | 4.3 | 13.0 | 2.1 | 4.9 | 9.8 | 2.6 | 5.4 | | | |
| 95 | 81.1 | 1.1 | 1.6 | 57.5 | 1.2 | 2.1 | 41.6 | 1.3 | 2.6 | 31.1 | 1.5 | 3.1 | 23.6 | 1.6 | 3.7 | 18.3 | 1.8 | 4.3 | 13.8 | 2.1 | 4.9 | 10.9 | 2.5 | 5.3 | | | |
| 100 | 85.4 | 1.1 | 1.6 | 60.5 | 1.2 | 2.1 | 43.8 | 1.3 | 2.6 | 32.7 | 1.5 | 3.1 | 24.9 | 1.6 | 3.7 | 19.3 | 1.8 | 4.3 | 14.6 | 2.1 | 4.9 | 11.6 | 2.4 | 5.4 | | | |
| 105 | 89.7 | 1.1 | 1.6 | 63.6 | 1.2 | 2.1 | 46.0 | 1.3 | 2.6 | 34.4 | 1.5 | 3.1 | 26.5 | 1.6 | 3.7 | 20.3 | 1.8 | 4.3 | 15.4 | 2.1 | 4.9 | 12.4 | 2.4 | 5.4 | 9.7 | 2.8 | 5.8 |
| 110 | 94.0 | 1.1 | 1.6 | 66.6 | 1.2 | 2.1 | 48.2 | 1.3 | 2.6 | 36.0 | 1.5 | 3.1 | 27.7 | 1.6 | 3.7 | 21.3 | 1.8 | 4.3 | 16.2 | 2.1 | 4.9 | 13.1 | 2.4 | 5.4 | 10.8 | 2.6 | 5.8 |
| 115 | 98.2 | 1.1 | 1.6 | 69.6 | 1.2 | 2.1 | 50.4 | 1.3 | 2.6 | 37.6 | 1.5 | 3.1 | 29.0 | 1.6 | 3.7 | 22.3 | 1.8 | 4.3 | 17.0 | 2.1 | 4.9 | 13.8 | 2.3 | 5.4 | 11.5 | 2.6 | 5.8 |
| 120 | 102.5 | 1.1 | 1.6 | 72.6 | 1.2 | 2.1 | 52.5 | 1.3 | 2.6 | 39.3 | 1.5 | 3.1 | 30.2 | 1.6 | 3.7 | 23.3 | 1.8 | 4.3 | 17.9 | 2.1 | 4.9 | 14.5 | 2.3 | 5.4 | 12.2 | 2.6 | 5.8 |
| 125 | 106.8 | 1.1 | 1.6 | 75.7 | 1.2 | 2.1 | 54.7 | 1.3 | 2.6 | 40.9 | 1.5 | 3.1 | 31.5 | 1.6 | 3.7 | 24.3 | 1.8 | 4.3 | 18.7 | 2.1 | 4.9 | 15.2 | 2.3 | 5.4 | 12.8 | 2.5 | 5.8 |
| 130 | 111.0 | 1.1 | 1.6 | 78.7 | 1.2 | 2.1 | 56.9 | 1.3 | 2.6 | 42.5 | 1.5 | 3.1 | 32.7 | 1.6 | 3.7 | 25.3 | 1.8 | 4.3 | 19.4 | 2.1 | 4.9 | 15.9 | 2.3 | 5.4 | 13.4 | 2.5 | 5.8 |
| 135 | 115.3 | 1.1 | 1.6 | 81.7 | 1.2 | 2.1 | 59.1 | 1.3 | 2.6 | 44.2 | 1.5 | 3.1 | 34.0 | 1.6 | 3.7 | 26.3 | 1.8 | 4.3 | 20.2 | 2.0 | 4.9 | 16.6 | 2.3 | 5.4 | 14.1 | 2.5 | 5.8 |
| 140 | 119.6 | 1.1 | 1.6 | 84.7 | 1.2 | 2.1 | 61.3 | 1.3 | 2.6 | 45.8 | 1.5 | 3.1 | 35.2 | 1.6 | 3.7 | 27.3 | 1.8 | 4.3 | 21.0 | 2.0 | 4.9 | 17.2 | 2.3 | 5.4 | 14.7 | 2.5 | 5.8 |
| 145 | 123.8 | 1.1 | 1.6 | 87.8 | 1.2 | 2.1 | 63.5 | 1.3 | 2.6 | 47.5 | 1.5 | 3.1 | 36.5 | 1.6 | 3.7 | 28.7 | 1.8 | 4.3 | 21.8 | 2.0 | 4.9 | 17.9 | 2.3 | 5.4 | 15.3 | 2.5 | 5.8 |
| 150 | 128.1 | 1.1 | 1.6 | 90.8 | 1.2 | 2.1 | 65.7 | 1.3 | 2.6 | 49.1 | 1.5 | 3.1 | 37.8 | 1.6 | 3.7 | 29.7 | 1.8 | 4.3 | 22.6 | 2.0 | 4.9 | 18.6 | 2.3 | 5.4 | 15.9 | 2.4 | 5.8 |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table DV-12 Parabolic Diversion Design Chart (Retardance “D” and “C”, Grade 2.00%)



**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"**

**Grade 2.00 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 5.9 | 0.9 | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | 12.4 | 0.8 | 1.5 | 8.1 | 0.9 | 2.0 | 5.9 | 1.0 | 2.5 | | | | | | | | | | | | | | | | | | |
| 15 | 18.5 | 0.8 | 1.5 | 12.3 | 0.9 | 2.0 | 9.3 | 1.0 | 2.5 | 6.8 | 1.1 | 3.0 | 4.7 | 1.4 | 3.5 | | | | | | | | | | | | |
| 20 | 24.7 | 0.8 | 1.5 | 16.7 | 0.9 | 2.0 | 12.5 | 1.0 | 2.5 | 9.4 | 1.1 | 3.0 | 7.0 | 1.2 | 3.6 | 4.7 | 1.5 | 4.1 | | | | | | | | | |
| 25 | 30.8 | 0.8 | 1.5 | 20.8 | 0.9 | 2.0 | 15.9 | 1.0 | 2.4 | 11.8 | 1.1 | 3.0 | 9.0 | 1.2 | 3.5 | 6.8 | 1.3 | 4.1 | | | | | | | | | |
| 30 | 37.0 | 0.8 | 1.5 | 25.0 | 0.9 | 2.0 | 19.0 | 1.0 | 2.5 | 14.3 | 1.1 | 3.0 | 11.0 | 1.2 | 3.5 | 8.5 | 1.3 | 4.1 | 6.4 | 1.5 | 4.7 | | | | | | |
| 35 | 43.2 | 0.8 | 1.5 | 29.1 | 0.9 | 2.0 | 22.2 | 1.0 | 2.5 | 16.9 | 1.0 | 3.0 | 12.9 | 1.1 | 3.5 | 10.1 | 1.3 | 4.1 | 7.8 | 1.4 | 4.7 | | | | | | |
| 40 | 49.3 | 0.8 | 1.5 | 33.3 | 0.9 | 2.0 | 25.3 | 1.0 | 2.5 | 19.3 | 1.0 | 3.0 | 14.8 | 1.1 | 3.5 | 11.6 | 1.3 | 4.1 | 9.1 | 1.4 | 4.7 | 7.1 | 1.6 | 5.2 | | | |
| 45 | 55.5 | 0.8 | 1.5 | 37.4 | 0.9 | 2.0 | 28.5 | 1.0 | 2.5 | 21.7 | 1.0 | 3.0 | 16.7 | 1.1 | 3.5 | 13.1 | 1.3 | 4.1 | 10.4 | 1.4 | 4.7 | 8.2 | 1.6 | 5.2 | | | |
| 50 | 61.7 | 0.8 | 1.5 | 41.6 | 0.9 | 2.0 | 31.7 | 1.0 | 2.5 | 24.1 | 1.0 | 3.0 | 18.8 | 1.1 | 3.5 | 14.7 | 1.2 | 4.1 | 11.7 | 1.4 | 4.7 | 9.3 | 1.5 | 5.3 | 7.1 | 1.8 | 5.8 |
| 55 | 67.8 | 0.8 | 1.5 | 45.7 | 0.9 | 2.0 | 34.8 | 1.0 | 2.5 | 26.5 | 1.0 | 3.0 | 20.7 | 1.1 | 3.5 | 16.2 | 1.2 | 4.1 | 12.9 | 1.4 | 4.7 | 10.4 | 1.5 | 5.3 | 8.2 | 1.7 | 5.8 |
| 60 | 74.0 | 0.8 | 1.5 | 49.9 | 0.9 | 2.0 | 38.0 | 1.0 | 2.5 | 28.9 | 1.0 | 3.0 | 22.6 | 1.1 | 3.5 | 17.7 | 1.2 | 4.1 | 14.1 | 1.4 | 4.7 | 11.4 | 1.5 | 5.3 | 9.2 | 1.7 | 5.8 |
| 65 | 80.2 | 0.8 | 1.5 | 54.0 | 0.9 | 2.0 | 41.1 | 1.0 | 2.5 | 31.4 | 1.0 | 3.0 | 24.5 | 1.1 | 3.5 | 19.5 | 1.2 | 4.1 | 15.4 | 1.3 | 4.7 | 12.4 | 1.5 | 5.3 | 10.1 | 1.7 | 5.8 |
| 70 | 86.3 | 0.8 | 1.5 | 58.2 | 0.9 | 2.0 | 44.3 | 1.0 | 2.5 | 33.8 | 1.0 | 3.0 | 26.3 | 1.1 | 3.5 | 21.0 | 1.2 | 4.1 | 16.6 | 1.3 | 4.7 | 13.5 | 1.5 | 5.3 | 11.0 | 1.6 | 5.8 |
| 75 | 92.5 | 0.8 | 1.5 | 62.3 | 0.9 | 2.0 | 47.5 | 1.0 | 2.5 | 36.2 | 1.0 | 3.0 | 28.2 | 1.1 | 3.5 | 22.4 | 1.2 | 4.1 | 17.8 | 1.3 | 4.7 | 14.5 | 1.5 | 5.3 | 11.8 | 1.6 | 5.8 |
| 80 | 98.7 | 0.8 | 1.5 | 66.5 | 0.9 | 2.0 | 50.6 | 1.0 | 2.5 | 38.6 | 1.0 | 3.0 | 30.1 | 1.1 | 3.5 | 23.9 | 1.2 | 4.1 | 19.0 | 1.3 | 4.7 | 15.5 | 1.5 | 5.3 | 12.7 | 1.6 | 5.8 |
| 85 | 104.8 | 0.8 | 1.5 | 70.6 | 0.9 | 2.0 | 53.8 | 1.0 | 2.5 | 41.0 | 1.0 | 3.0 | 32.0 | 1.1 | 3.5 | 25.4 | 1.2 | 4.1 | 20.3 | 1.3 | 4.7 | 16.5 | 1.5 | 5.3 | 13.6 | 1.6 | 5.8 |
| 90 | 111.0 | 0.8 | 1.5 | 74.8 | 0.9 | 2.0 | 57.0 | 1.0 | 2.5 | 43.4 | 1.0 | 3.0 | 33.8 | 1.1 | 3.5 | 26.9 | 1.2 | 4.1 | 21.8 | 1.3 | 4.6 | 17.5 | 1.5 | 5.3 | 14.4 | 1.6 | 5.8 |
| 95 | 117.2 | 0.8 | 1.5 | 78.9 | 0.9 | 2.0 | 60.1 | 1.0 | 2.5 | 45.8 | 1.0 | 3.0 | 35.7 | 1.1 | 3.5 | 28.4 | 1.2 | 4.1 | 23.0 | 1.3 | 4.6 | 18.6 | 1.5 | 5.3 | 15.3 | 1.6 | 5.8 |
| 100 | 123.3 | 0.8 | 1.5 | 83.1 | 0.9 | 2.0 | 63.3 | 1.0 | 2.5 | 48.2 | 1.0 | 3.0 | 37.6 | 1.1 | 3.5 | 29.9 | 1.2 | 4.1 | 24.2 | 1.3 | 4.6 | 19.6 | 1.5 | 5.3 | 16.2 | 1.6 | 5.8 |
| 105 | 129.5 | 0.8 | 1.5 | 87.3 | 0.9 | 2.0 | 66.4 | 1.0 | 2.5 | 50.6 | 1.0 | 3.0 | 39.5 | 1.1 | 3.5 | 31.4 | 1.2 | 4.1 | 25.4 | 1.3 | 4.6 | 20.6 | 1.5 | 5.3 | 17.0 | 1.6 | 5.8 |
| 110 | 135.7 | 0.8 | 1.5 | 91.4 | 0.9 | 2.0 | 69.6 | 1.0 | 2.5 | 53.0 | 1.0 | 3.0 | 41.3 | 1.1 | 3.5 | 32.9 | 1.2 | 4.1 | 26.6 | 1.3 | 4.7 | 21.6 | 1.4 | 5.3 | 17.9 | 1.6 | 5.8 |
| 115 | 141.8 | 0.8 | 1.5 | 95.6 | 0.9 | 2.0 | 72.8 | 1.0 | 2.5 | 55.4 | 1.0 | 3.0 | 43.2 | 1.1 | 3.5 | 34.4 | 1.2 | 4.1 | 27.9 | 1.3 | 4.7 | 22.6 | 1.4 | 5.3 | 18.7 | 1.6 | 5.8 |
| 120 | 148.0 | 0.8 | 1.5 | 99.7 | 0.9 | 2.0 | 75.9 | 1.0 | 2.5 | 57.9 | 1.0 | 3.0 | 45.1 | 1.1 | 3.5 | 35.9 | 1.2 | 4.1 | 29.1 | 1.3 | 4.7 | 23.9 | 1.4 | 5.2 | 19.5 | 1.6 | 5.8 |
| 125 | 154.1 | 0.8 | 1.5 | 103.9 | 0.9 | 2.0 | 79.1 | 1.0 | 2.5 | 60.3 | 1.0 | 3.0 | 47.0 | 1.1 | 3.5 | 37.4 | 1.2 | 4.1 | 30.3 | 1.3 | 4.7 | 24.8 | 1.4 | 5.2 | 20.4 | 1.6 | 5.8 |
| 130 | 160.3 | 0.8 | 1.5 | 108.0 | 0.9 | 2.0 | 82.3 | 1.0 | 2.5 | 62.7 | 1.0 | 3.0 | 48.8 | 1.1 | 3.5 | 38.9 | 1.2 | 4.1 | 31.5 | 1.3 | 4.7 | 25.8 | 1.4 | 5.3 | 21.2 | 1.6 | 5.8 |
| 135 | 166.5 | 0.8 | 1.5 | 112.2 | 0.9 | 2.0 | 85.4 | 1.0 | 2.5 | 65.1 | 1.0 | 3.0 | 50.7 | 1.1 | 3.5 | 40.3 | 1.2 | 4.1 | 32.7 | 1.3 | 4.7 | 26.8 | 1.4 | 5.3 | 22.1 | 1.6 | 5.8 |
| 140 | 172.6 | 0.8 | 1.5 | 116.3 | 0.9 | 2.0 | 88.6 | 1.0 | 2.5 | 67.5 | 1.0 | 3.0 | 52.6 | 1.1 | 3.5 | 41.8 | 1.2 | 4.1 | 33.9 | 1.3 | 4.7 | 27.8 | 1.4 | 5.3 | 22.9 | 1.6 | 5.8 |
| 145 | 178.8 | 0.8 | 1.5 | 120.5 | 0.9 | 2.0 | 91.8 | 1.0 | 2.5 | 69.9 | 1.0 | 3.0 | 54.5 | 1.1 | 3.5 | 43.3 | 1.2 | 4.1 | 35.1 | 1.3 | 4.7 | 28.8 | 1.4 | 5.3 | 23.7 | 1.6 | 5.8 |
| 150 | 185.0 | 0.8 | 1.5 | 124.6 | 0.9 | 2.0 | 94.9 | 1.0 | 2.5 | 72.3 | 1.0 | 3.0 | 56.4 | 1.1 | 3.5 | 44.8 | 1.2 | 4.1 | 36.3 | 1.3 | 4.7 | 29.8 | 1.4 | 5.3 | 24.6 | 1.6 | 5.8 |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table DV-13 Parabolic Diversion Design Chart (Retardance “D” and “C”, Grade 4.00%)

**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"**

**Grade 4.00 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 8.5 | 0.6 | 1.4 | 5.9 | 0.7 | 1.8 | 4.1 | 0.8 | 2.3 | | | | | | | | | | | | | | | | | | |
| 10 | 17.2 | 0.6 | 1.4 | 12.1 | 0.7 | 1.8 | 8.8 | 0.7 | 2.3 | 6.7 | 0.8 | 2.8 | 5.2 | 0.9 | 3.3 | 3.8 | 1.0 | 3.9 | | | | | | | | | |
| 15 | 25.8 | 0.6 | 1.4 | 18.1 | 0.7 | 1.8 | 13.4 | 0.7 | 2.3 | 10.3 | 0.8 | 2.8 | 8.1 | 0.8 | 3.4 | 6.4 | 0.9 | 3.9 | 4.9 | 1.0 | 4.5 | | | | | | |
| 20 | 34.4 | 0.6 | 1.4 | 24.2 | 0.7 | 1.8 | 17.8 | 0.7 | 2.3 | 13.9 | 0.8 | 2.8 | 10.9 | 0.8 | 3.4 | 8.7 | 0.9 | 3.9 | 6.9 | 1.0 | 4.5 | 5.5 | 1.1 | 5.0 | | | |
| 25 | 43.0 | 0.6 | 1.4 | 30.2 | 0.7 | 1.9 | 22.3 | 0.7 | 2.3 | 17.4 | 0.8 | 2.8 | 13.8 | 0.8 | 3.3 | 10.9 | 0.9 | 3.9 | 8.6 | 1.0 | 4.5 | 7.1 | 1.0 | 5.1 | 5.7 | 1.2 | 5.6 |
| 30 | 51.6 | 0.6 | 1.4 | 36.3 | 0.7 | 1.9 | 26.7 | 0.7 | 2.3 | 20.8 | 0.8 | 2.8 | 16.5 | 0.8 | 3.3 | 13.2 | 0.9 | 3.9 | 10.7 | 0.9 | 4.5 | 8.7 | 1.0 | 5.1 | 7.1 | 1.1 | 5.6 |
| 35 | 60.2 | 0.6 | 1.4 | 42.3 | 0.7 | 1.9 | 31.1 | 0.7 | 2.3 | 24.3 | 0.8 | 2.8 | 19.3 | 0.8 | 3.4 | 15.6 | 0.9 | 3.9 | 12.5 | 0.9 | 4.5 | 10.3 | 1.0 | 5.0 | 8.4 | 1.1 | 5.6 |
| 40 | 68.8 | 0.6 | 1.4 | 48.3 | 0.7 | 1.9 | 35.6 | 0.7 | 2.3 | 27.8 | 0.8 | 2.8 | 22.0 | 0.8 | 3.4 | 17.8 | 0.9 | 3.9 | 14.4 | 0.9 | 4.5 | 11.8 | 1.0 | 5.0 | 9.8 | 1.1 | 5.7 |
| 45 | 77.4 | 0.6 | 1.4 | 54.4 | 0.7 | 1.9 | 40.0 | 0.7 | 2.4 | 31.2 | 0.8 | 2.8 | 24.8 | 0.8 | 3.4 | 20.0 | 0.9 | 3.9 | 16.4 | 0.9 | 4.4 | 13.3 | 1.0 | 5.0 | 11.1 | 1.1 | 5.7 |
| 50 | 86.0 | 0.6 | 1.4 | 60.4 | 0.7 | 1.9 | 44.5 | 0.7 | 2.4 | 34.7 | 0.8 | 2.8 | 27.5 | 0.8 | 3.4 | 22.2 | 0.9 | 3.9 | 18.2 | 0.9 | 4.4 | 14.9 | 1.0 | 5.0 | 12.3 | 1.1 | 5.7 |
| 55 | 94.6 | 0.6 | 1.4 | 66.5 | 0.7 | 1.9 | 48.9 | 0.7 | 2.4 | 38.2 | 0.8 | 2.8 | 30.3 | 0.8 | 3.4 | 24.4 | 0.9 | 3.9 | 20.0 | 0.9 | 4.4 | 16.6 | 1.0 | 5.0 | 13.6 | 1.1 | 5.7 |
| 60 | 103.2 | 0.6 | 1.4 | 72.5 | 0.7 | 1.9 | 53.4 | 0.7 | 2.4 | 41.7 | 0.8 | 2.8 | 33.0 | 0.8 | 3.4 | 26.6 | 0.9 | 3.9 | 21.8 | 0.9 | 4.5 | 18.1 | 1.0 | 5.0 | 14.9 | 1.1 | 5.7 |
| 65 | 111.8 | 0.6 | 1.4 | 78.5 | 0.7 | 1.9 | 57.8 | 0.7 | 2.4 | 45.1 | 0.8 | 2.8 | 35.8 | 0.8 | 3.4 | 28.9 | 0.9 | 3.9 | 23.6 | 0.9 | 4.5 | 19.6 | 1.0 | 5.0 | 16.2 | 1.1 | 5.7 |
| 70 | 120.4 | 0.6 | 1.4 | 84.6 | 0.7 | 1.9 | 62.3 | 0.7 | 2.4 | 48.6 | 0.8 | 2.8 | 38.6 | 0.8 | 3.4 | 31.1 | 0.9 | 3.9 | 25.4 | 0.9 | 4.5 | 21.1 | 1.0 | 5.0 | 17.7 | 1.1 | 5.6 |
| 75 | 129.0 | 0.6 | 1.4 | 90.6 | 0.7 | 1.9 | 66.7 | 0.7 | 2.4 | 52.1 | 0.8 | 2.8 | 41.3 | 0.8 | 3.4 | 33.3 | 0.9 | 3.9 | 27.2 | 0.9 | 4.5 | 22.6 | 1.0 | 5.0 | 19.0 | 1.1 | 5.6 |
| 80 | 137.6 | 0.6 | 1.4 | 96.7 | 0.7 | 1.9 | 71.2 | 0.7 | 2.4 | 55.5 | 0.8 | 2.8 | 44.1 | 0.8 | 3.4 | 35.5 | 0.9 | 3.9 | 29.1 | 0.9 | 4.5 | 24.1 | 1.0 | 5.0 | 20.2 | 1.1 | 5.6 |
| 85 | 146.2 | 0.6 | 1.4 | 102.7 | 0.7 | 1.9 | 75.6 | 0.7 | 2.4 | 59.0 | 0.8 | 2.8 | 46.8 | 0.8 | 3.4 | 37.7 | 0.9 | 3.9 | 30.9 | 0.9 | 4.5 | 25.6 | 1.0 | 5.0 | 21.5 | 1.1 | 5.6 |
| 90 | 154.8 | 0.6 | 1.4 | 108.7 | 0.7 | 1.9 | 80.0 | 0.7 | 2.4 | 62.5 | 0.8 | 2.8 | 49.6 | 0.8 | 3.4 | 39.9 | 0.9 | 3.9 | 32.7 | 0.9 | 4.5 | 27.1 | 1.0 | 5.0 | 22.8 | 1.1 | 5.6 |
| 95 | 163.4 | 0.6 | 1.4 | 114.8 | 0.7 | 1.9 | 84.5 | 0.7 | 2.4 | 65.9 | 0.8 | 2.8 | 52.3 | 0.8 | 3.4 | 42.2 | 0.9 | 3.9 | 34.5 | 0.9 | 4.5 | 28.6 | 1.0 | 5.0 | 24.0 | 1.1 | 5.6 |
| 100 | 172.0 | 0.6 | 1.4 | 120.8 | 0.7 | 1.9 | 88.9 | 0.7 | 2.4 | 69.4 | 0.8 | 2.8 | 55.1 | 0.8 | 3.4 | 44.4 | 0.9 | 3.9 | 36.3 | 0.9 | 4.5 | 30.1 | 1.0 | 5.0 | 25.3 | 1.1 | 5.6 |
| 105 | 180.6 | 0.6 | 1.4 | 126.9 | 0.7 | 1.9 | 93.4 | 0.7 | 2.4 | 72.9 | 0.8 | 2.8 | 57.8 | 0.8 | 3.4 | 46.6 | 0.9 | 3.9 | 38.1 | 0.9 | 4.5 | 31.6 | 1.0 | 5.0 | 26.5 | 1.1 | 5.6 |
| 110 | 189.2 | 0.6 | 1.4 | 132.9 | 0.7 | 1.9 | 97.8 | 0.7 | 2.4 | 76.3 | 0.8 | 2.8 | 60.6 | 0.8 | 3.4 | 48.8 | 0.9 | 3.9 | 39.9 | 0.9 | 4.5 | 33.1 | 1.0 | 5.0 | 27.8 | 1.1 | 5.6 |
| 115 | 197.8 | 0.6 | 1.4 | 138.9 | 0.7 | 1.9 | 102.3 | 0.7 | 2.4 | 79.8 | 0.8 | 2.8 | 63.3 | 0.8 | 3.4 | 51.0 | 0.9 | 3.9 | 41.7 | 0.9 | 4.5 | 34.6 | 1.0 | 5.0 | 29.0 | 1.1 | 5.6 |
| 120 | 206.4 | 0.6 | 1.4 | 145.0 | 0.7 | 1.9 | 106.7 | 0.7 | 2.4 | 83.3 | 0.8 | 2.8 | 66.1 | 0.8 | 3.4 | 53.3 | 0.9 | 3.9 | 43.6 | 0.9 | 4.5 | 36.1 | 1.0 | 5.0 | 30.2 | 1.1 | 5.7 |
| 125 | 215.0 | 0.6 | 1.4 | 151.0 | 0.7 | 1.9 | 111.2 | 0.7 | 2.4 | 86.8 | 0.8 | 2.8 | 68.8 | 0.8 | 3.4 | 55.5 | 0.9 | 3.9 | 45.4 | 0.9 | 4.5 | 37.6 | 1.0 | 5.0 | 31.5 | 1.1 | 5.7 |
| 130 | 223.7 | 0.6 | 1.4 | 157.1 | 0.7 | 1.9 | 115.6 | 0.7 | 2.4 | 90.2 | 0.8 | 2.8 | 71.6 | 0.8 | 3.4 | 57.7 | 0.9 | 3.9 | 47.2 | 0.9 | 4.5 | 39.1 | 1.0 | 5.0 | 32.7 | 1.1 | 5.7 |
| 135 | 232.3 | 0.6 | 1.4 | 163.1 | 0.7 | 1.9 | 120.1 | 0.7 | 2.4 | 93.7 | 0.8 | 2.8 | 74.3 | 0.8 | 3.4 | 59.9 | 0.9 | 3.9 | 49.0 | 0.9 | 4.5 | 40.6 | 1.0 | 5.0 | 34.0 | 1.1 | 5.7 |
| 140 | 240.9 | 0.6 | 1.4 | 169.1 | 0.7 | 1.9 | 124.5 | 0.7 | 2.4 | 97.2 | 0.8 | 2.8 | 77.1 | 0.8 | 3.4 | 62.1 | 0.9 | 3.9 | 50.8 | 0.9 | 4.5 | 42.1 | 1.0 | 5.0 | 35.2 | 1.1 | 5.7 |
| 145 | 249.5 | 0.6 | 1.4 | 175.2 | 0.7 | 1.9 | 129.0 | 0.7 | 2.4 | 100.6 | 0.8 | 2.8 | 79.8 | 0.8 | 3.4 | 64.3 | 0.9 | 3.9 | 52.6 | 0.9 | 4.5 | 43.6 | 1.0 | 5.0 | 36.5 | 1.1 | 5.7 |
| 150 | 258.1 | 0.6 | 1.4 | 181.2 | 0.7 | 1.9 | 133.4 | 0.7 | 2.4 | 104.1 | 0.8 | 2.8 | 82.6 | 0.8 | 3.4 | 66.6 | 0.9 | 3.9 | 54.4 | 0.9 | 4.5 | 45.1 | 1.0 | 5.0 | 37.8 | 1.1 | 5.7 |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table DV-14 Parabolic Diversion Design Chart (Retardance “D” and “C”, Grade 6.00%)

**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"**

**Grade 6.00 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 10.6 | 0.5 | 1.3 | 7.3 | 0.6 | 1.8 | 5.3 | 0.6 | 2.3 | 4.0 | 0.7 | 2.8 | 2.9 | 0.8 | 3.2 | | | | | | | | | | | | |
| 10 | 21.1 | 0.5 | 1.3 | 14.7 | 0.6 | 1.8 | 10.9 | 0.6 | 2.3 | 8.4 | 0.7 | 2.8 | 6.6 | 0.7 | 3.2 | 5.3 | 0.8 | 3.8 | 4.2 | 0.8 | 4.3 | | | | | | |
| 15 | 31.6 | 0.5 | 1.3 | 22.1 | 0.6 | 1.8 | 16.3 | 0.6 | 2.3 | 12.7 | 0.6 | 2.7 | 10.1 | 0.7 | 3.3 | 8.2 | 0.7 | 3.8 | 6.6 | 0.8 | 4.3 | 5.4 | 0.9 | 4.9 | 4.3 | 1.0 | 5.5 |
| 20 | 42.1 | 0.5 | 1.3 | 29.5 | 0.6 | 1.8 | 21.7 | 0.6 | 2.3 | 17.0 | 0.6 | 2.7 | 13.6 | 0.7 | 3.2 | 11.1 | 0.7 | 3.7 | 9.0 | 0.8 | 4.3 | 7.4 | 0.8 | 4.9 | 6.1 | 0.9 | 5.5 |
| 25 | 52.7 | 0.5 | 1.3 | 36.8 | 0.6 | 1.8 | 27.1 | 0.6 | 2.3 | 21.2 | 0.6 | 2.8 | 17.0 | 0.7 | 3.2 | 13.9 | 0.7 | 3.8 | 11.3 | 0.8 | 4.3 | 9.3 | 0.8 | 4.9 | 7.8 | 0.9 | 5.5 |
| 30 | 63.2 | 0.5 | 1.3 | 44.2 | 0.6 | 1.8 | 32.5 | 0.6 | 2.3 | 25.4 | 0.6 | 2.8 | 20.4 | 0.7 | 3.2 | 16.6 | 0.7 | 3.8 | 13.7 | 0.8 | 4.3 | 11.3 | 0.8 | 4.9 | 9.4 | 0.9 | 5.5 |
| 35 | 73.7 | 0.5 | 1.3 | 51.6 | 0.6 | 1.8 | 38.0 | 0.6 | 2.3 | 29.7 | 0.6 | 2.8 | 23.8 | 0.7 | 3.2 | 19.4 | 0.7 | 3.8 | 16.0 | 0.8 | 4.3 | 13.4 | 0.8 | 4.9 | 11.1 | 0.9 | 5.5 |
| 40 | 84.2 | 0.5 | 1.3 | 58.9 | 0.6 | 1.8 | 43.4 | 0.6 | 2.3 | 33.9 | 0.6 | 2.8 | 27.2 | 0.7 | 3.3 | 22.2 | 0.7 | 3.8 | 18.3 | 0.8 | 4.3 | 15.3 | 0.8 | 4.9 | 12.7 | 0.9 | 5.5 |
| 45 | 94.8 | 0.5 | 1.3 | 66.3 | 0.6 | 1.8 | 48.8 | 0.6 | 2.3 | 38.2 | 0.6 | 2.8 | 30.7 | 0.7 | 3.3 | 24.9 | 0.7 | 3.8 | 20.6 | 0.8 | 4.3 | 17.2 | 0.8 | 4.9 | 14.5 | 0.9 | 5.4 |
| 50 | 105.3 | 0.5 | 1.3 | 73.6 | 0.6 | 1.8 | 54.2 | 0.6 | 2.3 | 42.4 | 0.6 | 2.8 | 34.1 | 0.7 | 3.3 | 27.7 | 0.7 | 3.8 | 22.8 | 0.8 | 4.3 | 19.1 | 0.8 | 4.9 | 16.1 | 0.9 | 5.4 |
| 55 | 115.8 | 0.5 | 1.3 | 81.0 | 0.6 | 1.8 | 59.7 | 0.6 | 2.3 | 46.6 | 0.6 | 2.8 | 37.5 | 0.7 | 3.3 | 30.5 | 0.7 | 3.8 | 25.1 | 0.8 | 4.3 | 21.0 | 0.8 | 4.9 | 17.7 | 0.9 | 5.4 |
| 60 | 126.4 | 0.5 | 1.3 | 88.4 | 0.6 | 1.8 | 65.1 | 0.6 | 2.3 | 50.9 | 0.6 | 2.8 | 40.9 | 0.7 | 3.3 | 33.3 | 0.7 | 3.8 | 27.4 | 0.8 | 4.3 | 22.9 | 0.8 | 4.9 | 19.3 | 0.9 | 5.4 |
| 65 | 136.9 | 0.5 | 1.3 | 95.7 | 0.6 | 1.8 | 70.5 | 0.6 | 2.3 | 55.1 | 0.6 | 2.8 | 44.3 | 0.7 | 3.3 | 36.0 | 0.7 | 3.8 | 29.7 | 0.8 | 4.3 | 24.8 | 0.8 | 4.9 | 20.9 | 0.9 | 5.4 |
| 70 | 147.4 | 0.5 | 1.3 | 103.1 | 0.6 | 1.8 | 75.9 | 0.6 | 2.3 | 59.3 | 0.6 | 2.8 | 47.7 | 0.7 | 3.3 | 38.8 | 0.7 | 3.8 | 32.0 | 0.8 | 4.3 | 26.7 | 0.8 | 4.9 | 22.5 | 0.9 | 5.4 |
| 75 | 158.0 | 0.5 | 1.3 | 110.5 | 0.6 | 1.8 | 81.3 | 0.6 | 2.3 | 63.6 | 0.6 | 2.8 | 51.1 | 0.7 | 3.3 | 41.6 | 0.7 | 3.8 | 34.3 | 0.8 | 4.3 | 28.6 | 0.8 | 4.9 | 24.1 | 0.9 | 5.4 |
| 80 | 168.5 | 0.5 | 1.3 | 117.8 | 0.6 | 1.8 | 86.8 | 0.6 | 2.3 | 67.8 | 0.6 | 2.8 | 54.5 | 0.7 | 3.3 | 44.3 | 0.7 | 3.8 | 36.5 | 0.8 | 4.3 | 30.5 | 0.8 | 4.9 | 25.7 | 0.9 | 5.5 |
| 85 | 179.0 | 0.5 | 1.3 | 125.2 | 0.6 | 1.8 | 92.2 | 0.6 | 2.3 | 72.0 | 0.6 | 2.8 | 57.9 | 0.7 | 3.3 | 47.1 | 0.7 | 3.8 | 38.8 | 0.8 | 4.3 | 32.4 | 0.8 | 4.9 | 27.3 | 0.9 | 5.5 |
| 90 | 189.6 | 0.5 | 1.3 | 132.6 | 0.6 | 1.8 | 97.6 | 0.6 | 2.3 | 76.3 | 0.6 | 2.8 | 61.3 | 0.7 | 3.3 | 49.9 | 0.7 | 3.8 | 41.1 | 0.8 | 4.3 | 34.3 | 0.8 | 4.9 | 28.9 | 0.9 | 5.5 |
| 95 | 200.1 | 0.5 | 1.3 | 139.9 | 0.6 | 1.8 | 103.0 | 0.6 | 2.3 | 80.5 | 0.6 | 2.8 | 64.7 | 0.7 | 3.3 | 52.6 | 0.7 | 3.8 | 43.4 | 0.8 | 4.3 | 36.2 | 0.8 | 4.9 | 30.5 | 0.9 | 5.5 |
| 100 | 210.6 | 0.5 | 1.3 | 147.3 | 0.6 | 1.8 | 108.5 | 0.6 | 2.3 | 84.8 | 0.6 | 2.8 | 68.1 | 0.7 | 3.3 | 55.4 | 0.7 | 3.8 | 45.7 | 0.8 | 4.3 | 38.1 | 0.8 | 4.9 | 32.1 | 0.9 | 5.5 |
| 105 | 221.1 | 0.5 | 1.3 | 154.6 | 0.6 | 1.8 | 113.9 | 0.6 | 2.3 | 89.0 | 0.6 | 2.8 | 71.5 | 0.7 | 3.3 | 58.2 | 0.7 | 3.8 | 47.9 | 0.8 | 4.3 | 40.0 | 0.8 | 4.9 | 33.7 | 0.9 | 5.5 |
| 110 | 231.7 | 0.5 | 1.3 | 162.0 | 0.6 | 1.8 | 119.3 | 0.6 | 2.3 | 93.2 | 0.6 | 2.8 | 74.9 | 0.7 | 3.3 | 60.9 | 0.7 | 3.8 | 50.2 | 0.8 | 4.3 | 41.9 | 0.8 | 4.9 | 35.3 | 0.9 | 5.5 |
| 115 | 242.2 | 0.5 | 1.3 | 169.4 | 0.6 | 1.8 | 124.7 | 0.6 | 2.3 | 97.5 | 0.6 | 2.8 | 78.3 | 0.7 | 3.3 | 63.7 | 0.7 | 3.8 | 52.5 | 0.8 | 4.3 | 43.8 | 0.8 | 4.9 | 36.9 | 0.9 | 5.5 |
| 120 | 252.7 | 0.5 | 1.3 | 176.7 | 0.6 | 1.8 | 130.2 | 0.6 | 2.3 | 101.7 | 0.6 | 2.8 | 81.7 | 0.7 | 3.3 | 66.5 | 0.7 | 3.8 | 54.8 | 0.8 | 4.3 | 45.7 | 0.8 | 4.9 | 38.5 | 0.9 | 5.5 |
| 125 | 263.3 | 0.5 | 1.3 | 184.1 | 0.6 | 1.8 | 135.6 | 0.6 | 2.3 | 106.0 | 0.6 | 2.8 | 85.1 | 0.7 | 3.3 | 69.3 | 0.7 | 3.8 | 57.1 | 0.8 | 4.3 | 47.6 | 0.8 | 4.9 | 40.1 | 0.9 | 5.5 |
| 130 | 273.8 | 0.5 | 1.3 | 191.5 | 0.6 | 1.8 | 141.0 | 0.6 | 2.3 | 110.2 | 0.6 | 2.8 | 88.5 | 0.7 | 3.3 | 72.0 | 0.7 | 3.8 | 59.4 | 0.8 | 4.3 | 49.5 | 0.8 | 4.9 | 41.7 | 0.9 | 5.5 |
| 135 | 284.3 | 0.5 | 1.3 | 198.8 | 0.6 | 1.8 | 146.4 | 0.6 | 2.3 | 114.4 | 0.6 | 2.8 | 91.9 | 0.7 | 3.3 | 74.8 | 0.7 | 3.8 | 61.6 | 0.8 | 4.3 | 51.4 | 0.8 | 4.9 | 43.3 | 0.9 | 5.5 |
| 140 | 294.9 | 0.5 | 1.3 | 206.2 | 0.6 | 1.8 | 151.8 | 0.6 | 2.3 | 118.7 | 0.6 | 2.8 | 95.3 | 0.7 | 3.3 | 77.6 | 0.7 | 3.8 | 63.9 | 0.8 | 4.3 | 53.3 | 0.8 | 4.9 | 44.9 | 0.9 | 5.5 |
| 145 | 305.4 | 0.5 | 1.3 | 213.6 | 0.6 | 1.8 | 157.3 | 0.6 | 2.3 | 122.9 | 0.6 | 2.8 | 98.7 | 0.7 | 3.3 | 80.3 | 0.7 | 3.8 | 66.2 | 0.8 | 4.3 | 55.2 | 0.8 | 4.9 | 46.5 | 0.9 | 5.5 |
| 150 | 315.9 | 0.5 | 1.3 | 220.9 | 0.6 | 1.8 | 162.7 | 0.6 | 2.3 | 127.1 | 0.6 | 2.8 | 102.1 | 0.7 | 3.3 | 83.1 | 0.7 | 3.8 | 68.5 | 0.8 | 4.3 | 57.1 | 0.8 | 4.9 | 48.1 | 0.9 | 5.5 |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second.
Depth "D" does not include allowance for freeboard or settlement.

Table DV-15 Parabolic Diversion Design Chart (Retardance “D” and “C”, Grade 8.00%)

**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"**

**Grade 8.00 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 12.0 | 0.5 | 1.3 | 8.5 | 0.5 | 1.7 | 6.2 | 0.5 | 2.2 | 4.6 | 0.6 | 2.7 | 3.7 | 0.6 | 3.2 | 2.9 | 0.7 | 3.6 | | | | | | | | | |
| 10 | 24.1 | 0.5 | 1.3 | 16.9 | 0.5 | 1.7 | 12.6 | 0.5 | 2.2 | 9.6 | 0.6 | 2.7 | 7.8 | 0.6 | 3.2 | 6.3 | 0.6 | 3.7 | 5.1 | 0.7 | 4.2 | 4.2 | 0.8 | 4.8 | 3.2 | 0.9 | 5.3 |
| 15 | 36.1 | 0.5 | 1.3 | 25.3 | 0.5 | 1.7 | 18.9 | 0.5 | 2.2 | 14.4 | 0.6 | 2.7 | 11.8 | 0.6 | 3.2 | 9.7 | 0.6 | 3.7 | 7.9 | 0.7 | 4.2 | 6.5 | 0.7 | 4.8 | 5.4 | 0.8 | 5.3 |
| 20 | 48.1 | 0.5 | 1.3 | 33.8 | 0.5 | 1.7 | 25.2 | 0.5 | 2.2 | 19.2 | 0.6 | 2.7 | 15.8 | 0.6 | 3.2 | 12.9 | 0.6 | 3.7 | 10.7 | 0.7 | 4.2 | 8.8 | 0.7 | 4.8 | 7.4 | 0.8 | 5.3 |
| 25 | 60.1 | 0.5 | 1.3 | 42.2 | 0.5 | 1.7 | 31.5 | 0.5 | 2.2 | 24.0 | 0.6 | 2.7 | 19.7 | 0.6 | 3.2 | 16.2 | 0.6 | 3.7 | 13.4 | 0.7 | 4.2 | 11.2 | 0.7 | 4.7 | 9.3 | 0.8 | 5.3 |
| 30 | 72.1 | 0.5 | 1.3 | 50.6 | 0.5 | 1.7 | 37.8 | 0.5 | 2.2 | 28.8 | 0.6 | 2.7 | 23.6 | 0.6 | 3.2 | 19.4 | 0.6 | 3.7 | 16.1 | 0.7 | 4.2 | 13.5 | 0.7 | 4.8 | 11.3 | 0.7 | 5.3 |
| 35 | 84.1 | 0.5 | 1.3 | 59.1 | 0.5 | 1.7 | 44.1 | 0.5 | 2.2 | 33.6 | 0.6 | 2.7 | 27.6 | 0.6 | 3.2 | 22.6 | 0.6 | 3.7 | 18.7 | 0.7 | 4.2 | 15.7 | 0.7 | 4.8 | 13.3 | 0.7 | 5.3 |
| 40 | 96.2 | 0.5 | 1.3 | 67.5 | 0.5 | 1.7 | 50.4 | 0.5 | 2.2 | 38.4 | 0.6 | 2.7 | 31.5 | 0.6 | 3.2 | 25.8 | 0.6 | 3.7 | 21.4 | 0.7 | 4.2 | 17.9 | 0.7 | 4.8 | 15.2 | 0.7 | 5.3 |
| 45 | 108.2 | 0.5 | 1.3 | 76.0 | 0.5 | 1.7 | 56.7 | 0.5 | 2.2 | 43.2 | 0.6 | 2.7 | 35.4 | 0.6 | 3.2 | 29.0 | 0.6 | 3.7 | 24.1 | 0.7 | 4.2 | 20.2 | 0.7 | 4.8 | 17.1 | 0.7 | 5.3 |
| 50 | 120.2 | 0.5 | 1.3 | 84.4 | 0.5 | 1.7 | 63.0 | 0.5 | 2.2 | 48.0 | 0.6 | 2.7 | 39.4 | 0.6 | 3.2 | 32.3 | 0.6 | 3.7 | 26.8 | 0.7 | 4.2 | 22.4 | 0.7 | 4.8 | 19.0 | 0.7 | 5.3 |
| 55 | 132.2 | 0.5 | 1.3 | 92.8 | 0.5 | 1.7 | 69.3 | 0.5 | 2.2 | 52.8 | 0.6 | 2.7 | 43.3 | 0.6 | 3.2 | 35.5 | 0.6 | 3.7 | 29.4 | 0.7 | 4.2 | 24.7 | 0.7 | 4.8 | 20.9 | 0.7 | 5.3 |
| 60 | 144.2 | 0.5 | 1.3 | 101.3 | 0.5 | 1.7 | 75.6 | 0.5 | 2.2 | 57.6 | 0.6 | 2.7 | 47.2 | 0.6 | 3.2 | 38.7 | 0.6 | 3.7 | 32.1 | 0.7 | 4.2 | 26.9 | 0.7 | 4.8 | 22.8 | 0.7 | 5.3 |
| 65 | 156.3 | 0.5 | 1.3 | 109.7 | 0.5 | 1.7 | 81.8 | 0.5 | 2.2 | 62.4 | 0.6 | 2.7 | 51.2 | 0.6 | 3.2 | 41.9 | 0.6 | 3.7 | 34.8 | 0.7 | 4.2 | 29.1 | 0.7 | 4.8 | 24.7 | 0.7 | 5.3 |
| 70 | 168.3 | 0.5 | 1.3 | 118.2 | 0.5 | 1.7 | 88.1 | 0.5 | 2.2 | 67.2 | 0.6 | 2.7 | 55.1 | 0.6 | 3.2 | 45.2 | 0.6 | 3.7 | 37.5 | 0.7 | 4.2 | 31.4 | 0.7 | 4.8 | 26.6 | 0.7 | 5.3 |
| 75 | 180.3 | 0.5 | 1.3 | 126.6 | 0.5 | 1.7 | 94.4 | 0.5 | 2.2 | 72.0 | 0.6 | 2.7 | 59.0 | 0.6 | 3.2 | 48.4 | 0.6 | 3.7 | 40.1 | 0.7 | 4.2 | 33.6 | 0.7 | 4.8 | 28.5 | 0.7 | 5.3 |
| 80 | 192.3 | 0.5 | 1.3 | 135.0 | 0.5 | 1.7 | 100.7 | 0.5 | 2.2 | 76.8 | 0.6 | 2.7 | 63.0 | 0.6 | 3.2 | 51.6 | 0.6 | 3.7 | 42.8 | 0.7 | 4.2 | 35.9 | 0.7 | 4.8 | 30.3 | 0.7 | 5.3 |
| 85 | 204.3 | 0.5 | 1.3 | 143.5 | 0.5 | 1.7 | 107.0 | 0.5 | 2.2 | 81.6 | 0.6 | 2.7 | 66.9 | 0.6 | 3.2 | 54.9 | 0.6 | 3.7 | 45.5 | 0.7 | 4.2 | 38.1 | 0.7 | 4.8 | 32.2 | 0.7 | 5.3 |
| 90 | 216.4 | 0.5 | 1.3 | 151.9 | 0.5 | 1.7 | 113.3 | 0.5 | 2.2 | 86.4 | 0.6 | 2.7 | 70.8 | 0.6 | 3.2 | 58.1 | 0.6 | 3.7 | 48.1 | 0.7 | 4.2 | 40.3 | 0.7 | 4.8 | 34.1 | 0.7 | 5.3 |
| 95 | 228.4 | 0.5 | 1.3 | 160.3 | 0.5 | 1.7 | 119.6 | 0.5 | 2.2 | 91.2 | 0.6 | 2.7 | 74.8 | 0.6 | 3.2 | 61.3 | 0.6 | 3.7 | 50.8 | 0.7 | 4.2 | 42.6 | 0.7 | 4.8 | 36.0 | 0.7 | 5.3 |
| 100 | 240.4 | 0.5 | 1.3 | 168.8 | 0.5 | 1.7 | 125.9 | 0.5 | 2.2 | 96.0 | 0.6 | 2.7 | 78.7 | 0.6 | 3.2 | 64.5 | 0.6 | 3.7 | 53.5 | 0.7 | 4.2 | 44.8 | 0.7 | 4.8 | 37.9 | 0.7 | 5.3 |
| 105 | 252.4 | 0.5 | 1.3 | 177.2 | 0.5 | 1.7 | 132.2 | 0.5 | 2.2 | 100.8 | 0.6 | 2.7 | 82.6 | 0.6 | 3.2 | 67.8 | 0.6 | 3.7 | 56.2 | 0.7 | 4.2 | 47.1 | 0.7 | 4.8 | 39.8 | 0.7 | 5.3 |
| 110 | 264.4 | 0.5 | 1.3 | 185.7 | 0.5 | 1.7 | 138.5 | 0.5 | 2.2 | 105.6 | 0.6 | 2.7 | 86.6 | 0.6 | 3.2 | 71.0 | 0.6 | 3.7 | 58.8 | 0.7 | 4.2 | 49.3 | 0.7 | 4.8 | 41.7 | 0.7 | 5.3 |
| 115 | 276.5 | 0.5 | 1.3 | 194.1 | 0.5 | 1.7 | 144.8 | 0.5 | 2.2 | 110.4 | 0.6 | 2.7 | 90.5 | 0.6 | 3.2 | 74.2 | 0.6 | 3.7 | 61.5 | 0.7 | 4.2 | 51.5 | 0.7 | 4.8 | 43.6 | 0.7 | 5.3 |
| 120 | 288.5 | 0.5 | 1.3 | 202.5 | 0.5 | 1.7 | 151.1 | 0.5 | 2.2 | 115.2 | 0.6 | 2.7 | 94.4 | 0.6 | 3.2 | 77.4 | 0.6 | 3.7 | 64.2 | 0.7 | 4.2 | 53.8 | 0.7 | 4.8 | 45.5 | 0.7 | 5.3 |
| 125 | 300.5 | 0.5 | 1.3 | 211.0 | 0.5 | 1.7 | 157.4 | 0.5 | 2.2 | 120.0 | 0.6 | 2.7 | 98.4 | 0.6 | 3.2 | 80.7 | 0.6 | 3.7 | 66.9 | 0.7 | 4.2 | 56.0 | 0.7 | 4.8 | 47.4 | 0.7 | 5.3 |
| 130 | 312.5 | 0.5 | 1.3 | 219.4 | 0.5 | 1.7 | 163.7 | 0.5 | 2.2 | 124.8 | 0.6 | 2.7 | 102.3 | 0.6 | 3.2 | 83.9 | 0.6 | 3.7 | 69.5 | 0.7 | 4.2 | 58.3 | 0.7 | 4.8 | 49.3 | 0.7 | 5.3 |
| 135 | 324.5 | 0.5 | 1.3 | 227.9 | 0.5 | 1.7 | 170.0 | 0.5 | 2.2 | 129.6 | 0.6 | 2.7 | 106.2 | 0.6 | 3.2 | 87.1 | 0.6 | 3.7 | 72.2 | 0.7 | 4.2 | 60.5 | 0.7 | 4.8 | 51.2 | 0.7 | 5.3 |
| 140 | 336.6 | 0.5 | 1.3 | 236.3 | 0.5 | 1.7 | 176.3 | 0.5 | 2.2 | 134.4 | 0.6 | 2.7 | 110.2 | 0.6 | 3.2 | 90.3 | 0.6 | 3.7 | 74.9 | 0.7 | 4.2 | 62.7 | 0.7 | 4.8 | 53.1 | 0.7 | 5.3 |
| 145 | 348.6 | 0.5 | 1.3 | 244.7 | 0.5 | 1.7 | 182.6 | 0.5 | 2.2 | 139.2 | 0.6 | 2.7 | 114.1 | 0.6 | 3.2 | 93.6 | 0.6 | 3.7 | 77.6 | 0.7 | 4.2 | 65.0 | 0.7 | 4.8 | 55.0 | 0.7 | 5.3 |
| 150 | 360.6 | 0.5 | 1.3 | 253.2 | 0.5 | 1.7 | 188.9 | 0.5 | 2.2 | 144.0 | 0.6 | 2.7 | 118.0 | 0.6 | 3.2 | 96.8 | 0.6 | 3.7 | 80.2 | 0.7 | 4.2 | 67.2 | 0.7 | 4.8 | 56.9 | 0.7 | 5.3 |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second
Depth "D" does not include allowance for freeboard or settlement

Table DV-16 Parabolic Diversion Design Chart (Retardance “D” and “C”, Grade 10.00%)

**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"**

**Grade 10.00 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 13.3 | 0.4 | 1.3 | 9.4 | 0.5 | 1.7 | 6.8 | 0.5 | 2.2 | 5.3 | 0.5 | 2.6 | 4.1 | 0.6 | 3.2 | 3.4 | 0.6 | 3.6 | 2.6 | 0.7 | 4.1 | | | | | | |
| 10 | 26.6 | 0.4 | 1.3 | 18.7 | 0.5 | 1.7 | 13.8 | 0.5 | 2.2 | 10.9 | 0.5 | 2.6 | 8.5 | 0.6 | 3.2 | 7.1 | 0.6 | 3.6 | 5.9 | 0.6 | 4.1 | 4.9 | 0.7 | 4.7 | 4.0 | 0.7 | 5.3 |
| 15 | 39.9 | 0.4 | 1.3 | 28.0 | 0.5 | 1.7 | 20.7 | 0.5 | 2.2 | 16.3 | 0.5 | 2.6 | 12.8 | 0.6 | 3.2 | 10.9 | 0.6 | 3.6 | 9.0 | 0.6 | 4.1 | 7.5 | 0.6 | 4.7 | 6.3 | 0.7 | 5.2 |
| 20 | 53.2 | 0.4 | 1.3 | 37.4 | 0.5 | 1.7 | 27.6 | 0.5 | 2.2 | 21.7 | 0.5 | 2.7 | 17.0 | 0.6 | 3.2 | 14.5 | 0.6 | 3.6 | 12.1 | 0.6 | 4.1 | 10.2 | 0.8 | 4.6 | 8.5 | 0.7 | 5.2 |
| 25 | 66.5 | 0.4 | 1.3 | 46.7 | 0.5 | 1.7 | 34.5 | 0.5 | 2.2 | 27.1 | 0.5 | 2.7 | 21.3 | 0.6 | 3.2 | 18.1 | 0.6 | 3.6 | 15.1 | 0.6 | 4.1 | 12.7 | 0.6 | 4.7 | 10.8 | 0.7 | 5.2 |
| 30 | 79.8 | 0.4 | 1.3 | 56.1 | 0.5 | 1.7 | 41.4 | 0.5 | 2.2 | 32.5 | 0.5 | 2.7 | 25.5 | 0.6 | 3.2 | 21.7 | 0.6 | 3.6 | 18.1 | 0.6 | 4.1 | 15.2 | 0.6 | 4.7 | 12.9 | 0.7 | 5.2 |
| 35 | 93.1 | 0.4 | 1.3 | 65.4 | 0.5 | 1.7 | 48.3 | 0.5 | 2.2 | 37.9 | 0.5 | 2.7 | 29.8 | 0.6 | 3.2 | 25.3 | 0.6 | 3.6 | 21.1 | 0.6 | 4.1 | 17.8 | 0.6 | 4.7 | 15.1 | 0.7 | 5.2 |
| 40 | 106.4 | 0.4 | 1.3 | 74.7 | 0.5 | 1.7 | 55.2 | 0.5 | 2.2 | 43.3 | 0.5 | 2.7 | 34.0 | 0.6 | 3.2 | 29.0 | 0.6 | 3.6 | 24.1 | 0.6 | 4.1 | 20.3 | 0.6 | 4.7 | 17.2 | 0.7 | 5.2 |
| 45 | 119.7 | 0.4 | 1.3 | 84.1 | 0.5 | 1.7 | 62.1 | 0.5 | 2.2 | 48.8 | 0.5 | 2.7 | 38.3 | 0.6 | 3.2 | 32.6 | 0.6 | 3.6 | 27.2 | 0.6 | 4.1 | 22.8 | 0.6 | 4.7 | 19.4 | 0.7 | 5.2 |
| 50 | 133.0 | 0.4 | 1.3 | 93.4 | 0.5 | 1.7 | 69.0 | 0.5 | 2.2 | 54.2 | 0.5 | 2.7 | 42.5 | 0.6 | 3.2 | 36.2 | 0.6 | 3.6 | 30.2 | 0.6 | 4.1 | 25.4 | 0.6 | 4.7 | 21.5 | 0.7 | 5.2 |
| 55 | 146.3 | 0.4 | 1.3 | 102.8 | 0.5 | 1.7 | 75.9 | 0.5 | 2.2 | 59.6 | 0.5 | 2.7 | 46.8 | 0.6 | 3.2 | 39.8 | 0.6 | 3.6 | 33.2 | 0.6 | 4.1 | 27.9 | 0.6 | 4.7 | 23.7 | 0.7 | 5.2 |
| 60 | 159.6 | 0.4 | 1.3 | 112.1 | 0.5 | 1.7 | 82.8 | 0.5 | 2.2 | 65.0 | 0.5 | 2.7 | 51.0 | 0.6 | 3.2 | 43.4 | 0.6 | 3.6 | 36.2 | 0.6 | 4.1 | 30.5 | 0.6 | 4.7 | 25.9 | 0.7 | 5.2 |
| 65 | 172.9 | 0.4 | 1.3 | 121.4 | 0.5 | 1.7 | 89.7 | 0.5 | 2.2 | 70.4 | 0.5 | 2.7 | 55.3 | 0.6 | 3.2 | 47.1 | 0.6 | 3.6 | 39.2 | 0.6 | 4.1 | 33.0 | 0.6 | 4.7 | 28.0 | 0.7 | 5.2 |
| 70 | 186.2 | 0.4 | 1.3 | 130.8 | 0.5 | 1.7 | 96.6 | 0.5 | 2.2 | 75.8 | 0.5 | 2.7 | 59.5 | 0.6 | 3.2 | 50.7 | 0.6 | 3.6 | 42.2 | 0.6 | 4.1 | 35.5 | 0.6 | 4.7 | 30.2 | 0.7 | 5.2 |
| 75 | 199.5 | 0.4 | 1.3 | 140.1 | 0.5 | 1.7 | 103.5 | 0.5 | 2.2 | 81.2 | 0.5 | 2.7 | 63.8 | 0.6 | 3.2 | 54.3 | 0.6 | 3.6 | 45.2 | 0.6 | 4.1 | 38.1 | 0.6 | 4.7 | 32.3 | 0.7 | 5.2 |
| 80 | 212.8 | 0.4 | 1.3 | 149.5 | 0.5 | 1.7 | 110.5 | 0.5 | 2.2 | 86.7 | 0.5 | 2.7 | 68.0 | 0.6 | 3.2 | 57.9 | 0.6 | 3.6 | 48.3 | 0.6 | 4.1 | 40.6 | 0.6 | 4.7 | 34.5 | 0.7 | 5.2 |
| 85 | 226.1 | 0.4 | 1.3 | 158.8 | 0.5 | 1.7 | 117.4 | 0.5 | 2.2 | 92.1 | 0.5 | 2.7 | 72.3 | 0.6 | 3.2 | 61.5 | 0.6 | 3.6 | 51.3 | 0.6 | 4.1 | 43.1 | 0.6 | 4.7 | 36.6 | 0.7 | 5.2 |
| 90 | 239.4 | 0.4 | 1.3 | 168.1 | 0.5 | 1.7 | 124.3 | 0.5 | 2.2 | 97.5 | 0.5 | 2.7 | 76.5 | 0.6 | 3.2 | 65.2 | 0.6 | 3.6 | 54.3 | 0.6 | 4.1 | 45.7 | 0.6 | 4.7 | 38.8 | 0.7 | 5.2 |
| 95 | 252.7 | 0.4 | 1.3 | 177.5 | 0.5 | 1.7 | 131.2 | 0.5 | 2.2 | 102.9 | 0.5 | 2.7 | 80.8 | 0.6 | 3.2 | 68.8 | 0.6 | 3.6 | 57.3 | 0.6 | 4.1 | 48.2 | 0.6 | 4.7 | 40.9 | 0.7 | 5.2 |
| 100 | 266.0 | 0.4 | 1.3 | 186.8 | 0.5 | 1.7 | 138.1 | 0.5 | 2.2 | 108.3 | 0.5 | 2.7 | 85.0 | 0.6 | 3.2 | 72.4 | 0.6 | 3.6 | 60.3 | 0.6 | 4.1 | 50.7 | 0.6 | 4.7 | 43.1 | 0.7 | 5.2 |
| 105 | 279.3 | 0.4 | 1.3 | 196.2 | 0.5 | 1.7 | 145.0 | 0.5 | 2.2 | 113.7 | 0.5 | 2.7 | 89.3 | 0.6 | 3.2 | 76.0 | 0.6 | 3.6 | 63.3 | 0.6 | 4.1 | 53.3 | 0.6 | 4.7 | 45.2 | 0.7 | 5.2 |
| 110 | 292.6 | 0.4 | 1.3 | 205.5 | 0.5 | 1.7 | 151.9 | 0.5 | 2.2 | 119.2 | 0.5 | 2.7 | 93.5 | 0.6 | 3.2 | 79.6 | 0.6 | 3.6 | 66.4 | 0.6 | 4.1 | 55.8 | 0.6 | 4.7 | 47.4 | 0.7 | 5.2 |
| 115 | 305.9 | 0.4 | 1.3 | 214.9 | 0.5 | 1.7 | 158.8 | 0.5 | 2.2 | 124.8 | 0.5 | 2.7 | 97.8 | 0.6 | 3.2 | 83.3 | 0.6 | 3.6 | 69.4 | 0.6 | 4.1 | 58.3 | 0.6 | 4.7 | 49.5 | 0.7 | 5.3 |
| 120 | 319.2 | 0.4 | 1.3 | 224.2 | 0.5 | 1.7 | 165.7 | 0.5 | 2.2 | 130.0 | 0.5 | 2.7 | 102.0 | 0.6 | 3.2 | 86.9 | 0.6 | 3.6 | 72.4 | 0.6 | 4.1 | 60.9 | 0.6 | 4.7 | 51.7 | 0.7 | 5.3 |
| 125 | 332.5 | 0.4 | 1.3 | 233.5 | 0.5 | 1.7 | 172.6 | 0.5 | 2.2 | 135.4 | 0.5 | 2.7 | 106.3 | 0.6 | 3.2 | 90.5 | 0.6 | 3.6 | 75.4 | 0.6 | 4.1 | 63.4 | 0.6 | 4.7 | 53.8 | 0.7 | 5.3 |
| 130 | 345.8 | 0.4 | 1.3 | 242.9 | 0.5 | 1.7 | 179.5 | 0.5 | 2.2 | 140.8 | 0.5 | 2.7 | 110.5 | 0.6 | 3.2 | 94.1 | 0.6 | 3.6 | 78.4 | 0.6 | 4.1 | 66.0 | 0.6 | 4.7 | 56.0 | 0.7 | 5.3 |
| 135 | 359.1 | 0.4 | 1.3 | 252.2 | 0.5 | 1.7 | 186.4 | 0.5 | 2.2 | 146.2 | 0.5 | 2.7 | 114.8 | 0.6 | 3.2 | 97.7 | 0.6 | 3.6 | 81.4 | 0.6 | 4.1 | 68.5 | 0.6 | 4.7 | 58.1 | 0.7 | 5.3 |
| 140 | 372.4 | 0.4 | 1.3 | 261.6 | 0.5 | 1.7 | 193.3 | 0.5 | 2.2 | 151.7 | 0.5 | 2.7 | 119.0 | 0.6 | 3.2 | 101.3 | 0.6 | 3.6 | 84.4 | 0.6 | 4.1 | 71.0 | 0.6 | 4.7 | 60.3 | 0.7 | 5.3 |
| 145 | 385.7 | 0.4 | 1.3 | 270.9 | 0.5 | 1.7 | 200.2 | 0.5 | 2.2 | 157.1 | 0.5 | 2.7 | 123.3 | 0.6 | 3.2 | 105.0 | 0.6 | 3.6 | 87.5 | 0.6 | 4.1 | 73.6 | 0.6 | 4.7 | 62.5 | 0.7 | 5.3 |
| 150 | 399.0 | 0.4 | 1.3 | 280.2 | 0.5 | 1.7 | 207.1 | 0.5 | 2.2 | 162.5 | 0.5 | 2.7 | 127.5 | 0.6 | 3.2 | 108.6 | 0.6 | 3.6 | 90.5 | 0.6 | 4.1 | 76.1 | 0.6 | 4.7 | 64.6 | 0.7 | 5.3 |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

# Grass Swale (GS)

## Practice Description

A grass swale is a natural or constructed channel that is shaped or graded to required dimensions and established in suitable vegetation for the stable conveyance of runoff without causing damage to the channel by erosion. This practice applies to sites where concentrated runoff will cause erosion damage, a vegetative lining provides sufficient stability for the channel as designed, and space is available for a relatively large cross section. Typical situations where concentrated flow areas are addressed with a grass swale include roadside ditches, channels at property boundaries, outlets for diversions and other concentrated flow areas subject to channel erosion. Grassed swales are generally considered permanent structures but may be used as a temporary measure.

## Planning Considerations

Grass swales should be carefully built to the design cross section, shape and dimensions. Swales are hydraulic structures and as such depend upon the hydraulic parameters to function satisfactorily. Vegetated swales should be well established before large flows are permitted in the channel.

The design of a channel cross section and lining is based primarily upon the volume and velocity of flow expected in the channel. This practice covers grassed swales with low velocity flows (generally less than 5 ft/sec). Where high velocities are anticipated lined swales should be used (see Lined Swale practice or Riprap-lined Swale practice). Lined swales should also be used where there is continuous flow in the swale, which would prevent establishment of vegetation within the flow area.

Besides the primary design considerations of capacity and velocity, a number of other important factors should be taken into account when selecting a cross section (Figure GS-1). These factors include land availability, compatibility with land use and surrounding environment, safety, maintenance requirements outlet conditions, etc.

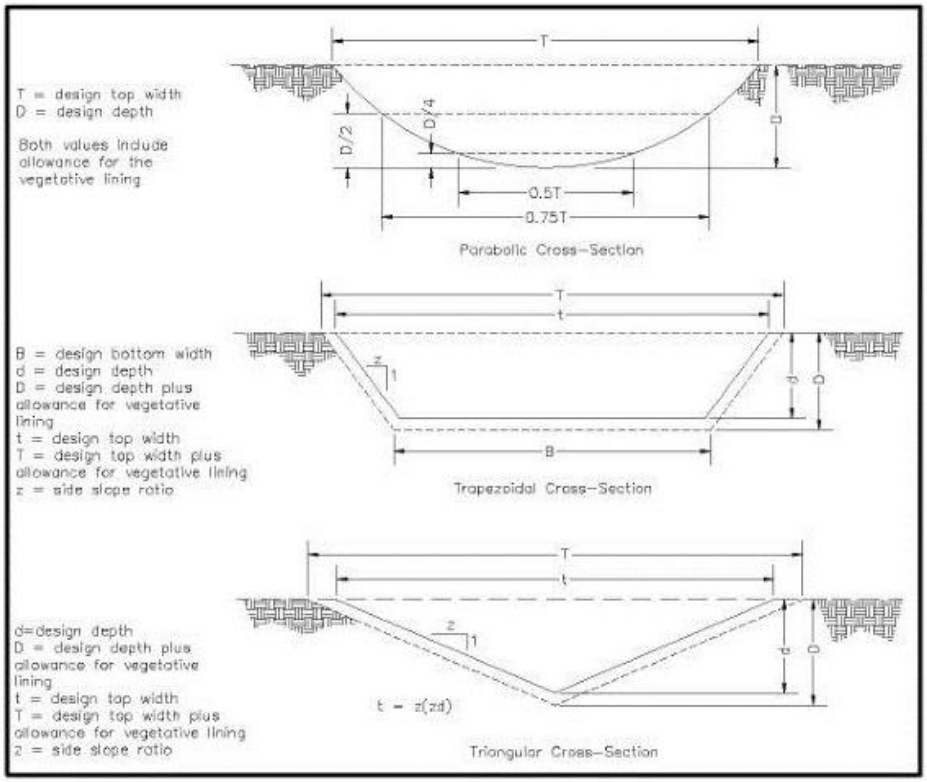



Figure GS-1 Typical Grass Swale Cross section

### *Triangular Shaped Ditches*

Triangular shaped ditches are generally used where the quantity of water to be handled is relatively small, such as along roadsides. A triangular grass swale will suffice where velocities in the ditch are low.

### *Parabolic Channels*

Parabolic channels are often used where the quantity of water to be handled is larger and where space is available for a wide, shallow channel with low velocity flow.

### *Trapezoidal Channels*

Trapezoidal channels are often used where the quantity of water to be carried is large and conditions require that it be carried at a relatively high velocity. Trapezoidal ditches lined with concrete, riprap, or others similar materials are considered lined swales or riprap lined swales. In some cases, erosion control

blankets (see Erosion Control Blanket practice) and high end hydraulic mulch (see Mulching practice) can be used to establish vegetation.

### *Other Considerations*

Outlet conditions for all channels should be considered. Appropriate measures must be taken to dissipate the energy of the flow to prevent scour at the outlet of the swale.

*Grass swales should be protected from erosion by concentrated flows. The methods of protecting grass swales would include, but not be limited to the following:*

- Vegetation.
- Biodegradable linings and vegetation.

The type and intensity of the protective linings will determine the design of the grass swale.

If velocities exceed stable velocities, for vegetated swales or vegetation with biodegradable linings, then other linings should be used (see Lined Swale or Riprap-lined Swale practice).

The time of the year should be considered when planning grass swales. Grass swales that are seeded to establish vegetation should not be planned for construction during late fall, winter or early spring. Grass swales constructed during mid-summer to early fall may need temporary seeding followed by permanent seeding at the recommended times. The vegetation species should be recommended for the area of the state that it is planned.

## Design Criteria

### *Capacity*

*Note: This design example uses the Permissible Velocity approach. Grass swale design using the Tractive Stress approach can also be used but is not discussed in this document.*

Grass swales shall be designed to convey the peak rate of runoff as shown in Table GS-1. Adjustments should be made for release rates from structures and other drainage facilities. Grass swales shall also be designed to comply with local stormwater ordinances. Grass swales should be designed for greater capacity whenever there is danger of flooding or out of bank flow cannot be tolerated.

Table GS-1 Design Frequency for Grassed Swale

| Grass Swale Type | Typical Area of Protection | 24 Hour Design Storm Frequency |
|---|---|---|
| Temporary Swale | Construction Areas | 2-year |
| | Building Sites | 5-year |
| Permanent Swale | Agricultural Land | 10-year |
| | Reclaimed Mined Land | 10-year |
| | Isolated Buildings | 10-year |
| | Urban areas, Residential, School, Industrial Areas, Recreation Areas, etc. | 10-year |

Peak rates of runoff values used to determine the capacity requirements should be calculated using accepted engineering methods. Some accepted methods are:

- Natural Resources Conservation Service, National Engineering Handbook Series, Part 650, Engineering Field Handbook, Chapter 2, Estimating Runoff.
- Natural Resources Conservation Service, formerly Soil Conservation Service, Technical Release 55, Urban Hydrology for Small Watersheds.
- Other comparable methods.

### *Grade of Grass Swale*

After selecting a location for the grassed swale that will minimize the impacts to the site and maximize the intended use, the grade in the grass swales should be determined. The grade in feet per 100 feet of length can be determined from a topographic map of the site or from a detailed survey of the planned grassed swale location.

### *Retardance*

The grass species used and the degree of maintenance planned for the vegetation determines the retardance of the swale (see Table GS-2).

Generally, the retardance used for the design of grassed swales should be “D” and “C” to produce a stable velocity and adequate capacity to carry the design storm.

Table GS-2 Retardance for Grassed Swales

| Retardance | Species [1] | Cover Condition |
|---|---|---|
| A | Reed Canarygrass | Excellent stand, tall (average 36”) |
| | Yellow Bluestem Ischaemum | Excellent stand, tall (average 36”) |
| B | Smooth Bromegrass | Good stand, mowed (average 12 to 15”) |
| | Bermudagrass | Good stand, tall (average 12) |
| | Native Grass mixture (Little Bluestem, Blue Grama, and other long and short Midwest Grasses) | Good stand, unmowed |
| | Tall Fescue | Good stand, unmowed (average 18”) |
| | Lespedeza Sericea | Good stand, not woody, tall (average 19”) |
| | Grass-Legume mixture-Timothy, smooth Bromegrass, or Orchardgrass | Good stand, uncut (average 20”) |
| | Reed Canarygrass | Good stand, mowed (average 12 to 15”) |
| | Tall Fescue, with Bird’s Foot Trefoil or Ladino Clover | Good stand, uncut (average 18”) |
| | Blue Grama | Good stand, uncut (average 13”) |
| C | Bahiagrass | Good stand, uncut (average 6 to 8”) |
| | Bermudagrass | Good stand, mowed (average 6”) |
| | Redtop | Good stand, headed (15 to 20) |
| | Grass-legume mixture-summer (Orchardgrass, Redtop, Italian Ryegrass, and Common Lespedeza) | Good stand, uncut (6 to 8”) |
| | Centipedegrass | Very dense cover (average 6”) |
| | Kentucky Bluegrass | Good stand, headed (6 to 12”) |
| D | Bermudagrass | Good stand, cut to 2.5” height |
| | Red Fescue | Good stand, headed (12 to 18”) |
| | Buffalograss | Good stand, uncut (3 to 6”) |
| | Grass-Legume mixture-fall, spring (Orchard Grass, Redtop, Italian Ryegrass, and Common Lespedeza) | Good stand, uncut (4 to 5”) |
| | Lespedeza Sericea | After cutting to 2” height. Very good stand before cutting |
| E | Bermudagrass | Good stand, cut to 1.5” height. |
| | Bermudagrass | Burned stubble |

1/ Species to establish should be selected based on suitability of soil and expected management.

*Velocities*

Classify the soil where the swale is to be constructed into erosion resistant cohesive (clayey) fine and coarse-grained soils or easily eroded noncohesive silt, clays and sands.

Determine the type of vegetative cover to be established in the swale.

Use the swale grade, cover and soil erodibility to determine permissible velocity using Table GS-3.

Table GS-3 Permissible Velocities in Grassed Swales

| Cover | Slope Range[2] | Permissible Velocity[1] Erosion Resistant Soils[3] (clayey) | Permissible Velocity[1] Easily Eroded Soils[4] (sandy) |
|---|---|---|---|
| | *percent* | ft/sec | ft/sec |
| **Bermudagrass** | < 5 | 8 | 6 |
| | 5-10 | 7 | 4 |
| | over 10 | 6 | 3 |
| **Bahiagrass** | <5 | 7 | 5 |
| **Tall Fescue** | 5-10 | 6 | 4 |
| | over 10 | 5 | 3 |
| **Sericea Lespedeza** **Weeping Lovegrass** | <5[5] | 3.5 | 2.5 |

[1]Use velocities exceeding (5ft/sec) only where good covers and proper maintenance can be obtained.
[2]Do not use on slopes steeper than 10 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.
[3]Cohesive (clayey) fine-grain soils and coarse-grain soils with cohesive fines with a plasticity index of 10 to 40 (CL, CH, SC, and CG).
[4] Soils that do not meet requirements for erosion-resistant soils.
[5] Do not use on slopes steeper than 5 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

### *Swale Dimensions*

The swale may be triangular shaped, parabolic or trapezoidal as discussed in the planning considerations of this standard and shown in Figure GS-1.

Using the peak discharge, swale grade, permissible velocity and retardance, parabolic dimensions can be determined using Table GS-4, Sheets 1 through 14.

Design dimensions for triangular shaped and trapezoidal shaped swales can be determined using Manning's equation or other accepted engineering designs.

The design water surface elevation of a channel receiving water from other tributary sources shall be equal to or less than the design water surface elevation of the contributing source. The design water surface elevation of contributing and receiving waters should be the same, whenever practical.

*A minimum depth may be necessary to provide adequate outlets for subsurface drains and tributary channels.*

### *Drainage*

Polyethylene drainage tubing, tile or other suitable subsurface drainage measures shall be provided for sites having high water tables or seepage problems.

### *Freeboard*

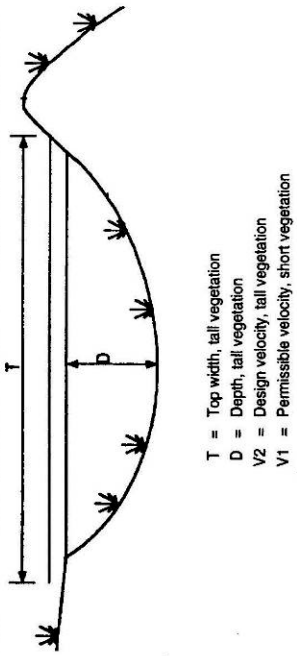
The minimum freeboard is 0.25 feet in depth. Freeboard is not required on grass swales with less than 1% slope and where out-of-bank flow will not be damaging and can be tolerated in the normal operation at the site.

Table GS-4 Parabolic Grass Swale Design Sheet 1 of 14

**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"**

**Grade 0.25 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25 | 9.3 | 2.3 | 1.7 | | | | | | | | | | | | | | | | | | | | | | | | |
| 30 | 11.7 | 2.2 | 1.8 | | | | | | | | | | | | | | | | | | | | | | | | |
| 35 | 14.1 | 2.1 | 1.7 | | | | | | | | | | | | | | | | | | | | | | | | |
| 40 | 16.3 | 2.1 | 1.8 | | | | | | | | | | | | | | | | | | | | | | | | |
| 45 | 18.5 | 2.1 | 1.8 | 10.4 | 2.8 | 2.3 | | | | | | | | | | | | | | | | | | | | | |
| 50 | 20.7 | 2.1 | 1.8 | 12.3 | 2.6 | 2.3 | | | | | | | | | | | | | | | | | | | | | |
| 55 | 22.9 | 2.1 | 1.8 | 13.8 | 2.6 | 2.3 | | | | | | | | | | | | | | | | | | | | | |
| 60 | 25.0 | 2.0 | 1.8 | 15.3 | 2.5 | 2.3 | | | | | | | | | | | | | | | | | | | | | |
| 65 | 27.2 | 2.0 | 1.8 | 16.8 | 2.5 | 2.3 | 10.4 | 3.4 | 2.8 | | | | | | | | | | | | | | | | | | |
| 70 | 29.3 | 2.0 | 1.8 | 18.2 | 2.5 | 2.3 | 12.1 | 3.1 | 2.8 | | | | | | | | | | | | | | | | | | |
| 75 | 31.9 | 2.0 | 1.7 | 19.7 | 2.4 | 2.3 | 13.5 | 3.0 | 2.8 | | | | | | | | | | | | | | | | | | |
| 80 | 34.0 | 2.0 | 1.7 | 21.1 | 2.4 | 2.3 | 14.7 | 2.9 | 2.8 | | | | | | | | | | | | | | | | | | |
| 85 | 36.1 | 2.0 | 1.7 | 22.5 | 2.4 | 2.3 | 15.8 | 2.9 | 2.8 | | | | | | | | | | | | | | | | | | |
| 90 | 38.2 | 2.0 | 1.7 | 23.9 | 2.4 | 2.3 | 16.9 | 2.8 | 2.8 | | | | | | | | | | | | | | | | | | |
| 95 | 40.3 | 2.0 | 1.7 | 25.3 | 2.4 | 2.3 | 18.0 | 2.8 | 2.8 | | | | | | | | | | | | | | | | | | |
| 100 | 42.4 | 2.0 | 1.7 | 26.7 | 2.4 | 2.3 | 19.1 | 2.8 | 2.8 | | | | | | | | | | | | | | | | | | |
| 105 | 44.6 | 2.0 | 1.7 | 28.1 | 2.4 | 2.3 | 20.2 | 2.8 | 2.8 | | | | | | | | | | | | | | | | | | |
| 110 | 46.7 | 2.0 | 1.7 | 29.5 | 2.4 | 2.3 | 21.3 | 2.8 | 2.8 | 12.9 | 3.8 | 3.4 | | | | | | | | | | | | | | | |
| 115 | 48.8 | 2.0 | 1.7 | 30.8 | 2.4 | 2.3 | 22.3 | 2.8 | 2.8 | 14.0 | 3.7 | 3.4 | | | | | | | | | | | | | | | |
| 120 | 50.9 | 2.0 | 1.7 | 32.2 | 2.4 | 2.3 | 23.4 | 2.8 | 2.8 | 15.3 | 3.5 | 3.4 | | | | | | | | | | | | | | | |
| 125 | 53.0 | 2.0 | 1.8 | 33.6 | 2.4 | 2.3 | 24.4 | 2.8 | 2.8 | 16.1 | 3.5 | 3.4 | | | | | | | | | | | | | | | |
| 130 | 55.1 | 2.0 | 1.8 | 35.0 | 2.4 | 2.3 | 25.5 | 2.8 | 2.8 | 16.9 | 3.4 | 3.4 | | | | | | | | | | | | | | | |
| 135 | 57.3 | 2.0 | 1.8 | 36.4 | 2.4 | 2.3 | 26.5 | 2.7 | 2.8 | 17.7 | 3.4 | 3.4 | | | | | | | | | | | | | | | |
| 140 | 59.4 | 2.0 | 1.8 | 38.3 | 2.4 | 2.3 | 27.6 | 2.7 | 2.8 | 18.5 | 3.4 | 3.4 | | | | | | | | | | | | | | | |
| 145 | 61.5 | 2.0 | 1.8 | 39.7 | 2.4 | 2.3 | 28.6 | 2.7 | 2.8 | 19.3 | 3.3 | 3.4 | | | | | | | | | | | | | | | |
| 150 | 63.6 | 2.0 | 1.8 | 41.1 | 2.4 | 2.3 | 29.6 | 2.7 | 2.8 | 20.1 | 3.3 | 3.4 | | | | | | | | | | | | | | | |




RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 2 of 14

**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"**

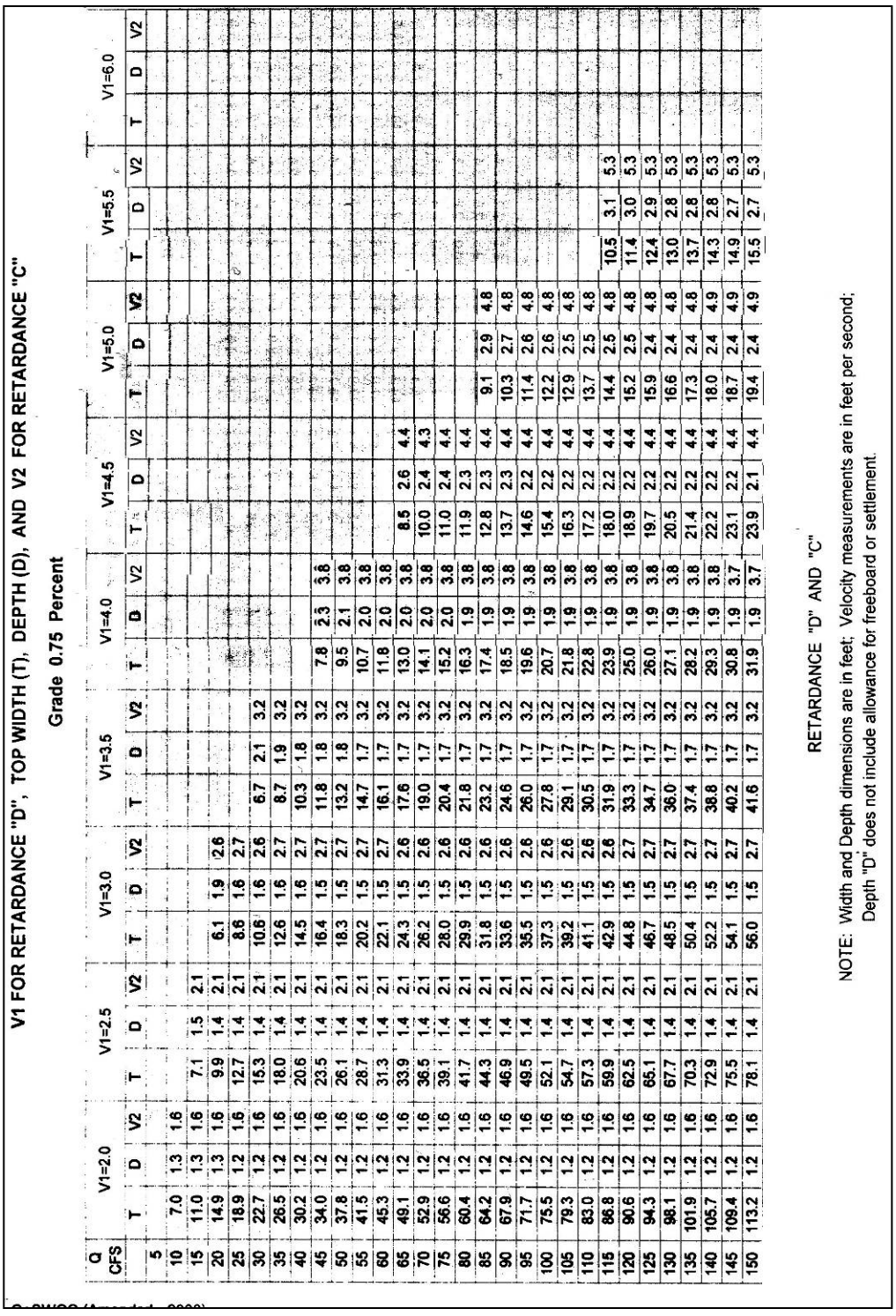
**Grade 0.50 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | 8.4 | 1.6 | 1.7 | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | 11.7 | 1.5 | 1.7 | 7.1 | 2.0 | 2.2 | | | | | | | | | | | | | | | | | | | | | |
| 25 | 14.9 | 1.5 | 1.7 | 9.7 | 1.8 | 2.2 | | | | | | | | | | | | | | | | | | | | | |
| 30 | 18.0 | 1.5 | 1.7 | 12.0 | 1.7 | 2.2 | | | | | | | | | | | | | | | | | | | | | |
| 35 | 21.0 | 1.5 | 1.7 | 14.2 | 1.7 | 2.2 | 9.3 | 2.1 | 2.7 | | | | | | | | | | | | | | | | | | |
| 40 | 24.4 | 1.5 | 1.7 | 16.3 | 1.7 | 2.2 | 10.9 | 2.0 | 2.7 | | | | | | | | | | | | | | | | | | |
| 45 | 27.4 | 1.5 | 1.7 | 18.5 | 1.7 | 2.2 | 12.5 | 2.0 | 2.7 | | | | | | | | | | | | | | | | | | |
| 50 | 30.5 | 1.5 | 1.7 | 20.6 | 1.7 | 2.2 | 14.1 | 1.9 | 2.7 | 8.7 | 2.6 | 3.3 | | | | | | | | | | | | | | | |
| 55 | 33.5 | 1.5 | 1.7 | 22.7 | 1.7 | 2.2 | 15.7 | 1.9 | 2.7 | 10.4 | 2.4 | 3.3 | | | | | | | | | | | | | | | |
| 60 | 36.6 | 1.5 | 1.7 | 24.8 | 1.7 | 2.2 | 17.2 | 1.9 | 2.7 | 11.7 | 2.3 | 3.3 | | | | | | | | | | | | | | | |
| 65 | 39.6 | 1.5 | 1.7 | 27.3 | 1.7 | 2.2 | 18.8 | 1.9 | 2.7 | 12.9 | 2.3 | 3.3 | | | | | | | | | | | | | | | |
| 70 | 42.6 | 1.5 | 1.7 | 29.4 | 1.7 | 2.2 | 20.3 | 1.9 | 2.7 | 14.0 | 2.2 | 3.3 | 9.8 | 2.8 | 3.8 | | | | | | | | | | | | |
| 75 | 45.7 | 1.5 | 1.7 | 31.4 | 1.7 | 2.2 | 21.8 | 1.9 | 2.7 | 15.2 | 2.2 | 3.3 | 11.3 | 2.7 | 3.8 | | | | | | | | | | | | |
| 80 | 48.7 | 1.5 | 1.7 | 33.5 | 1.7 | 2.2 | 23.3 | 1.9 | 2.7 | 16.3 | 2.2 | 3.3 | 12.2 | 2.6 | 3.8 | | | | | | | | | | | | |
| 85 | 51.7 | 1.5 | 1.7 | 35.6 | 1.6 | 2.2 | 24.8 | 1.9 | 2.7 | 17.4 | 2.2 | 3.3 | 13.2 | 2.5 | 3.8 | | | | | | | | | | | | |
| 90 | 54.8 | 1.5 | 1.7 | 37.7 | 1.6 | 2.2 | 26.3 | 1.9 | 2.7 | 18.5 | 2.2 | 3.3 | 14.2 | 2.5 | 3.8 | | | | | | | | | | | | |
| 95 | 57.8 | 1.5 | 1.7 | 39.8 | 1.6 | 2.2 | 27.8 | 1.9 | 2.7 | 19.6 | 2.2 | 3.3 | 15.1 | 2.5 | 3.8 | | | | | | | | | | | | |
| 100 | 60.9 | 1.5 | 1.7 | 41.9 | 1.6 | 2.2 | 29.7 | 1.9 | 2.7 | 20.7 | 2.2 | 3.3 | 16.0 | 2.5 | 3.8 | 11.0 | 3.2 | 4.3 | | | | | | | | | |
| 105 | 63.9 | 1.5 | 1.7 | 44.0 | 1.6 | 2.2 | 31.2 | 1.9 | 2.7 | 21.8 | 2.2 | 3.3 | 16.9 | 2.5 | 3.8 | 12.3 | 3.0 | 4.3 | | | | | | | | | |
| 110 | 66.9 | 1.5 | 1.7 | 46.1 | 1.6 | 2.2 | 32.6 | 1.9 | 2.7 | 22.9 | 2.2 | 3.3 | 17.8 | 2.4 | 3.8 | 13.1 | 2.9 | 4.3 | | | | | | | | | |
| 115 | 70.0 | 1.5 | 1.7 | 48.1 | 1.6 | 2.2 | 34.1 | 1.9 | 2.7 | 24.0 | 2.1 | 3.3 | 18.7 | 2.4 | 3.8 | 13.9 | 2.9 | 4.3 | | | | | | | | | |
| 120 | 73.0 | 1.5 | 1.7 | 50.2 | 1.6 | 2.2 | 35.6 | 1.9 | 2.7 | 25.1 | 2.1 | 3.3 | 19.6 | 2.4 | 3.8 | 14.6 | 2.9 | 4.3 | | | | | | | | | |
| 125 | 76.1 | 1.5 | 1.7 | 52.3 | 1.6 | 2.2 | 37.1 | 1.9 | 2.7 | 26.2 | 2.1 | 3.3 | 20.5 | 2.4 | 3.8 | 15.4 | 2.8 | 4.3 | | | | | | | | | |
| 130 | 79.1 | 1.5 | 1.7 | 54.4 | 1.6 | 2.2 | 38.5 | 1.9 | 2.7 | 27.3 | 2.1 | 3.3 | 21.3 | 2.4 | 3.8 | 16.1 | 2.8 | 4.3 | | | | | | | | | |
| 135 | 82.1 | 1.5 | 1.7 | 56.5 | 1.6 | 2.2 | 40.0 | 1.9 | 2.7 | 28.4 | 2.1 | 3.3 | 22.2 | 2.4 | 3.8 | 16.9 | 2.8 | 4.3 | | | | | | | | | |
| 140 | 85.2 | 1.5 | 1.7 | 58.6 | 1.6 | 2.2 | 41.5 | 1.9 | 2.7 | 29.4 | 2.1 | 3.3 | 23.1 | 2.4 | 3.8 | 17.6 | 2.8 | 4.3 | | | | | | | | | |
| 145 | 88.2 | 1.5 | 1.7 | 60.7 | 1.6 | 2.2 | 43.0 | 1.9 | 2.7 | 30.5 | 2.1 | 3.3 | 24.0 | 2.4 | 3.8 | 18.3 | 2.8 | 4.3 | 12.3 | 3.7 | 4.9 | | | | | | |
| 150 | 91.3 | 1.6 | 1.7 | 62.8 | 1.6 | 2.2 | 44.5 | 1.9 | 2.7 | 31.6 | 2.1 | 3.3 | 24.8 | 2.4 | 3.8 | 19.0 | 2.7 | 4.3 | 13.1 | 3.5 | 4.9 | | | | | | |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 3 of 14



**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"**

**Grade 0.75 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | 7.0 | 1.3 | 1.6 | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | 11.0 | 1.3 | 1.6 | 7.1 | 1.5 | 2.1 | | | | | | | | | | | | | | | | | | | | | |
| 20 | 14.9 | 1.3 | 1.6 | 9.9 | 1.4 | 2.1 | 6.1 | 1.9 | 2.6 | | | | | | | | | | | | | | | | | | |
| 25 | 18.9 | 1.2 | 1.6 | 12.7 | 1.4 | 2.1 | 8.6 | 1.6 | 2.7 | | | | | | | | | | | | | | | | | | |
| 30 | 22.7 | 1.2 | 1.6 | 15.3 | 1.4 | 2.1 | 10.6 | 1.6 | 2.6 | 6.7 | 2.1 | 3.2 | | | | | | | | | | | | | | | |
| 35 | 26.5 | 1.2 | 1.6 | 18.0 | 1.4 | 2.1 | 12.6 | 1.6 | 2.7 | 8.7 | 1.9 | 3.2 | | | | | | | | | | | | | | | |
| 40 | 30.2 | 1.2 | 1.6 | 20.6 | 1.4 | 2.1 | 14.5 | 1.6 | 2.7 | 10.3 | 1.8 | 3.2 | | | | | | | | | | | | | | | |
| 45 | 34.0 | 1.2 | 1.6 | 23.5 | 1.4 | 2.1 | 16.4 | 1.5 | 2.7 | 11.8 | 1.8 | 3.2 | 7.8 | 2.3 | 3.8 | | | | | | | | | | | | |
| 50 | 37.8 | 1.2 | 1.6 | 26.1 | 1.4 | 2.1 | 18.3 | 1.5 | 2.7 | 13.2 | 1.8 | 3.2 | 9.5 | 2.1 | 3.8 | | | | | | | | | | | | |
| 55 | 41.5 | 1.2 | 1.6 | 28.7 | 1.4 | 2.1 | 20.2 | 1.5 | 2.7 | 14.7 | 1.7 | 3.2 | 10.7 | 2.0 | 3.8 | | | | | | | | | | | | |
| 60 | 45.3 | 1.2 | 1.6 | 31.3 | 1.4 | 2.1 | 22.1 | 1.5 | 2.7 | 16.1 | 1.7 | 3.2 | 11.8 | 2.0 | 3.8 | | | | | | | | | | | | |
| 65 | 49.1 | 1.2 | 1.6 | 33.9 | 1.4 | 2.1 | 24.3 | 1.5 | 2.6 | 17.6 | 1.7 | 3.2 | 13.0 | 2.0 | 3.8 | 8.5 | 2.6 | 4.4 | | | | | | | | | |
| 70 | 52.9 | 1.2 | 1.6 | 36.5 | 1.4 | 2.1 | 26.2 | 1.5 | 2.6 | 19.0 | 1.7 | 3.2 | 14.1 | 2.0 | 3.8 | 10.0 | 2.4 | 4.3 | | | | | | | | | |
| 75 | 56.6 | 1.2 | 1.6 | 39.1 | 1.4 | 2.1 | 28.0 | 1.5 | 2.6 | 20.4 | 1.7 | 3.2 | 15.2 | 2.0 | 3.8 | 11.0 | 2.4 | 4.4 | | | | | | | | | |
| 80 | 60.4 | 1.2 | 1.6 | 41.7 | 1.4 | 2.1 | 29.9 | 1.5 | 2.6 | 21.8 | 1.7 | 3.2 | 16.3 | 1.9 | 3.8 | 11.9 | 2.3 | 4.4 | | | | | | | | | |
| 85 | 64.2 | 1.2 | 1.6 | 44.3 | 1.4 | 2.1 | 31.8 | 1.5 | 2.6 | 23.2 | 1.7 | 3.2 | 17.4 | 1.9 | 3.8 | 12.8 | 2.3 | 4.4 | 9.1 | 2.9 | 4.8 | | | | | | |
| 90 | 67.9 | 1.2 | 1.6 | 46.9 | 1.4 | 2.1 | 33.6 | 1.5 | 2.6 | 24.6 | 1.7 | 3.2 | 18.5 | 1.9 | 3.8 | 13.7 | 2.3 | 4.4 | 10.3 | 2.7 | 4.8 | | | | | | |
| 95 | 71.7 | 1.2 | 1.6 | 49.5 | 1.4 | 2.1 | 35.5 | 1.5 | 2.6 | 26.0 | 1.7 | 3.2 | 19.6 | 1.9 | 3.8 | 14.6 | 2.2 | 4.4 | 11.4 | 2.6 | 4.8 | | | | | | |
| 100 | 75.5 | 1.2 | 1.6 | 52.1 | 1.4 | 2.1 | 37.3 | 1.5 | 2.6 | 27.8 | 1.7 | 3.2 | 20.7 | 1.9 | 3.8 | 15.4 | 2.2 | 4.4 | 12.2 | 2.6 | 4.8 | | | | | | |
| 105 | 79.3 | 1.2 | 1.6 | 54.7 | 1.4 | 2.1 | 39.2 | 1.5 | 2.6 | 29.1 | 1.7 | 3.2 | 21.8 | 1.9 | 3.8 | 16.3 | 2.2 | 4.4 | 12.9 | 2.5 | 4.8 | | | | | | |
| 110 | 83.0 | 1.2 | 1.6 | 57.3 | 1.4 | 2.1 | 41.1 | 1.5 | 2.6 | 30.5 | 1.7 | 3.2 | 22.8 | 1.9 | 3.8 | 17.2 | 2.2 | 4.4 | 13.7 | 2.5 | 4.8 | | | | | | |
| 115 | 86.8 | 1.2 | 1.6 | 59.9 | 1.4 | 2.1 | 42.9 | 1.5 | 2.6 | 31.9 | 1.7 | 3.2 | 23.9 | 1.9 | 3.8 | 18.0 | 2.2 | 4.4 | 14.4 | 2.5 | 4.8 | 10.5 | 3.1 | 5.3 | | | |
| 120 | 90.6 | 1.2 | 1.6 | 62.5 | 1.4 | 2.1 | 44.8 | 1.5 | 2.7 | 33.3 | 1.7 | 3.2 | 25.0 | 1.9 | 3.8 | 18.9 | 2.2 | 4.4 | 15.2 | 2.5 | 4.8 | 11.4 | 3.0 | 5.3 | | | |
| 125 | 94.3 | 1.2 | 1.6 | 65.1 | 1.4 | 2.1 | 46.7 | 1.5 | 2.7 | 34.7 | 1.7 | 3.2 | 26.0 | 1.9 | 3.8 | 19.7 | 2.2 | 4.4 | 15.9 | 2.4 | 4.8 | 12.4 | 2.9 | 5.3 | | | |
| 130 | 98.1 | 1.2 | 1.6 | 67.7 | 1.4 | 2.1 | 48.5 | 1.5 | 2.7 | 36.0 | 1.7 | 3.2 | 27.1 | 1.9 | 3.8 | 20.5 | 2.2 | 4.4 | 16.6 | 2.4 | 4.8 | 13.0 | 2.8 | 5.3 | | | |
| 135 | 101.9 | 1.2 | 1.6 | 70.3 | 1.4 | 2.1 | 50.4 | 1.5 | 2.7 | 37.4 | 1.7 | 3.2 | 28.2 | 1.9 | 3.8 | 21.4 | 2.2 | 4.4 | 17.3 | 2.4 | 4.8 | 13.7 | 2.8 | 5.3 | | | |
| 140 | 105.7 | 1.2 | 1.6 | 72.9 | 1.4 | 2.1 | 52.2 | 1.5 | 2.7 | 38.8 | 1.7 | 3.2 | 29.3 | 1.9 | 3.8 | 22.2 | 2.2 | 4.4 | 18.0 | 2.4 | 4.9 | 14.3 | 2.8 | 5.3 | | | |
| 145 | 109.4 | 1.2 | 1.6 | 75.5 | 1.4 | 2.1 | 54.1 | 1.5 | 2.7 | 40.2 | 1.7 | 3.2 | 30.8 | 1.9 | 3.7 | 23.1 | 2.2 | 4.4 | 18.7 | 2.4 | 4.9 | 14.9 | 2.7 | 5.3 | | | |
| 150 | 113.2 | 1.2 | 1.6 | 78.1 | 1.4 | 2.1 | 56.0 | 1.5 | 2.7 | 41.6 | 1.7 | 3.2 | 31.9 | 1.9 | 3.7 | 23.9 | 2.1 | 4.4 | 19.4 | 2.4 | 4.9 | 15.5 | 2.7 | 5.3 | | | |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 4 of 14

**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"**

**Grade 1.00 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | 8.2 | 1.2 | 1.6 | 5.2 | 1.4 | 2.0 | | | | | | | | | | | | | | | | | | | | | |
| 15 | 12.6 | 1.1 | 1.6 | 8.7 | 1.3 | 2.1 | 5.5 | 1.6 | 2.6 | | | | | | | | | | | | | | | | | | |
| 20 | 17.1 | 1.1 | 1.6 | 11.8 | 1.2 | 2.1 | 8.2 | 1.4 | 2.6 | | | | | | | | | | | | | | | | | | |
| 25 | 21.4 | 1.1 | 1.6 | 14.9 | 1.2 | 2.1 | 10.5 | 1.4 | 2.6 | 7.3 | 1.6 | 3.1 | | | | | | | | | | | | | | | |
| 30 | 25.7 | 1.1 | 1.6 | 18.0 | 1.2 | 2.1 | 12.8 | 1.4 | 2.6 | 9.1 | 1.6 | 3.2 | | | | | | | | | | | | | | | |
| 35 | 29.9 | 1.1 | 1.6 | 21.2 | 1.2 | 2.1 | 15.0 | 1.3 | 2.6 | 10.9 | 1.5 | 3.1 | 7.8 | 1.8 | 3.7 | | | | | | | | | | | | |
| 40 | 34.2 | 1.1 | 1.6 | 24.3 | 1.2 | 2.1 | 17.3 | 1.3 | 2.6 | 12.6 | 1.5 | 3.1 | 9.2 | 1.7 | 3.7 | | | | | | | | | | | | |
| 45 | 38.5 | 1.1 | 1.6 | 27.3 | 1.2 | 2.1 | 19.5 | 1.3 | 2.6 | 14.3 | 1.5 | 3.1 | 10.6 | 1.7 | 3.7 | 7.2 | 2.2 | 4.3 | | | | | | | | | |
| 50 | 42.7 | 1.1 | 1.6 | 30.3 | 1.2 | 2.1 | 21.9 | 1.3 | 2.6 | 16.0 | 1.5 | 3.2 | 11.9 | 1.7 | 3.7 | 8.8 | 2.0 | 4.3 | | | | | | | | | |
| 55 | 47.0 | 1.1 | 1.6 | 33.3 | 1.2 | 2.1 | 24.1 | 1.3 | 2.6 | 17.7 | 1.5 | 3.2 | 13.3 | 1.7 | 3.7 | 9.9 | 1.9 | 4.3 | | | | | | | | | |
| 60 | 51.3 | 1.1 | 1.6 | 36.3 | 1.2 | 2.1 | 26.3 | 1.3 | 2.6 | 19.3 | 1.5 | 3.2 | 14.6 | 1.7 | 3.7 | 11.0 | 1.9 | 4.3 | | | | | | | | | |
| 65 | 55.5 | 1.1 | 1.6 | 39.4 | 1.2 | 2.1 | 28.5 | 1.3 | 2.6 | 21.0 | 1.5 | 3.2 | 15.9 | 1.6 | 3.7 | 12.1 | 1.9 | 4.3 | 8.0 | 2.5 | 4.9 | | | | | | |
| 70 | 59.8 | 1.1 | 1.6 | 42.4 | 1.2 | 2.1 | 30.7 | 1.3 | 2.6 | 22.7 | 1.5 | 3.2 | 17.1 | 1.6 | 3.7 | 13.2 | 1.9 | 4.3 | 9.5 | 2.3 | 4.8 | | | | | | |
| 75 | 64.1 | 1.1 | 1.6 | 45.4 | 1.2 | 2.1 | 32.9 | 1.3 | 2.6 | 24.6 | 1.5 | 3.1 | 18.5 | 1.6 | 3.7 | 14.2 | 1.8 | 4.3 | 10.4 | 2.2 | 4.9 | | | | | | |
| 80 | 68.3 | 1.1 | 1.6 | 48.4 | 1.2 | 2.1 | 35.0 | 1.3 | 2.6 | 26.2 | 1.5 | 3.1 | 19.8 | 1.6 | 3.7 | 15.2 | 1.8 | 4.3 | 11.3 | 2.2 | 4.9 | 8.8 | 2.7 | 5.4 | | | |
| 85 | 72.6 | 1.1 | 1.6 | 51.5 | 1.2 | 2.1 | 37.2 | 1.3 | 2.6 | 27.9 | 1.5 | 3.1 | 21.0 | 1.6 | 3.7 | 16.3 | 1.8 | 4.3 | 12.1 | 2.2 | 4.9 | 9.8 | 2.6 | 5.4 | | | |
| 90 | 76.9 | 1.1 | 1.6 | 54.5 | 1.2 | 2.1 | 39.4 | 1.3 | 2.6 | 29.5 | 1.5 | 3.1 | 22.3 | 1.6 | 3.7 | 17.3 | 1.8 | 4.3 | 13.0 | 2.1 | 4.9 | 10.9 | 2.5 | 5.3 | | | |
| 95 | 81.1 | 1.1 | 1.6 | 57.5 | 1.2 | 2.1 | 41.6 | 1.3 | 2.6 | 31.1 | 1.5 | 3.1 | 23.6 | 1.6 | 3.7 | 18.3 | 1.8 | 4.3 | 13.8 | 2.1 | 4.9 | 11.6 | 2.4 | 5.4 | | | |
| 100 | 85.4 | 1.1 | 1.6 | 60.5 | 1.2 | 2.1 | 43.8 | 1.3 | 2.6 | 32.7 | 1.5 | 3.1 | 24.9 | 1.6 | 3.7 | 19.3 | 1.8 | 4.3 | 14.6 | 2.1 | 4.9 | 12.4 | 2.4 | 5.4 | 9.7 | 2.8 | 5.8 |
| 105 | 89.7 | 1.1 | 1.6 | 63.6 | 1.2 | 2.1 | 46.0 | 1.3 | 2.6 | 34.4 | 1.5 | 3.1 | 26.5 | 1.6 | 3.7 | 20.3 | 1.8 | 4.3 | 15.4 | 2.1 | 4.9 | 13.1 | 2.4 | 5.4 | 10.8 | 2.6 | 5.8 |
| 110 | 94.0 | 1.1 | 1.6 | 66.6 | 1.2 | 2.1 | 48.2 | 1.3 | 2.6 | 36.0 | 1.5 | 3.1 | 27.7 | 1.6 | 3.7 | 21.3 | 1.8 | 4.3 | 16.2 | 2.1 | 4.9 | 13.8 | 2.3 | 5.4 | 11.5 | 2.6 | 5.8 |
| 115 | 98.2 | 1.1 | 1.6 | 69.6 | 1.2 | 2.1 | 50.4 | 1.3 | 2.6 | 37.6 | 1.5 | 3.1 | 29.0 | 1.6 | 3.7 | 22.3 | 1.8 | 4.3 | 17.0 | 2.1 | 4.9 | 14.5 | 2.3 | 5.4 | 12.2 | 2.6 | 5.8 |
| 120 | 102.5 | 1.1 | 1.6 | 72.6 | 1.2 | 2.1 | 52.5 | 1.3 | 2.6 | 39.3 | 1.5 | 3.1 | 30.2 | 1.6 | 3.7 | 23.3 | 1.8 | 4.3 | 17.9 | 2.1 | 4.9 | 15.2 | 2.3 | 5.4 | 12.8 | 2.5 | 5.8 |
| 125 | 106.8 | 1.1 | 1.6 | 75.7 | 1.2 | 2.1 | 54.7 | 1.3 | 2.6 | 40.9 | 1.5 | 3.1 | 31.5 | 1.6 | 3.7 | 24.3 | 1.8 | 4.3 | 18.7 | 2.1 | 4.9 | 15.9 | 2.3 | 5.4 | 13.4 | 2.5 | 5.8 |
| 130 | 111.0 | 1.1 | 1.6 | 78.7 | 1.2 | 2.1 | 56.9 | 1.3 | 2.6 | 42.5 | 1.5 | 3.1 | 32.7 | 1.6 | 3.7 | 25.3 | 1.8 | 4.3 | 19.4 | 2.1 | 4.9 | 16.6 | 2.3 | 5.4 | 14.1 | 2.5 | 5.8 |
| 135 | 115.3 | 1.1 | 1.6 | 81.7 | 1.2 | 2.1 | 59.1 | 1.3 | 2.6 | 44.2 | 1.5 | 3.1 | 34.0 | 1.6 | 3.7 | 26.3 | 1.8 | 4.3 | 20.2 | 2.0 | 4.9 | 17.2 | 2.3 | 5.4 | 14.7 | 2.5 | 5.8 |
| 140 | 119.6 | 1.1 | 1.6 | 84.7 | 1.2 | 2.1 | 61.3 | 1.3 | 2.6 | 45.8 | 1.5 | 3.1 | 35.2 | 1.6 | 3.7 | 27.3 | 1.8 | 4.3 | 21.0 | 2.0 | 4.9 | 17.9 | 2.3 | 5.4 | 15.3 | 2.5 | 5.8 |
| 145 | 123.8 | 1.1 | 1.6 | 87.8 | 1.2 | 2.1 | 63.5 | 1.3 | 2.6 | 47.5 | 1.5 | 3.1 | 36.5 | 1.6 | 3.7 | 28.7 | 1.8 | 4.3 | 21.8 | 2.0 | 4.9 | 18.6 | 2.3 | 5.4 | 15.9 | 2.4 | 5.8 |
| 150 | 128.1 | 1.1 | 1.6 | 90.8 | 1.2 | 2.1 | 65.7 | 1.3 | 2.6 | 49.1 | 1.5 | 3.1 | 37.8 | 1.6 | 3.7 | 29.7 | 1.8 | 4.3 | 22.6 | 2.0 | 4.9 | | | | | | |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 5 of 14

**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"**

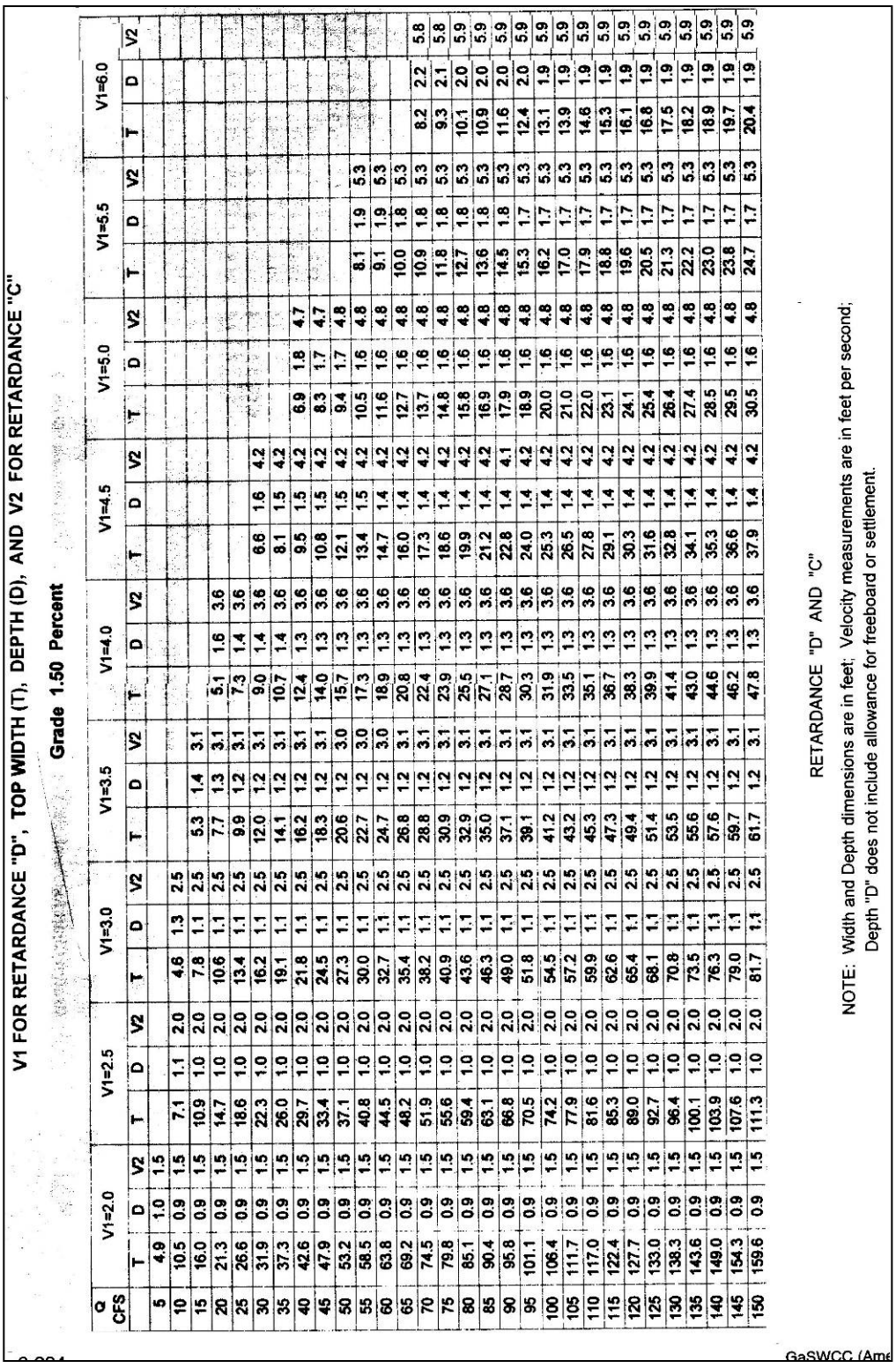
**Grade 1.25 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 4.1 | 1.2 | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | 9.4 | 1.0 | 1.5 | 6.3 | 1.2 | 2.0 | | | | | | | | | | | | | | | | | | | | | |
| 15 | 14.3 | 1.0 | 1.6 | 9.9 | 1.1 | 2.0 | 6.8 | 1.3 | 2.6 | | | | | | | | | | | | | | | | | | |
| 20 | 19.4 | 1.0 | 1.5 | 13.4 | 1.1 | 2.0 | 9.5 | 1.2 | 2.6 | 6.7 | 1.4 | 3.1 | | | | | | | | | | | | | | | |
| 25 | 24.2 | 1.0 | 1.5 | 17.0 | 1.1 | 2.0 | 12.1 | 1.2 | 2.6 | 8.8 | 1.4 | 3.1 | 5.9 | 1.7 | 3.6 | | | | | | | | | | | | |
| 30 | 29.0 | 1.0 | 1.6 | 20.4 | 1.1 | 2.0 | 14.6 | 1.2 | 2.6 | 10.7 | 1.4 | 3.1 | 7.8 | 1.6 | 3.7 | | | | | | | | | | | | |
| 35 | 33.8 | 1.0 | 1.6 | 23.8 | 1.1 | 2.0 | 17.1 | 1.2 | 2.6 | 12.7 | 1.3 | 3.1 | 9.4 | 1.5 | 3.7 | 6.5 | 1.9 | 4.2 | | | | | | | | | |
| 40 | 38.6 | 1.0 | 1.6 | 27.1 | 1.1 | 2.0 | 19.8 | 1.2 | 2.5 | 14.6 | 1.3 | 3.1 | 10.9 | 1.5 | 3.7 | 8.1 | 1.7 | 4.2 | | | | | | | | | |
| 45 | 43.5 | 1.0 | 1.6 | 30.5 | 1.1 | 2.0 | 22.3 | 1.2 | 2.5 | 16.5 | 1.3 | 3.1 | 12.5 | 1.5 | 3.7 | 9.4 | 1.7 | 4.2 | | | | | | | | | |
| 50 | 48.3 | 1.0 | 1.6 | 33.9 | 1.1 | 2.0 | 24.8 | 1.2 | 2.5 | 18.3 | 1.3 | 3.1 | 13.9 | 1.5 | 3.7 | 10.6 | 1.7 | 4.2 | 7.7 | 2.0 | 4.8 | | | | | | |
| 55 | 53.1 | 1.0 | 1.6 | 37.3 | 1.1 | 2.0 | 27.2 | 1.2 | 2.6 | 20.5 | 1.3 | 3.1 | 15.4 | 1.5 | 3.7 | 11.8 | 1.6 | 4.3 | 9.0 | 1.9 | 4.8 | | | | | | |
| 60 | 57.9 | 1.0 | 1.6 | 40.7 | 1.1 | 2.0 | 29.7 | 1.2 | 2.6 | 22.3 | 1.3 | 3.1 | 16.9 | 1.5 | 3.7 | 13.0 | 1.6 | 4.3 | 10.1 | 1.9 | 4.8 | | | | | | |
| 65 | 62.8 | 1.0 | 1.6 | 44.1 | 1.1 | 2.0 | 32.2 | 1.2 | 2.6 | 24.2 | 1.3 | 3.1 | 18.3 | 1.5 | 3.7 | 14.2 | 1.6 | 4.3 | 11.1 | 1.8 | 4.8 | 8.0 | 2.3 | 5.3 | | | |
| 70 | 67.6 | 1.0 | 1.6 | 47.5 | 1.1 | 2.0 | 34.6 | 1.2 | 2.6 | 26.0 | 1.3 | 3.1 | 19.8 | 1.4 | 3.7 | 15.4 | 1.6 | 4.3 | 12.0 | 1.8 | 4.8 | 9.3 | 2.1 | 5.3 | | | |
| 75 | 72.4 | 1.0 | 1.6 | 50.8 | 1.1 | 2.0 | 37.1 | 1.2 | 2.6 | 27.9 | 1.3 | 3.1 | 21.2 | 1.4 | 3.7 | 16.5 | 1.6 | 4.3 | 13.0 | 1.8 | 4.8 | 10.1 | 2.1 | 5.3 | | | |
| 80 | 77.2 | 1.0 | 1.6 | 54.2 | 1.1 | 2.0 | 39.6 | 1.2 | 2.6 | 29.7 | 1.3 | 3.1 | 23.0 | 1.4 | 3.6 | 17.7 | 1.6 | 4.3 | 14.0 | 1.8 | 4.8 | 11.0 | 2.0 | 5.3 | | | |
| 85 | 82.1 | 1.0 | 1.6 | 57.6 | 1.1 | 2.0 | 42.0 | 1.2 | 2.6 | 31.6 | 1.3 | 3.1 | 24.4 | 1.4 | 3.6 | 18.8 | 1.6 | 4.3 | 14.9 | 1.8 | 4.8 | 11.8 | 2.0 | 5.3 | | | |
| 90 | 86.9 | 1.0 | 1.6 | 61.0 | 1.1 | 2.0 | 44.5 | 1.2 | 2.6 | 33.5 | 1.3 | 3.1 | 25.8 | 1.4 | 3.6 | 20.0 | 1.6 | 4.3 | 15.9 | 1.8 | 4.8 | 12.6 | 2.0 | 5.3 | 9.1 | 2.5 | 5.9 |
| 95 | 91.7 | 1.0 | 1.6 | 64.4 | 1.1 | 2.0 | 47.0 | 1.2 | 2.6 | 35.3 | 1.3 | 3.1 | 27.3 | 1.4 | 3.6 | 21.1 | 1.6 | 4.3 | 16.8 | 1.8 | 4.8 | 13.4 | 2.0 | 5.4 | 10.2 | 2.4 | 5.9 |
| 100 | 96.6 | 1.0 | 1.6 | 67.8 | 1.1 | 2.0 | 49.4 | 1.2 | 2.6 | 37.2 | 1.3 | 3.1 | 28.7 | 1.4 | 3.6 | 22.3 | 1.6 | 4.3 | 17.7 | 1.8 | 4.8 | 14.2 | 2.0 | 5.4 | 10.9 | 2.3 | 5.9 |
| 105 | 101.4 | 1.0 | 1.6 | 71.2 | 1.1 | 2.0 | 51.9 | 1.2 | 2.6 | 39.0 | 1.3 | 3.1 | 30.1 | 1.4 | 3.6 | 23.4 | 1.6 | 4.3 | 18.7 | 1.8 | 4.8 | 15.0 | 2.0 | 5.4 | 11.6 | 2.3 | 5.9 |
| 110 | 106.2 | 1.0 | 1.6 | 74.6 | 1.1 | 2.0 | 54.4 | 1.2 | 2.6 | 40.9 | 1.3 | 3.1 | 31.6 | 1.4 | 3.6 | 24.6 | 1.6 | 4.3 | 19.6 | 1.7 | 4.8 | 15.8 | 2.0 | 5.4 | 12.3 | 2.3 | 5.9 |
| 115 | 111.0 | 1.0 | 1.6 | 78.0 | 1.1 | 2.0 | 56.8 | 1.2 | 2.6 | 42.7 | 1.3 | 3.1 | 33.0 | 1.4 | 3.6 | 26.1 | 1.6 | 4.2 | 20.5 | 1.7 | 4.8 | 16.6 | 1.9 | 5.4 | 13.0 | 2.2 | 5.9 |
| 120 | 115.9 | 1.0 | 1.6 | 81.3 | 1.1 | 2.0 | 59.3 | 1.2 | 2.6 | 44.6 | 1.3 | 3.1 | 34.4 | 1.4 | 3.6 | 27.2 | 1.6 | 4.2 | 21.5 | 1.7 | 4.8 | 17.3 | 1.9 | 5.4 | 13.6 | 2.2 | 5.9 |
| 125 | 120.7 | 1.0 | 1.6 | 84.7 | 1.1 | 2.0 | 61.8 | 1.2 | 2.6 | 46.4 | 1.3 | 3.1 | 35.9 | 1.4 | 3.6 | 28.3 | 1.6 | 4.2 | 22.4 | 1.7 | 4.8 | 18.1 | 1.9 | 5.4 | 14.3 | 2.2 | 5.9 |
| 130 | 125.5 | 1.0 | 1.6 | 88.1 | 1.1 | 2.0 | 64.3 | 1.2 | 2.6 | 48.3 | 1.3 | 3.1 | 37.3 | 1.4 | 3.7 | 29.5 | 1.6 | 4.2 | 23.3 | 1.7 | 4.8 | 18.9 | 1.9 | 5.4 | 14.9 | 2.2 | 5.9 |
| 135 | 130.3 | 1.0 | 1.6 | 91.5 | 1.1 | 2.0 | 66.7 | 1.2 | 2.6 | 50.2 | 1.3 | 3.1 | 38.7 | 1.4 | 3.7 | 30.6 | 1.6 | 4.2 | 24.2 | 1.7 | 4.8 | 19.6 | 1.9 | 5.4 | 15.6 | 2.2 | 5.9 |
| 140 | 135.2 | 1.0 | 1.6 | 94.9 | 1.1 | 2.0 | 69.2 | 1.2 | 2.6 | 52.0 | 1.3 | 3.1 | 40.2 | 1.4 | 3.7 | 31.7 | 1.6 | 4.2 | 25.1 | 1.7 | 4.8 | 20.4 | 1.9 | 5.4 | 16.2 | 2.2 | 5.9 |
| 145 | 140.0 | 1.0 | 1.6 | 98.3 | 1.1 | 2.0 | 71.7 | 1.2 | 2.6 | 53.9 | 1.3 | 3.1 | 41.6 | 1.4 | 3.7 | 32.9 | 1.6 | 4.2 | 26.1 | 1.7 | 4.8 | 21.2 | 1.9 | 5.4 | 16.9 | 2.2 | 5.9 |
| 150 | 144.8 | 1.0 | 1.6 | 101.7 | 1.1 | 2.0 | 74.1 | 1.2 | 2.6 | 55.7 | 1.3 | 3.1 | 43.0 | 1.4 | 3.7 | 34.0 | 1.6 | 4.2 | 27.0 | 1.7 | 4.8 | 21.9 | 1.9 | 5.4 | 17.5 | 2.2 | 5.9 |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 6 of 14



**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"**

**Grade 1.50 Percent**

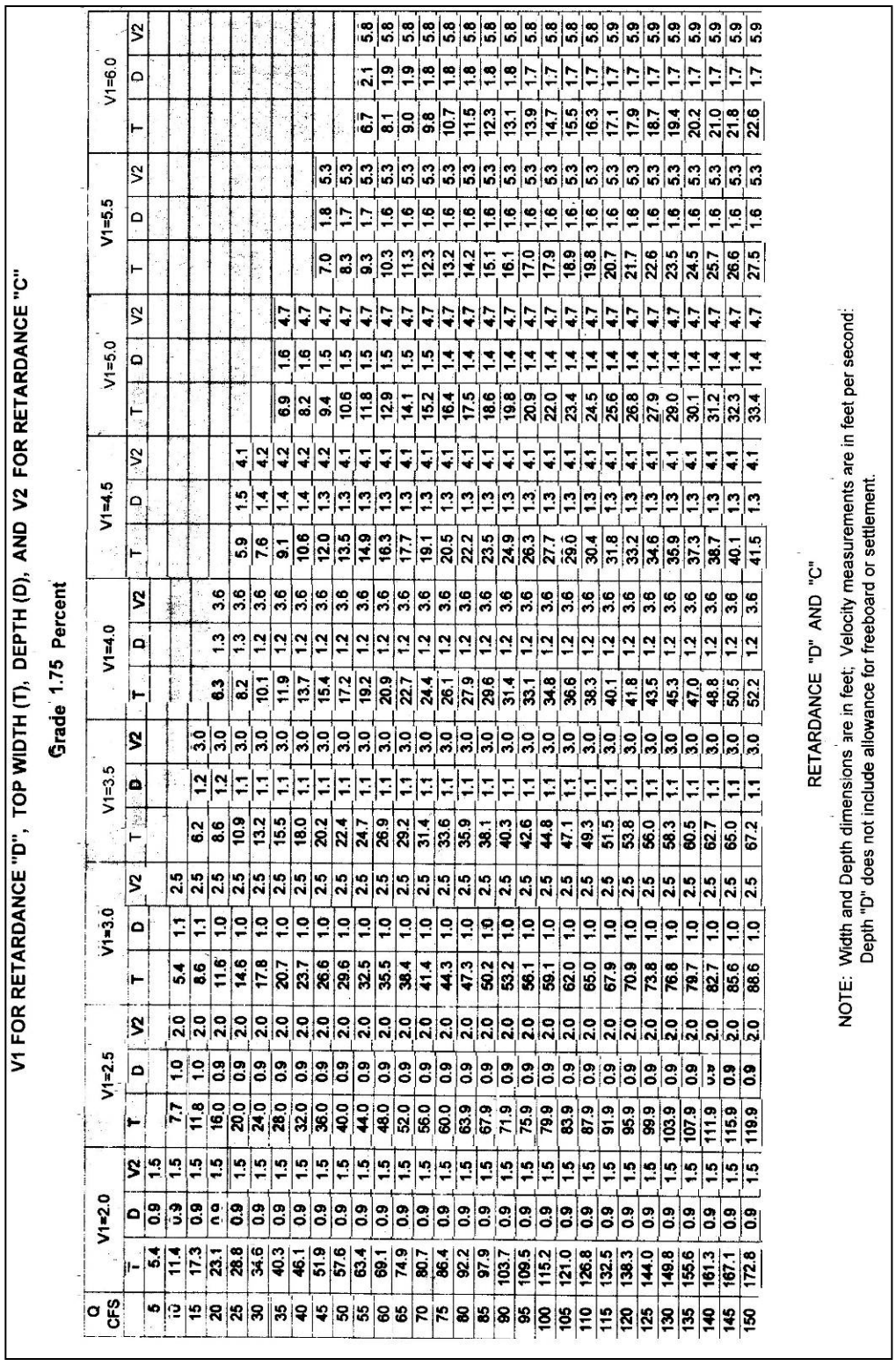
| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 4.9 | 1.0 | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | 10.5 | 0.9 | 1.5 | 7.1 | 1.1 | 2.0 | 4.8 | 1.3 | 2.5 | | | | | | | | | | | | | | | | | | |
| 15 | 16.0 | 0.9 | 1.5 | 10.9 | 1.0 | 2.0 | 7.8 | 1.1 | 2.5 | 5.3 | 1.4 | 3.1 | | | | | | | | | | | | | | | |
| 20 | 21.3 | 0.9 | 1.5 | 14.7 | 1.0 | 2.0 | 10.6 | 1.1 | 2.5 | 7.7 | 1.3 | 3.1 | 5.1 | 1.6 | 3.6 | | | | | | | | | | | | |
| 25 | 26.6 | 0.9 | 1.5 | 18.6 | 1.0 | 2.0 | 13.4 | 1.1 | 2.5 | 9.9 | 1.2 | 3.1 | 7.3 | 1.4 | 3.6 | | | | | | | | | | | | |
| 30 | 31.9 | 0.9 | 1.5 | 22.3 | 1.0 | 2.0 | 16.2 | 1.1 | 2.5 | 12.0 | 1.2 | 3.1 | 9.0 | 1.4 | 3.6 | 6.6 | 1.6 | 4.2 | | | | | | | | | |
| 35 | 37.3 | 0.9 | 1.5 | 26.0 | 1.0 | 2.0 | 19.1 | 1.1 | 2.5 | 14.1 | 1.2 | 3.1 | 10.7 | 1.4 | 3.6 | 8.1 | 1.5 | 4.2 | | | | | | | | | |
| 40 | 42.6 | 0.9 | 1.5 | 29.7 | 1.0 | 2.0 | 21.8 | 1.1 | 2.5 | 16.2 | 1.2 | 3.1 | 12.4 | 1.3 | 3.6 | 9.5 | 1.5 | 4.2 | 6.9 | 1.8 | 4.7 | | | | | | |
| 45 | 47.9 | 0.9 | 1.5 | 33.4 | 1.0 | 2.0 | 24.5 | 1.1 | 2.5 | 18.3 | 1.2 | 3.1 | 14.0 | 1.3 | 3.6 | 10.8 | 1.5 | 4.2 | 8.3 | 1.7 | 4.7 | | | | | | |
| 50 | 53.2 | 0.9 | 1.5 | 37.1 | 1.0 | 2.0 | 27.3 | 1.1 | 2.5 | 20.6 | 1.2 | 3.0 | 15.7 | 1.3 | 3.6 | 12.1 | 1.5 | 4.2 | 9.4 | 1.7 | 4.8 | | | | | | |
| 55 | 58.5 | 0.9 | 1.5 | 40.8 | 1.0 | 2.0 | 30.0 | 1.1 | 2.5 | 22.7 | 1.2 | 3.0 | 17.3 | 1.3 | 3.6 | 13.4 | 1.5 | 4.2 | 10.5 | 1.6 | 4.8 | 8.1 | 1.9 | 5.3 | | | |
| 60 | 63.8 | 0.9 | 1.5 | 44.5 | 1.0 | 2.0 | 32.7 | 1.1 | 2.5 | 24.7 | 1.2 | 3.0 | 18.9 | 1.3 | 3.6 | 14.7 | 1.4 | 4.2 | 11.6 | 1.6 | 4.8 | 9.1 | 1.9 | 5.3 | | | |
| 65 | 69.2 | 0.9 | 1.5 | 48.2 | 1.0 | 2.0 | 35.4 | 1.1 | 2.5 | 26.8 | 1.2 | 3.1 | 20.8 | 1.3 | 3.6 | 16.0 | 1.4 | 4.2 | 12.7 | 1.6 | 4.8 | 10.0 | 1.8 | 5.3 | | | |
| 70 | 74.5 | 0.9 | 1.5 | 51.9 | 1.0 | 2.0 | 38.2 | 1.1 | 2.5 | 28.8 | 1.2 | 3.1 | 22.4 | 1.3 | 3.6 | 17.3 | 1.4 | 4.2 | 13.7 | 1.6 | 4.8 | 10.9 | 1.8 | 5.3 | 8.2 | 2.2 | 5.8 |
| 75 | 79.8 | 0.9 | 1.5 | 55.6 | 1.0 | 2.0 | 40.9 | 1.1 | 2.5 | 30.9 | 1.2 | 3.1 | 23.9 | 1.3 | 3.6 | 18.6 | 1.4 | 4.2 | 14.8 | 1.6 | 4.8 | 11.8 | 1.8 | 5.3 | 9.3 | 2.1 | 5.8 |
| 80 | 85.1 | 0.9 | 1.5 | 59.4 | 1.0 | 2.0 | 43.6 | 1.1 | 2.5 | 32.9 | 1.2 | 3.1 | 25.5 | 1.3 | 3.6 | 19.9 | 1.4 | 4.2 | 15.8 | 1.6 | 4.8 | 12.7 | 1.8 | 5.3 | 10.1 | 2.0 | 5.9 |
| 85 | 90.4 | 0.9 | 1.5 | 63.1 | 1.0 | 2.0 | 46.3 | 1.1 | 2.5 | 35.0 | 1.2 | 3.1 | 27.1 | 1.3 | 3.6 | 21.2 | 1.4 | 4.2 | 16.9 | 1.6 | 4.8 | 13.6 | 1.8 | 5.3 | 10.9 | 2.0 | 5.9 |
| 90 | 95.8 | 0.9 | 1.5 | 66.8 | 1.0 | 2.0 | 49.0 | 1.1 | 2.5 | 37.1 | 1.2 | 3.1 | 28.7 | 1.3 | 3.6 | 22.8 | 1.4 | 4.1 | 17.9 | 1.6 | 4.8 | 14.5 | 1.8 | 5.3 | 11.6 | 2.0 | 5.9 |
| 95 | 101.1 | 0.9 | 1.5 | 70.5 | 1.0 | 2.0 | 51.8 | 1.1 | 2.5 | 39.1 | 1.2 | 3.1 | 30.3 | 1.3 | 3.6 | 24.0 | 1.4 | 4.2 | 18.9 | 1.6 | 4.8 | 15.3 | 1.7 | 5.3 | 12.4 | 2.0 | 5.9 |
| 100 | 106.4 | 0.9 | 1.5 | 74.2 | 1.0 | 2.0 | 54.5 | 1.1 | 2.5 | 41.2 | 1.2 | 3.1 | 31.9 | 1.3 | 3.6 | 25.3 | 1.4 | 4.2 | 20.0 | 1.6 | 4.8 | 16.2 | 1.7 | 5.3 | 13.1 | 1.9 | 5.9 |
| 105 | 111.7 | 0.9 | 1.5 | 77.9 | 1.0 | 2.0 | 57.2 | 1.1 | 2.5 | 43.2 | 1.2 | 3.1 | 33.5 | 1.3 | 3.6 | 26.5 | 1.4 | 4.2 | 21.0 | 1.6 | 4.8 | 17.0 | 1.7 | 5.3 | 13.9 | 1.9 | 5.9 |
| 110 | 117.0 | 0.9 | 1.5 | 81.6 | 1.0 | 2.0 | 59.9 | 1.1 | 2.5 | 45.3 | 1.2 | 3.1 | 35.1 | 1.3 | 3.6 | 27.8 | 1.4 | 4.2 | 22.0 | 1.6 | 4.8 | 17.9 | 1.7 | 5.3 | 14.8 | 1.9 | 5.9 |
| 115 | 122.4 | 0.9 | 1.5 | 85.3 | 1.0 | 2.0 | 62.6 | 1.1 | 2.5 | 47.3 | 1.2 | 3.1 | 36.7 | 1.3 | 3.6 | 29.1 | 1.4 | 4.2 | 23.1 | 1.6 | 4.8 | 18.8 | 1.7 | 5.3 | 15.3 | 1.9 | 5.9 |
| 120 | 127.7 | 0.9 | 1.5 | 89.0 | 1.0 | 2.0 | 65.4 | 1.1 | 2.5 | 49.4 | 1.2 | 3.1 | 38.3 | 1.3 | 3.6 | 30.3 | 1.4 | 4.2 | 24.1 | 1.6 | 4.8 | 19.6 | 1.7 | 5.3 | 16.1 | 1.9 | 5.9 |
| 125 | 133.0 | 0.9 | 1.5 | 92.7 | 1.0 | 2.0 | 68.1 | 1.1 | 2.5 | 51.4 | 1.2 | 3.1 | 39.9 | 1.3 | 3.6 | 31.6 | 1.4 | 4.2 | 25.4 | 1.6 | 4.8 | 20.5 | 1.7 | 5.3 | 16.8 | 1.9 | 5.9 |
| 130 | 138.3 | 0.9 | 1.5 | 96.4 | 1.0 | 2.0 | 70.8 | 1.1 | 2.5 | 53.5 | 1.2 | 3.1 | 41.4 | 1.3 | 3.6 | 32.8 | 1.4 | 4.2 | 26.4 | 1.6 | 4.8 | 21.3 | 1.7 | 5.3 | 17.5 | 1.9 | 5.9 |
| 135 | 143.6 | 0.9 | 1.5 | 100.1 | 1.0 | 2.0 | 73.5 | 1.1 | 2.5 | 55.6 | 1.2 | 3.1 | 43.0 | 1.3 | 3.6 | 34.1 | 1.4 | 4.2 | 27.4 | 1.6 | 4.8 | 22.2 | 1.7 | 5.3 | 18.2 | 1.9 | 5.9 |
| 140 | 149.0 | 0.9 | 1.5 | 103.9 | 1.0 | 2.0 | 76.3 | 1.1 | 2.5 | 57.6 | 1.2 | 3.1 | 44.6 | 1.3 | 3.6 | 35.3 | 1.4 | 4.2 | 28.5 | 1.6 | 4.8 | 23.0 | 1.7 | 5.3 | 18.9 | 1.9 | 5.9 |
| 145 | 154.3 | 0.9 | 1.5 | 107.6 | 1.0 | 2.0 | 79.0 | 1.1 | 2.5 | 59.7 | 1.2 | 3.1 | 46.2 | 1.3 | 3.6 | 36.6 | 1.4 | 4.2 | 29.5 | 1.6 | 4.8 | 23.8 | 1.7 | 5.3 | 19.7 | 1.9 | 5.9 |
| 150 | 159.6 | 0.9 | 1.5 | 111.3 | 1.0 | 2.0 | 81.7 | 1.1 | 2.5 | 61.7 | 1.2 | 3.1 | 47.8 | 1.3 | 3.6 | 37.9 | 1.4 | 4.2 | 30.5 | 1.6 | 4.8 | 24.7 | 1.7 | 5.3 | 20.4 | 1.9 | 5.9 |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet. Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

GaSWCC (Ame

Table GS-4 Parabolic Grass Swale Design Sheet 7 of 14



**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"**

**Grade 1.75 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 5.4 | 0.9 | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | 11.4 | 0.9 | 1.5 | 7.7 | 1.0 | 2.0 | 5.4 | 1.1 | 2.5 | | | | | | | | | | | | | | | | | | |
| 15 | 17.3 | 0.9 | 1.5 | 11.8 | 1.0 | 2.0 | 8.6 | 1.1 | 2.5 | 6.2 | 1.2 | 3.0 | | | | | | | | | | | | | | | |
| 20 | 23.1 | 0.9 | 1.5 | 16.0 | 0.9 | 2.0 | 11.6 | 1.0 | 2.5 | 8.6 | 1.2 | 3.0 | 6.3 | 1.3 | 3.6 | | | | | | | | | | | | |
| 25 | 28.8 | 0.9 | 1.5 | 20.0 | 0.9 | 2.0 | 14.6 | 1.0 | 2.5 | 10.9 | 1.1 | 3.0 | 8.2 | 1.3 | 3.6 | 5.9 | 1.5 | 4.1 | | | | | | | | | |
| 30 | 34.6 | 0.9 | 1.5 | 24.0 | 0.9 | 2.0 | 17.8 | 1.0 | 2.5 | 13.2 | 1.1 | 3.0 | 10.1 | 1.2 | 3.6 | 7.6 | 1.4 | 4.2 | | | | | | | | | |
| 35 | 40.3 | 0.9 | 1.5 | 28.0 | 0.9 | 2.0 | 20.7 | 1.0 | 2.5 | 15.5 | 1.1 | 3.0 | 11.9 | 1.2 | 3.6 | 9.1 | 1.4 | 4.2 | 6.9 | 1.6 | 4.7 | | | | | | |
| 40 | 46.1 | 0.9 | 1.5 | 32.0 | 0.9 | 2.0 | 23.7 | 1.0 | 2.5 | 18.0 | 1.1 | 3.0 | 13.7 | 1.2 | 3.6 | 10.6 | 1.4 | 4.2 | 8.2 | 1.6 | 4.7 | | | | | | |
| 45 | 51.9 | 0.9 | 1.5 | 36.0 | 0.9 | 2.0 | 26.6 | 1.0 | 2.5 | 20.2 | 1.1 | 3.0 | 15.4 | 1.2 | 3.6 | 12.0 | 1.3 | 4.2 | 9.4 | 1.5 | 4.7 | 7.0 | 1.8 | 5.3 | | | |
| 50 | 57.6 | 0.9 | 1.5 | 40.0 | 0.9 | 2.0 | 29.6 | 1.0 | 2.5 | 22.4 | 1.1 | 3.0 | 17.2 | 1.2 | 3.6 | 13.5 | 1.3 | 4.1 | 10.6 | 1.5 | 4.7 | 8.3 | 1.7 | 5.3 | | | |
| 55 | 63.4 | 0.9 | 1.5 | 44.0 | 0.9 | 2.0 | 32.5 | 1.0 | 2.5 | 24.7 | 1.1 | 3.0 | 19.2 | 1.2 | 3.6 | 14.9 | 1.3 | 4.1 | 11.8 | 1.5 | 4.7 | 9.3 | 1.7 | 5.3 | 6.7 | 2.1 | 5.8 |
| 60 | 69.1 | 0.9 | 1.5 | 48.0 | 0.9 | 2.0 | 35.5 | 1.0 | 2.5 | 26.9 | 1.1 | 3.0 | 20.9 | 1.2 | 3.6 | 16.3 | 1.3 | 4.1 | 12.9 | 1.5 | 4.7 | 10.3 | 1.6 | 5.3 | 8.1 | 1.9 | 5.8 |
| 65 | 74.9 | 0.9 | 1.5 | 52.0 | 0.9 | 2.0 | 38.4 | 1.0 | 2.5 | 29.2 | 1.1 | 3.0 | 22.7 | 1.2 | 3.6 | 17.7 | 1.3 | 4.1 | 14.1 | 1.5 | 4.7 | 11.3 | 1.6 | 5.3 | 9.0 | 1.9 | 5.8 |
| 70 | 80.7 | 0.9 | 1.5 | 56.0 | 0.9 | 2.0 | 41.4 | 1.0 | 2.5 | 31.4 | 1.1 | 3.0 | 24.4 | 1.2 | 3.6 | 19.1 | 1.3 | 4.1 | 15.2 | 1.5 | 4.7 | 12.3 | 1.6 | 5.3 | 9.8 | 1.8 | 5.8 |
| 75 | 86.4 | 0.9 | 1.5 | 60.0 | 0.9 | 2.0 | 44.3 | 1.0 | 2.5 | 33.6 | 1.1 | 3.0 | 26.1 | 1.2 | 3.6 | 20.5 | 1.3 | 4.1 | 16.4 | 1.4 | 4.7 | 13.2 | 1.6 | 5.3 | 10.7 | 1.8 | 5.8 |
| 80 | 92.2 | 0.9 | 1.5 | 63.9 | 0.9 | 2.0 | 47.3 | 1.0 | 2.5 | 35.9 | 1.1 | 3.0 | 27.9 | 1.2 | 3.6 | 22.2 | 1.3 | 4.1 | 17.5 | 1.4 | 4.7 | 14.2 | 1.6 | 5.3 | 11.5 | 1.8 | 5.8 |
| 85 | 97.9 | 0.9 | 1.5 | 67.9 | 0.9 | 2.0 | 50.2 | 1.0 | 2.5 | 38.1 | 1.1 | 3.0 | 29.6 | 1.2 | 3.6 | 23.5 | 1.3 | 4.1 | 18.6 | 1.4 | 4.7 | 15.1 | 1.6 | 5.3 | 12.3 | 1.8 | 5.8 |
| 90 | 103.7 | 0.9 | 1.5 | 71.9 | 0.9 | 2.0 | 53.2 | 1.0 | 2.5 | 40.3 | 1.1 | 3.0 | 31.4 | 1.2 | 3.6 | 24.9 | 1.3 | 4.1 | 19.8 | 1.4 | 4.7 | 16.1 | 1.6 | 5.3 | 13.1 | 1.8 | 5.8 |
| 95 | 109.5 | 0.9 | 1.5 | 75.9 | 0.9 | 2.0 | 56.1 | 1.0 | 2.5 | 42.6 | 1.1 | 3.0 | 33.1 | 1.2 | 3.6 | 26.3 | 1.3 | 4.1 | 20.9 | 1.4 | 4.7 | 17.0 | 1.6 | 5.3 | 13.9 | 1.7 | 5.8 |
| 100 | 115.2 | 0.9 | 1.5 | 79.9 | 0.9 | 2.0 | 59.1 | 1.0 | 2.5 | 44.8 | 1.1 | 3.0 | 34.8 | 1.2 | 3.6 | 27.7 | 1.3 | 4.1 | 22.0 | 1.4 | 4.7 | 17.9 | 1.6 | 5.3 | 14.7 | 1.7 | 5.8 |
| 105 | 121.0 | 0.9 | 1.5 | 83.9 | 0.9 | 2.0 | 62.0 | 1.0 | 2.5 | 47.1 | 1.1 | 3.0 | 36.6 | 1.2 | 3.6 | 29.0 | 1.3 | 4.1 | 23.4 | 1.4 | 4.7 | 18.9 | 1.6 | 5.3 | 15.5 | 1.7 | 5.8 |
| 110 | 126.8 | 0.9 | 1.5 | 87.9 | 0.9 | 2.0 | 65.0 | 1.0 | 2.5 | 49.3 | 1.1 | 3.0 | 38.3 | 1.2 | 3.6 | 30.4 | 1.3 | 4.1 | 24.5 | 1.4 | 4.7 | 19.8 | 1.6 | 5.3 | 16.3 | 1.7 | 5.8 |
| 115 | 132.5 | 0.9 | 1.5 | 91.9 | 0.9 | 2.0 | 67.9 | 1.0 | 2.5 | 51.5 | 1.1 | 3.0 | 40.1 | 1.2 | 3.6 | 31.8 | 1.3 | 4.1 | 25.6 | 1.4 | 4.7 | 20.7 | 1.6 | 5.3 | 17.1 | 1.7 | 5.9 |
| 120 | 138.3 | 0.9 | 1.5 | 95.9 | 0.9 | 2.0 | 70.9 | 1.0 | 2.5 | 53.8 | 1.1 | 3.0 | 41.8 | 1.2 | 3.6 | 33.2 | 1.3 | 4.1 | 26.8 | 1.4 | 4.7 | 21.7 | 1.6 | 5.3 | 17.9 | 1.7 | 5.9 |
| 125 | 144.0 | 0.9 | 1.5 | 99.9 | 0.9 | 2.0 | 73.8 | 1.0 | 2.5 | 56.0 | 1.1 | 3.0 | 43.5 | 1.2 | 3.6 | 34.6 | 1.3 | 4.1 | 27.9 | 1.4 | 4.7 | 22.6 | 1.6 | 5.3 | 18.7 | 1.7 | 5.9 |
| 130 | 149.8 | 0.9 | 1.5 | 103.9 | 0.9 | 2.0 | 76.8 | 1.0 | 2.5 | 58.3 | 1.1 | 3.0 | 45.3 | 1.2 | 3.6 | 35.9 | 1.3 | 4.1 | 28.0 | 1.4 | 4.7 | 23.5 | 1.6 | 5.3 | 19.4 | 1.7 | 5.9 |
| 135 | 155.6 | 0.9 | 1.5 | 107.9 | 0.9 | 2.0 | 79.7 | 1.0 | 2.5 | 60.5 | 1.1 | 3.0 | 47.0 | 1.2 | 3.6 | 37.3 | 1.3 | 4.1 | 30.1 | 1.4 | 4.7 | 24.5 | 1.6 | 5.3 | 20.2 | 1.7 | 5.9 |
| 140 | 161.3 | 0.9 | 1.5 | 111.9 | 0.9 | 2.0 | 82.7 | 1.0 | 2.5 | 62.7 | 1.1 | 3.0 | 48.8 | 1.2 | 3.6 | 38.7 | 1.3 | 4.1 | 31.2 | 1.4 | 4.7 | 25.7 | 1.6 | 5.3 | 21.0 | 1.7 | 5.9 |
| 145 | 167.1 | 0.9 | 1.5 | 115.9 | 0.9 | 2.0 | 85.6 | 1.0 | 2.5 | 65.0 | 1.1 | 3.0 | 50.5 | 1.2 | 3.6 | 40.1 | 1.3 | 4.1 | 32.3 | 1.4 | 4.7 | 26.6 | 1.6 | 5.3 | 21.8 | 1.7 | 5.9 |
| 150 | 172.8 | 0.9 | 1.5 | 119.9 | 0.9 | 2.0 | 88.6 | 1.0 | 2.5 | 67.2 | 1.1 | 3.0 | 52.2 | 1.2 | 3.6 | 41.5 | 1.3 | 4.1 | 33.4 | 1.4 | 4.7 | 27.5 | 1.6 | 5.3 | 22.6 | 1.7 | 5.9 |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second.
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 8 of 14

**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"**

**Grade 2.00 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 5.9 | 0.9 | 1.5 | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | 12.4 | 0.8 | 1.5 | 8.1 | 0.9 | 2.0 | 5.9 | 1.0 | 2.5 | | | | | | | | | | | | | | | | | | |
| 15 | 18.5 | 0.8 | 1.5 | 12.3 | 0.9 | 2.0 | 9.3 | 1.0 | 2.5 | 6.8 | 1.1 | 3.0 | 4.7 | 1.4 | 3.5 | | | | | | | | | | | | |
| 20 | 24.7 | 0.8 | 1.5 | 16.7 | 0.9 | 2.0 | 12.5 | 1.0 | 2.5 | 9.4 | 1.1 | 3.0 | 7.0 | 1.2 | 3.6 | 4.7 | 1.5 | 4.1 | | | | | | | | | |
| 25 | 30.8 | 0.8 | 1.5 | 20.8 | 0.9 | 2.0 | 15.9 | 1.0 | 2.4 | 11.8 | 1.1 | 3.0 | 9.0 | 1.2 | 3.5 | 6.8 | 1.3 | 4.1 | | | | | | | | | |
| 30 | 37.0 | 0.8 | 1.5 | 25.0 | 0.9 | 2.0 | 19.0 | 1.0 | 2.5 | 14.3 | 1.1 | 3.0 | 11.0 | 1.2 | 3.5 | 8.5 | 1.3 | 4.1 | 6.4 | 1.5 | 4.7 | | | | | | |
| 35 | 43.2 | 0.8 | 1.5 | 29.1 | 0.9 | 2.0 | 22.2 | 1.0 | 2.5 | 16.9 | 1.0 | 3.0 | 12.9 | 1.1 | 3.5 | 10.1 | 1.3 | 4.1 | 7.8 | 1.4 | 4.7 | | | | | | |
| 40 | 49.3 | 0.8 | 1.5 | 33.3 | 0.9 | 2.0 | 25.3 | 1.0 | 2.5 | 19.3 | 1.0 | 3.0 | 14.8 | 1.1 | 3.5 | 11.6 | 1.3 | 4.1 | 9.1 | 1.4 | 4.7 | 7.1 | 1.6 | 5.2 | | | |
| 45 | 55.5 | 0.8 | 1.5 | 37.4 | 0.9 | 2.0 | 28.5 | 1.0 | 2.5 | 21.7 | 1.0 | 3.0 | 16.7 | 1.1 | 3.5 | 13.1 | 1.3 | 4.1 | 10.4 | 1.4 | 4.7 | 8.2 | 1.8 | 5.2 | | | |
| 50 | 61.7 | 0.8 | 1.5 | 41.6 | 0.9 | 2.0 | 31.7 | 1.0 | 2.5 | 24.1 | 1.0 | 3.0 | 18.8 | 1.1 | 3.5 | 14.7 | 1.2 | 4.1 | 11.7 | 1.4 | 4.7 | 9.3 | 1.5 | 5.3 | 7.1 | 1.6 | 5.8 |
| 55 | 67.8 | 0.8 | 1.5 | 45.7 | 0.9 | 2.0 | 34.8 | 1.0 | 2.5 | 26.5 | 1.0 | 3.0 | 20.7 | 1.1 | 3.5 | 16.2 | 1.2 | 4.1 | 12.9 | 1.4 | 4.7 | 10.4 | 1.5 | 5.3 | 8.2 | 1.7 | 5.8 |
| 60 | 74.0 | 0.8 | 1.5 | 49.9 | 0.9 | 2.0 | 38.0 | 1.0 | 2.5 | 28.9 | 1.0 | 3.0 | 22.6 | 1.1 | 3.5 | 17.7 | 1.2 | 4.1 | 14.1 | 1.4 | 4.7 | 11.4 | 1.5 | 5.3 | 9.2 | 1.7 | 5.8 |
| 65 | 80.2 | 0.8 | 1.5 | 54.0 | 0.9 | 2.0 | 41.1 | 1.0 | 2.5 | 31.4 | 1.0 | 3.0 | 24.5 | 1.1 | 3.5 | 19.5 | 1.2 | 4.1 | 15.4 | 1.3 | 4.7 | 12.4 | 1.5 | 5.3 | 10.1 | 1.7 | 5.8 |
| 70 | 86.3 | 0.8 | 1.5 | 58.2 | 0.9 | 2.0 | 44.3 | 1.0 | 2.5 | 33.8 | 1.0 | 3.0 | 26.3 | 1.1 | 3.5 | 21.0 | 1.2 | 4.1 | 16.6 | 1.3 | 4.7 | 13.5 | 1.5 | 5.3 | 11.0 | 1.6 | 5.8 |
| 75 | 92.5 | 0.8 | 1.5 | 62.3 | 0.9 | 2.0 | 47.5 | 1.0 | 2.5 | 36.2 | 1.0 | 3.0 | 28.2 | 1.1 | 3.5 | 22.4 | 1.2 | 4.1 | 17.8 | 1.3 | 4.7 | 14.5 | 1.5 | 5.3 | 11.8 | 1.6 | 5.8 |
| 80 | 98.7 | 0.8 | 1.5 | 66.5 | 0.9 | 2.0 | 50.6 | 1.0 | 2.5 | 38.6 | 1.0 | 3.0 | 30.1 | 1.1 | 3.5 | 23.9 | 1.2 | 4.1 | 19.0 | 1.3 | 4.7 | 15.5 | 1.5 | 5.3 | 12.7 | 1.6 | 5.8 |
| 85 | 104.8 | 0.8 | 1.5 | 70.6 | 0.9 | 2.0 | 53.8 | 1.0 | 2.5 | 41.0 | 1.0 | 3.0 | 32.0 | 1.1 | 3.5 | 25.4 | 1.2 | 4.1 | 20.3 | 1.3 | 4.7 | 16.5 | 1.5 | 5.3 | 13.6 | 1.6 | 5.8 |
| 90 | 111.0 | 0.8 | 1.5 | 74.8 | 0.9 | 2.0 | 57.0 | 1.0 | 2.5 | 43.4 | 1.0 | 3.0 | 33.8 | 1.1 | 3.5 | 26.9 | 1.2 | 4.1 | 21.8 | 1.3 | 4.6 | 17.5 | 1.5 | 5.3 | 14.4 | 1.6 | 5.8 |
| 95 | 117.2 | 0.8 | 1.5 | 78.9 | 0.9 | 2.0 | 60.1 | 1.0 | 2.5 | 45.8 | 1.0 | 3.0 | 35.7 | 1.1 | 3.5 | 28.4 | 1.2 | 4.1 | 23.0 | 1.3 | 4.6 | 18.6 | 1.5 | 5.3 | 15.3 | 1.6 | 5.8 |
| 100 | 123.3 | 0.8 | 1.5 | 83.1 | 0.9 | 2.0 | 63.3 | 1.0 | 2.5 | 48.2 | 1.0 | 3.0 | 37.6 | 1.1 | 3.5 | 29.9 | 1.2 | 4.1 | 24.2 | 1.3 | 4.6 | 19.6 | 1.5 | 5.3 | 16.2 | 1.6 | 5.8 |
| 105 | 129.5 | 0.8 | 1.5 | 87.3 | 0.9 | 2.0 | 66.4 | 1.0 | 2.5 | 50.6 | 1.0 | 3.0 | 39.5 | 1.1 | 3.5 | 31.4 | 1.2 | 4.1 | 25.4 | 1.3 | 4.6 | 20.6 | 1.5 | 5.3 | 17.0 | 1.6 | 5.8 |
| 110 | 135.7 | 0.8 | 1.5 | 91.4 | 0.9 | 2.0 | 69.6 | 1.0 | 2.5 | 53.0 | 1.0 | 3.0 | 41.3 | 1.1 | 3.5 | 32.9 | 1.2 | 4.1 | 26.6 | 1.3 | 4.7 | 21.6 | 1.4 | 5.3 | 17.9 | 1.6 | 5.8 |
| 115 | 141.8 | 0.8 | 1.5 | 95.6 | 0.9 | 2.0 | 72.8 | 1.0 | 2.5 | 55.4 | 1.0 | 3.0 | 43.2 | 1.1 | 3.5 | 34.4 | 1.2 | 4.1 | 27.9 | 1.3 | 4.7 | 22.6 | 1.4 | 5.3 | 18.7 | 1.6 | 5.8 |
| 120 | 148.0 | 0.8 | 1.5 | 99.7 | 0.9 | 2.0 | 75.9 | 1.0 | 2.5 | 57.9 | 1.0 | 3.0 | 45.1 | 1.1 | 3.5 | 35.9 | 1.2 | 4.1 | 29.1 | 1.3 | 4.7 | 23.9 | 1.4 | 5.2 | 19.5 | 1.6 | 5.8 |
| 125 | 154.1 | 0.8 | 1.5 | 103.9 | 0.9 | 2.0 | 79.1 | 1.0 | 2.5 | 60.3 | 1.0 | 3.0 | 47.0 | 1.1 | 3.5 | 37.4 | 1.2 | 4.1 | 30.3 | 1.3 | 4.7 | 24.8 | 1.4 | 5.2 | 20.4 | 1.6 | 5.8 |
| 130 | 160.3 | 0.8 | 1.5 | 108.0 | 0.9 | 2.0 | 82.3 | 1.0 | 2.5 | 62.7 | 1.0 | 3.0 | 48.8 | 1.1 | 3.5 | 38.9 | 1.2 | 4.1 | 31.5 | 1.3 | 4.7 | 25.8 | 1.4 | 5.3 | 21.2 | 1.6 | 5.8 |
| 135 | 166.5 | 0.8 | 1.5 | 112.2 | 0.9 | 2.0 | 85.4 | 1.0 | 2.5 | 65.1 | 1.0 | 3.0 | 50.7 | 1.1 | 3.5 | 40.3 | 1.2 | 4.1 | 32.7 | 1.3 | 4.7 | 26.8 | 1.4 | 5.3 | 22.1 | 1.6 | 5.8 |
| 140 | 172.6 | 0.8 | 1.5 | 116.3 | 0.9 | 2.0 | 88.6 | 1.0 | 2.5 | 67.5 | 1.0 | 3.0 | 52.6 | 1.1 | 3.5 | 41.8 | 1.2 | 4.1 | 33.9 | 1.3 | 4.7 | 27.8 | 1.4 | 5.3 | 22.9 | 1.6 | 5.8 |
| 145 | 178.8 | 0.8 | 1.5 | 120.5 | 0.9 | 2.0 | 91.8 | 1.0 | 2.5 | 69.9 | 1.0 | 3.0 | 54.5 | 1.1 | 3.5 | 43.3 | 1.2 | 4.1 | 35.1 | 1.3 | 4.7 | 28.8 | 1.4 | 5.3 | 23.7 | 1.6 | 5.8 |
| 150 | 185.0 | 0.8 | 1.5 | 124.6 | 0.9 | 2.0 | 94.9 | 1.0 | 2.5 | 72.3 | 1.0 | 3.0 | 56.4 | 1.1 | 3.5 | 44.8 | 1.2 | 4.1 | 36.3 | 1.3 | 4.7 | 29.8 | 1.4 | 5.3 | 24.6 | 1.6 | 5.8 |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 9 of 14

**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"**

**Grade 3.00 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 7.4 | 0.7 | 1.4 | 4.9 | 0.8 | 1.9 | 3.2 | 1.0 | 2.3 | | | | | | | | | | | | | | | | | | |
| 10 | 15.1 | 0.7 | 1.4 | 10.2 | 0.8 | 1.9 | 7.6 | 0.8 | 2.4 | 5.7 | 0.9 | 2.9 | 4.0 | 1.1 | 3.4 | | | | | | | | | | | | |
| 15 | 22.6 | 0.7 | 1.4 | 15.6 | 0.8 | 1.9 | 11.5 | 0.8 | 2.4 | 8.8 | 0.9 | 2.9 | 6.7 | 1.0 | 3.4 | 5.1 | 1.1 | 4.0 | | | | | | | | | |
| 20 | 30.1 | 0.7 | 1.4 | 20.7 | 0.8 | 1.9 | 15.5 | 0.8 | 2.4 | 11.8 | 0.9 | 2.9 | 9.2 | 0.9 | 3.4 | 7.2 | 1.0 | 4.0 | 5.5 | 1.2 | 4.6 | | | | | | |
| 25 | 37.6 | 0.7 | 1.4 | 25.9 | 0.8 | 1.9 | 19.4 | 0.8 | 2.4 | 15.0 | 0.9 | 2.9 | 11.6 | 0.9 | 3.4 | 9.2 | 1.0 | 4.0 | 7.2 | 1.1 | 4.6 | 5.6 | 1.3 | 5.1 | | | |
| 30 | 45.1 | 0.7 | 1.4 | 31.1 | 0.8 | 1.9 | 23.3 | 0.8 | 2.4 | 18.0 | 0.9 | 2.9 | 14.0 | 0.9 | 3.4 | 11.1 | 1.0 | 4.0 | 8.9 | 1.1 | 4.6 | 7.1 | 1.2 | 5.2 | 5.3 | 1.5 | 5.7 |
| 35 | 52.7 | 0.7 | 1.4 | 36.2 | 0.8 | 1.9 | 27.1 | 0.8 | 2.4 | 21.0 | 0.9 | 2.9 | 16.5 | 0.9 | 3.4 | 13.0 | 1.0 | 4.0 | 10.5 | 1.1 | 4.6 | 8.4 | 1.2 | 5.2 | 6.7 | 1.4 | 5.7 |
| 40 | 60.2 | 0.7 | 1.4 | 41.4 | 0.8 | 1.9 | 31.0 | 0.8 | 2.4 | 24.0 | 0.9 | 2.9 | 18.9 | 0.9 | 3.4 | 14.9 | 1.0 | 4.0 | 12.0 | 1.1 | 4.6 | 9.8 | 1.2 | 5.2 | 7.9 | 1.3 | 5.7 |
| 45 | 67.7 | 0.7 | 1.4 | 46.6 | 0.8 | 1.9 | 34.9 | 0.8 | 2.4 | 27.0 | 0.9 | 2.9 | 21.2 | 0.9 | 3.4 | 17.0 | 1.0 | 4.0 | 13.6 | 1.1 | 4.6 | 11.1 | 1.2 | 5.2 | 9.1 | 1.3 | 5.7 |
| 50 | 75.2 | 0.7 | 1.4 | 51.8 | 0.8 | 1.9 | 38.8 | 0.8 | 2.4 | 29.9 | 0.9 | 2.9 | 23.6 | 0.9 | 3.4 | 18.9 | 1.0 | 4.0 | 15.2 | 1.1 | 4.6 | 12.4 | 1.2 | 5.2 | 10.2 | 1.3 | 5.7 |
| 55 | 82.8 | 0.7 | 1.4 | 56.9 | 0.8 | 1.9 | 42.6 | 0.8 | 2.4 | 32.9 | 0.9 | 2.9 | 25.9 | 0.9 | 3.4 | 20.8 | 1.0 | 4.0 | 16.7 | 1.1 | 4.6 | 13.7 | 1.2 | 5.2 | 11.3 | 1.3 | 5.7 |
| 60 | 90.3 | 0.7 | 1.4 | 62.1 | 0.8 | 1.9 | 46.5 | 0.8 | 2.4 | 35.9 | 0.9 | 2.9 | 28.3 | 0.9 | 3.4 | 22.7 | 1.0 | 4.0 | 18.5 | 1.1 | 4.5 | 14.9 | 1.2 | 5.2 | 12.4 | 1.3 | 5.7 |
| 65 | 97.8 | 0.7 | 1.4 | 67.3 | 0.8 | 1.9 | 50.4 | 0.8 | 2.4 | 38.9 | 0.9 | 2.9 | 30.6 | 0.9 | 3.4 | 24.6 | 1.0 | 4.0 | 20.0 | 1.1 | 4.5 | 16.2 | 1.2 | 5.2 | 13.5 | 1.3 | 5.7 |
| 70 | 105.3 | 0.7 | 1.4 | 72.4 | 0.8 | 1.9 | 54.3 | 0.8 | 2.4 | 41.9 | 0.9 | 2.9 | 33.0 | 0.9 | 3.4 | 26.4 | 1.0 | 4.0 | 21.5 | 1.1 | 4.5 | 17.5 | 1.2 | 5.2 | 14.5 | 1.3 | 5.7 |
| 75 | 112.8 | 0.7 | 1.4 | 77.6 | 0.8 | 1.9 | 58.1 | 0.8 | 2.4 | 44.9 | 0.9 | 2.9 | 35.3 | 0.9 | 3.4 | 28.3 | 1.0 | 4.0 | 23.1 | 1.1 | 4.5 | 19.1 | 1.2 | 5.1 | 15.6 | 1.3 | 5.7 |
| 80 | 120.4 | 0.7 | 1.4 | 82.8 | 0.8 | 1.9 | 62.0 | 0.8 | 2.4 | 47.9 | 0.9 | 2.9 | 37.7 | 0.9 | 3.4 | 30.2 | 1.0 | 4.0 | 24.6 | 1.1 | 4.5 | 20.3 | 1.2 | 5.1 | 16.7 | 1.3 | 5.7 |
| 85 | 127.9 | 0.7 | 1.4 | 88.0 | 0.8 | 1.9 | 65.9 | 0.8 | 2.4 | 50.9 | 0.9 | 2.9 | 40.1 | 0.9 | 3.4 | 32.1 | 1.0 | 4.0 | 26.1 | 1.1 | 4.5 | 21.6 | 1.2 | 5.1 | 17.8 | 1.2 | 5.7 |
| 90 | 135.4 | 0.7 | 1.4 | 93.1 | 0.8 | 1.9 | 69.8 | 0.8 | 2.4 | 53.9 | 0.9 | 2.9 | 42.4 | 0.9 | 3.4 | 34.0 | 1.0 | 4.0 | 27.7 | 1.1 | 4.5 | 22.9 | 1.2 | 5.1 | 18.9 | 1.2 | 5.7 |
| 95 | 142.9 | 0.7 | 1.4 | 98.3 | 0.8 | 1.9 | 73.6 | 0.8 | 2.4 | 56.9 | 0.9 | 2.9 | 44.8 | 0.9 | 3.4 | 35.9 | 1.0 | 4.0 | 29.2 | 1.1 | 4.5 | 24.1 | 1.2 | 5.1 | 20.2 | 1.2 | 5.7 |
| 100 | 150.5 | 0.7 | 1.4 | 103.5 | 0.8 | 1.9 | 77.5 | 0.8 | 2.4 | 59.9 | 0.9 | 2.9 | 47.1 | 0.9 | 3.4 | 37.8 | 1.0 | 4.0 | 30.7 | 1.1 | 4.5 | 25.4 | 1.2 | 5.1 | 21.2 | 1.2 | 5.7 |
| 105 | 158.0 | 0.7 | 1.4 | 108.7 | 0.8 | 1.9 | 81.4 | 0.8 | 2.4 | 62.8 | 0.9 | 2.9 | 49.5 | 0.9 | 3.4 | 39.6 | 1.0 | 4.0 | 32.3 | 1.1 | 4.5 | 26.7 | 1.2 | 5.1 | 22.3 | 1.2 | 5.7 |
| 110 | 165.5 | 0.7 | 1.4 | 113.8 | 0.8 | 1.9 | 85.3 | 0.8 | 2.4 | 65.8 | 0.9 | 2.9 | 51.8 | 0.9 | 3.4 | 41.5 | 1.0 | 4.0 | 33.8 | 1.1 | 4.6 | 27.9 | 1.2 | 5.1 | 23.3 | 1.2 | 5.7 |
| 115 | 173.0 | 0.7 | 1.4 | 119.0 | 0.8 | 1.9 | 89.1 | 0.8 | 2.4 | 68.8 | 0.9 | 2.9 | 54.2 | 0.9 | 3.4 | 43.4 | 1.0 | 4.0 | 35.4 | 1.1 | 4.6 | 29.2 | 1.2 | 5.1 | 24.4 | 1.2 | 5.7 |
| 120 | 180.5 | 0.7 | 1.4 | 124.2 | 0.8 | 1.9 | 93.0 | 0.8 | 2.4 | 71.8 | 0.9 | 2.9 | 56.5 | 0.9 | 3.4 | 45.3 | 1.0 | 4.0 | 36.9 | 1.1 | 4.6 | 30.5 | 1.2 | 5.1 | 25.5 | 1.2 | 5.7 |
| 125 | 188.1 | 0.7 | 1.4 | 129.4 | 0.8 | 1.9 | 96.9 | 0.8 | 2.4 | 74.8 | 0.9 | 2.9 | 58.9 | 0.9 | 3.4 | 47.2 | 1.0 | 4.0 | 38.4 | 1.1 | 4.6 | 31.7 | 1.2 | 5.1 | 26.5 | 1.2 | 5.7 |
| 130 | 195.6 | 0.7 | 1.4 | 134.5 | 0.8 | 1.9 | 100.8 | 0.8 | 2.4 | 77.8 | 0.9 | 2.9 | 61.2 | 0.9 | 3.4 | 49.1 | 1.0 | 4.0 | 40.0 | 1.1 | 4.6 | 33.0 | 1.2 | 5.1 | 27.6 | 1.2 | 5.7 |
| 135 | 203.1 | 0.7 | 1.4 | 139.7 | 0.8 | 1.9 | 104.6 | 0.8 | 2.4 | 80.8 | 0.9 | 2.9 | 63.6 | 0.9 | 3.4 | 51.0 | 1.0 | 4.0 | 41.5 | 1.1 | 4.6 | 34.3 | 1.2 | 5.1 | 28.6 | 1.2 | 5.7 |
| 140 | 210.6 | 0.7 | 1.4 | 144.9 | 0.8 | 1.9 | 108.5 | 0.8 | 2.4 | 83.8 | 0.9 | 2.9 | 66.0 | 0.9 | 3.4 | 52.8 | 1.0 | 4.0 | 43.0 | 1.1 | 4.6 | 35.6 | 1.2 | 5.1 | 29.7 | 1.2 | 5.7 |
| 145 | 218.2 | 0.7 | 1.4 | 150.1 | 0.8 | 1.9 | 112.4 | 0.8 | 2.4 | 86.8 | 0.9 | 2.9 | 68.3 | 0.9 | 3.4 | 54.7 | 1.0 | 4.0 | 44.6 | 1.1 | 4.6 | 36.8 | 1.2 | 5.1 | 30.7 | 1.2 | 5.7 |
| 150 | 225.7 | 0.7 | 1.4 | 155.2 | 0.8 | 1.9 | 116.3 | 0.8 | 2.4 | 89.8 | 0.9 | 2.9 | 70.7 | 0.9 | 3.4 | 56.6 | 1.0 | 4.0 | 46.1 | 1.1 | 4.6 | 38.1 | 1.2 | 5.1 | 31.8 | 1.2 | 5.7 |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dir sions are in feet; Velocity measurements are in feet per second;
includ lowance for freeboarc settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 10 of 14

**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"**

**Grade 4.00 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 8.5 | 0.6 | 1.4 | 5.9 | 0.7 | 1.8 | 4.1 | 0.8 | 2.3 | | | | | | | | | | | | | | | | | | |
| 10 | 17.2 | 0.6 | 1.4 | 12.1 | 0.7 | 1.8 | 8.8 | 0.7 | 2.3 | 6.7 | 0.8 | 2.8 | 5.2 | 0.9 | 3.3 | 3.8 | 1.0 | 3.9 | | | | | | | | | |
| 15 | 25.8 | 0.6 | 1.4 | 18.1 | 0.7 | 1.8 | 13.4 | 0.7 | 2.3 | 10.3 | 0.8 | 2.8 | 8.1 | 0.8 | 3.4 | 6.4 | 0.9 | 3.9 | 4.9 | 1.0 | 4.5 | | | | | | |
| 20 | 34.4 | 0.6 | 1.4 | 24.2 | 0.7 | 1.8 | 17.8 | 0.7 | 2.3 | 13.9 | 0.8 | 2.8 | 10.9 | 0.8 | 3.4 | 8.7 | 0.9 | 3.9 | 6.9 | 1.0 | 4.5 | 5.5 | 1.1 | 5.0 | | | |
| 25 | 43.0 | 0.6 | 1.4 | 30.2 | 0.7 | 1.9 | 22.3 | 0.7 | 2.3 | 17.4 | 0.8 | 2.8 | 13.8 | 0.8 | 3.3 | 10.9 | 0.9 | 3.9 | 8.8 | 1.0 | 4.5 | 7.1 | 1.0 | 5.1 | 5.7 | 1.2 | 5.6 |
| 30 | 51.6 | 0.6 | 1.4 | 36.3 | 0.7 | 1.9 | 26.7 | 0.7 | 2.3 | 20.8 | 0.8 | 2.8 | 16.5 | 0.8 | 3.3 | 13.2 | 0.9 | 3.9 | 10.7 | 0.9 | 4.5 | 8.7 | 1.0 | 5.1 | 7.1 | 1.1 | 5.6 |
| 35 | 60.2 | 0.6 | 1.4 | 42.3 | 0.7 | 1.9 | 31.1 | 0.7 | 2.3 | 24.3 | 0.8 | 2.8 | 19.3 | 0.8 | 3.4 | 15.6 | 0.9 | 3.9 | 12.5 | 0.9 | 4.5 | 10.3 | 1.0 | 5.0 | 8.4 | 1.1 | 5.6 |
| 40 | 68.8 | 0.6 | 1.4 | 48.3 | 0.7 | 1.9 | 35.6 | 0.7 | 2.3 | 27.8 | 0.8 | 2.8 | 22.0 | 0.8 | 3.4 | 17.8 | 0.9 | 3.9 | 14.4 | 0.9 | 4.5 | 11.8 | 1.0 | 5.0 | 9.8 | 1.1 | 5.7 |
| 45 | 77.4 | 0.6 | 1.4 | 54.4 | 0.7 | 1.9 | 40.0 | 0.7 | 2.4 | 31.2 | 0.8 | 2.8 | 24.8 | 0.8 | 3.4 | 20.0 | 0.9 | 3.9 | 16.4 | 0.9 | 4.4 | 13.3 | 1.0 | 5.0 | 11.1 | 1.1 | 5.7 |
| 50 | 86.0 | 0.6 | 1.4 | 60.4 | 0.7 | 1.9 | 44.5 | 0.7 | 2.4 | 34.7 | 0.8 | 2.8 | 27.5 | 0.8 | 3.4 | 22.2 | 0.9 | 3.9 | 18.2 | 0.9 | 4.4 | 14.9 | 1.0 | 5.0 | 12.3 | 1.1 | 5.7 |
| 55 | 94.6 | 0.6 | 1.4 | 66.5 | 0.7 | 1.9 | 48.9 | 0.7 | 2.4 | 38.2 | 0.8 | 2.8 | 30.3 | 0.8 | 3.4 | 24.4 | 0.9 | 3.9 | 20.0 | 0.9 | 4.4 | 16.6 | 1.0 | 5.0 | 13.6 | 1.1 | 5.7 |
| 60 | 103.2 | 0.6 | 1.4 | 72.5 | 0.7 | 1.9 | 53.4 | 0.7 | 2.4 | 41.7 | 0.8 | 2.8 | 33.0 | 0.8 | 3.4 | 26.6 | 0.9 | 3.9 | 21.8 | 0.9 | 4.5 | 18.1 | 1.0 | 5.0 | 14.9 | 1.1 | 5.7 |
| 65 | 111.8 | 0.6 | 1.4 | 78.5 | 0.7 | 1.9 | 57.8 | 0.7 | 2.4 | 45.1 | 0.8 | 2.8 | 35.8 | 0.8 | 3.4 | 28.9 | 0.9 | 3.9 | 23.6 | 0.9 | 4.5 | 19.6 | 1.0 | 5.0 | 16.2 | 1.1 | 5.7 |
| 70 | 120.4 | 0.6 | 1.4 | 84.6 | 0.7 | 1.9 | 62.3 | 0.7 | 2.4 | 48.6 | 0.8 | 2.8 | 38.6 | 0.8 | 3.4 | 31.1 | 0.9 | 3.9 | 25.4 | 0.9 | 4.5 | 21.1 | 1.0 | 5.0 | 17.7 | 1.1 | 5.6 |
| 75 | 129.0 | 0.6 | 1.4 | 90.6 | 0.7 | 1.9 | 66.7 | 0.7 | 2.4 | 52.1 | 0.8 | 2.8 | 41.3 | 0.8 | 3.4 | 33.3 | 0.9 | 3.9 | 27.2 | 0.9 | 4.5 | 22.6 | 1.0 | 5.0 | 19.0 | 1.1 | 5.6 |
| 80 | 137.6 | 0.6 | 1.4 | 96.7 | 0.7 | 1.9 | 71.2 | 0.7 | 2.4 | 55.5 | 0.8 | 2.8 | 44.1 | 0.8 | 3.4 | 35.5 | 0.9 | 3.9 | 29.1 | 0.9 | 4.5 | 24.1 | 1.0 | 5.0 | 20.2 | 1.1 | 5.6 |
| 85 | 146.2 | 0.6 | 1.4 | 102.7 | 0.7 | 1.9 | 75.6 | 0.7 | 2.4 | 59.0 | 0.8 | 2.8 | 46.8 | 0.8 | 3.4 | 37.7 | 0.9 | 3.9 | 30.9 | 0.9 | 4.5 | 25.6 | 1.0 | 5.0 | 21.5 | 1.1 | 5.6 |
| 90 | 154.8 | 0.6 | 1.4 | 108.7 | 0.7 | 1.9 | 80.0 | 0.7 | 2.4 | 62.5 | 0.8 | 2.8 | 49.6 | 0.8 | 3.4 | 39.9 | 0.9 | 3.9 | 32.7 | 0.9 | 4.5 | 27.1 | 1.0 | 5.0 | 22.8 | 1.1 | 5.6 |
| 95 | 163.4 | 0.6 | 1.4 | 114.8 | 0.7 | 1.9 | 84.5 | 0.7 | 2.4 | 65.9 | 0.8 | 2.8 | 52.3 | 0.8 | 3.4 | 42.2 | 0.9 | 3.9 | 34.5 | 0.9 | 4.5 | 28.6 | 1.0 | 5.0 | 24.0 | 1.1 | 5.6 |
| 100 | 172.0 | 0.6 | 1.4 | 120.8 | 0.7 | 1.9 | 88.9 | 0.7 | 2.4 | 69.4 | 0.8 | 2.8 | 55.1 | 0.8 | 3.4 | 44.4 | 0.9 | 3.9 | 36.3 | 0.9 | 4.5 | 30.1 | 1.0 | 5.0 | 25.3 | 1.1 | 5.6 |
| 105 | 180.6 | 0.6 | 1.4 | 126.9 | 0.7 | 1.9 | 93.4 | 0.7 | 2.4 | 72.9 | 0.8 | 2.8 | 57.8 | 0.8 | 3.4 | 46.6 | 0.9 | 3.9 | 38.1 | 0.9 | 4.5 | 31.6 | 1.0 | 5.0 | 26.5 | 1.1 | 5.6 |
| 110 | 189.2 | 0.6 | 1.4 | 132.9 | 0.7 | 1.9 | 97.8 | 0.7 | 2.4 | 76.3 | 0.8 | 2.8 | 60.6 | 0.8 | 3.4 | 48.8 | 0.9 | 3.9 | 39.9 | 0.9 | 4.5 | 33.1 | 1.0 | 5.0 | 27.8 | 1.1 | 5.6 |
| 115 | 197.8 | 0.6 | 1.4 | 138.9 | 0.7 | 1.9 | 102.3 | 0.7 | 2.4 | 79.8 | 0.8 | 2.8 | 63.3 | 0.8 | 3.4 | 51.0 | 0.9 | 3.9 | 41.7 | 0.9 | 4.5 | 34.6 | 1.0 | 5.0 | 29.0 | 1.1 | 5.6 |
| 120 | 206.4 | 0.6 | 1.4 | 145.0 | 0.7 | 1.9 | 106.7 | 0.7 | 2.4 | 83.3 | 0.8 | 2.8 | 66.1 | 0.8 | 3.4 | 53.3 | 0.9 | 3.9 | 43.6 | 0.9 | 4.5 | 36.1 | 1.0 | 5.0 | 30.2 | 1.1 | 5.7 |
| 125 | 215.0 | 0.6 | 1.4 | 151.0 | 0.7 | 1.9 | 111.2 | 0.7 | 2.4 | 86.8 | 0.8 | 2.8 | 68.8 | 0.8 | 3.4 | 55.5 | 0.9 | 3.9 | 45.4 | 0.9 | 4.5 | 37.6 | 1.0 | 5.0 | 31.5 | 1.1 | 5.7 |
| 130 | 223.7 | 0.6 | 1.4 | 157.1 | 0.7 | 1.9 | 115.6 | 0.7 | 2.4 | 90.2 | 0.8 | 2.8 | 71.6 | 0.8 | 3.4 | 57.7 | 0.9 | 3.9 | 47.2 | 0.9 | 4.5 | 39.1 | 1.0 | 5.0 | 32.7 | 1.1 | 5.7 |
| 135 | 232.3 | 0.6 | 1.4 | 163.1 | 0.7 | 1.9 | 120.1 | 0.7 | 2.4 | 93.7 | 0.8 | 2.8 | 74.3 | 0.8 | 3.4 | 59.9 | 0.9 | 3.9 | 49.0 | 0.9 | 4.5 | 40.6 | 1.0 | 5.0 | 34.0 | 1.1 | 5.7 |
| 140 | 240.9 | 0.6 | 1.4 | 169.1 | 0.7 | 1.9 | 124.5 | 0.7 | 2.4 | 97.2 | 0.8 | 2.8 | 77.1 | 0.8 | 3.4 | 62.1 | 0.9 | 3.9 | 50.8 | 0.9 | 4.5 | 42.1 | 1.0 | 5.0 | 35.2 | 1.1 | 5.7 |
| 145 | 249.5 | 0.6 | 1.4 | 175.2 | 0.7 | 1.9 | 129.0 | 0.7 | 2.4 | 100.6 | 0.8 | 2.8 | 79.8 | 0.8 | 3.4 | 64.3 | 0.9 | 3.9 | 52.6 | 0.9 | 4.5 | 43.6 | 1.0 | 5.0 | 36.5 | 1.1 | 5.7 |
| 150 | 258.1 | 0.6 | 1.4 | 181.2 | 0.7 | 1.9 | 133.4 | 0.7 | 2.4 | 104.1 | 0.8 | 2.8 | 82.6 | 0.8 | 3.4 | 66.6 | 0.9 | 3.9 | 54.4 | 0.9 | 4.5 | 45.1 | 1.0 | 5.0 | 37.8 | 1.1 | 5.7 |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 11 of 14

**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"**

**Grade 5.00 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 9.5 | 0.6 | 1.4 | 6.7 | 0.6 | 1.8 | 4.7 | 0.7 | 2.3 | 3.5 | 0.8 | 2.8 | | | | | | | | | | | | | | | |
| 10 | 19.0 | 0.6 | 1.4 | 13.7 | 0.6 | 1.8 | 9.7 | 0.7 | 2.3 | 7.6 | 0.7 | 2.8 | 6.0 | 0.8 | 3.3 | 4.7 | 0.8 | 3.8 | 3.4 | 1.0 | 4.4 | | | | | | |
| 15 | 28.5 | 0.6 | 1.4 | 20.5 | 0.6 | 1.8 | 14.8 | 0.7 | 2.3 | 11.7 | 0.7 | 2.8 | 9.2 | 0.7 | 3.3 | 7.3 | 0.8 | 3.8 | 5.9 | 0.9 | 4.4 | 4.7 | 1.0 | 5.0 | | | |
| 20 | 38.0 | 0.6 | 1.4 | 27.3 | 0.6 | 1.8 | 19.7 | 0.7 | 2.3 | 15.5 | 0.7 | 2.8 | 12.4 | 0.7 | 3.3 | 9.9 | 0.8 | 3.8 | 8.0 | 0.9 | 4.4 | 6.5 | 0.9 | 4.9 | 5.3 | 1.0 | 5.5 |
| 25 | 47.5 | 0.6 | 1.4 | 34.1 | 0.6 | 1.8 | 24.6 | 0.7 | 2.3 | 19.4 | 0.7 | 2.8 | 15.5 | 0.7 | 3.3 | 12.6 | 0.8 | 3.8 | 10.1 | 0.8 | 4.4 | 8.3 | 0.9 | 5.0 | 6.8 | 1.0 | 5.6 |
| 30 | 57.0 | 0.6 | 1.4 | 40.9 | 0.6 | 1.8 | 29.5 | 0.7 | 2.3 | 23.3 | 0.7 | 2.8 | 18.6 | 0.7 | 3.3 | 15.1 | 0.8 | 3.8 | 12.2 | 0.8 | 4.4 | 10.1 | 0.9 | 5.0 | 8.3 | 1.0 | 5.6 |
| 35 | 66.5 | 0.6 | 1.4 | 47.7 | 0.6 | 1.8 | 34.4 | 0.7 | 2.3 | 27.2 | 0.7 | 2.8 | 21.7 | 0.7 | 3.3 | 17.6 | 0.8 | 3.8 | 14.5 | 0.8 | 4.4 | 11.8 | 0.9 | 5.0 | 9.8 | 1.0 | 5.6 |
| 40 | 76.0 | 0.6 | 1.4 | 54.6 | 0.6 | 1.8 | 39.4 | 0.7 | 2.3 | 31.0 | 0.7 | 2.8 | 24.8 | 0.7 | 3.3 | 20.1 | 0.8 | 3.8 | 16.5 | 0.8 | 4.4 | 13.6 | 0.9 | 5.0 | 11.3 | 1.0 | 5.5 |
| 45 | 85.5 | 0.6 | 1.4 | 61.4 | 0.6 | 1.8 | 44.3 | 0.7 | 2.3 | 34.9 | 0.7 | 2.8 | 27.9 | 0.7 | 3.3 | 22.6 | 0.8 | 3.8 | 18.6 | 0.8 | 4.4 | 15.5 | 0.9 | 4.9 | 12.8 | 1.0 | 5.5 |
| 50 | 95.0 | 0.6 | 1.4 | 68.2 | 0.6 | 1.8 | 49.2 | 0.7 | 2.3 | 38.8 | 0.7 | 2.8 | 31.0 | 0.7 | 3.3 | 25.1 | 0.8 | 3.8 | 20.6 | 0.8 | 4.4 | 17.2 | 0.9 | 4.9 | 14.3 | 1.0 | 5.5 |
| 55 | 104.6 | 0.6 | 1.4 | 75.0 | 0.6 | 1.8 | 54.1 | 0.7 | 2.3 | 42.7 | 0.7 | 2.8 | 34.1 | 0.7 | 3.3 | 27.6 | 0.8 | 3.8 | 22.7 | 0.8 | 4.4 | 18.9 | 0.9 | 4.9 | 15.9 | 0.9 | 5.5 |
| 60 | 114.1 | 0.6 | 1.4 | 81.8 | 0.6 | 1.8 | 59.0 | 0.7 | 2.3 | 46.6 | 0.7 | 2.8 | 37.2 | 0.7 | 3.3 | 30.1 | 0.8 | 3.8 | 24.7 | 0.8 | 4.4 | 20.6 | 0.9 | 4.9 | 17.3 | 0.9 | 5.5 |
| 65 | 123.6 | 0.6 | 1.4 | 88.6 | 0.6 | 1.8 | 63.9 | 0.7 | 2.3 | 50.4 | 0.7 | 2.8 | 40.3 | 0.7 | 3.3 | 32.6 | 0.8 | 3.8 | 26.8 | 0.8 | 4.4 | 22.3 | 0.9 | 4.9 | 18.8 | 0.9 | 5.5 |
| 70 | 133.1 | 0.6 | 1.4 | 95.5 | 0.6 | 1.8 | 68.9 | 0.7 | 2.3 | 54.3 | 0.7 | 2.8 | 43.4 | 0.7 | 3.3 | 35.1 | 0.8 | 3.8 | 28.9 | 0.8 | 4.4 | 24.0 | 0.9 | 4.9 | 20.2 | 0.9 | 5.5 |
| 75 | 142.6 | 0.6 | 1.4 | 102.3 | 0.6 | 1.8 | 73.8 | 0.7 | 2.3 | 58.2 | 0.7 | 2.8 | 46.5 | 0.7 | 3.3 | 37.7 | 0.8 | 3.8 | 30.9 | 0.8 | 4.4 | 25.7 | 0.9 | 4.9 | 21.6 | 0.9 | 5.5 |
| 80 | 152.1 | 0.6 | 1.4 | 109.1 | 0.6 | 1.8 | 78.7 | 0.7 | 2.3 | 62.1 | 0.7 | 2.8 | 49.6 | 0.7 | 3.3 | 40.2 | 0.8 | 3.8 | 33.0 | 0.8 | 4.4 | 27.4 | 0.9 | 4.9 | 23.1 | 0.9 | 5.5 |
| 85 | 161.6 | 0.6 | 1.4 | 115.9 | 0.6 | 1.8 | 83.6 | 0.7 | 2.3 | 65.9 | 0.7 | 2.8 | 52.7 | 0.7 | 3.3 | 42.7 | 0.8 | 3.8 | 35.0 | 0.8 | 4.4 | 29.1 | 0.9 | 5.0 | 24.5 | 0.9 | 5.5 |
| 90 | 171.1 | 0.6 | 1.4 | 122.7 | 0.6 | 1.8 | 88.5 | 0.7 | 2.3 | 69.8 | 0.7 | 2.8 | 55.8 | 0.7 | 3.3 | 45.2 | 0.8 | 3.8 | 37.1 | 0.8 | 4.4 | 30.9 | 0.9 | 5.0 | 26.0 | 0.9 | 5.5 |
| 95 | 180.6 | 0.6 | 1.4 | 129.6 | 0.6 | 1.8 | 93.4 | 0.7 | 2.3 | 73.7 | 0.7 | 2.8 | 58.9 | 0.7 | 3.3 | 47.7 | 0.8 | 3.8 | 39.2 | 0.8 | 4.4 | 32.6 | 0.9 | 5.0 | 27.4 | 0.9 | 5.5 |
| 100 | 190.1 | 0.6 | 1.4 | 136.4 | 0.6 | 1.8 | 98.4 | 0.7 | 2.3 | 77.6 | 0.7 | 2.8 | 62.0 | 0.7 | 3.3 | 50.2 | 0.8 | 3.8 | 41.2 | 0.8 | 4.4 | 34.3 | 0.9 | 5.0 | 28.8 | 0.9 | 5.5 |
| 105 | 199.6 | 0.6 | 1.4 | 143.2 | 0.6 | 1.8 | 103.3 | 0.7 | 2.3 | 81.5 | 0.7 | 2.8 | 65.1 | 0.7 | 3.3 | 52.7 | 0.8 | 3.8 | 43.3 | 0.8 | 4.4 | 36.0 | 0.9 | 5.0 | 30.3 | 0.9 | 5.5 |
| 110 | 209.1 | 0.6 | 1.4 | 150.0 | 0.6 | 1.8 | 108.2 | 0.7 | 2.3 | 85.3 | 0.7 | 2.8 | 68.2 | 0.7 | 3.3 | 55.2 | 0.8 | 3.8 | 45.3 | 0.8 | 4.4 | 37.7 | 0.9 | 5.0 | 31.7 | 0.9 | 5.5 |
| 115 | 218.6 | 0.6 | 1.4 | 156.8 | 0.6 | 1.8 | 113.1 | 0.7 | 2.3 | 89.2 | 0.7 | 2.8 | 71.3 | 0.7 | 3.3 | 57.7 | 0.8 | 3.8 | 47.4 | 0.8 | 4.4 | 39.4 | 0.9 | 5.0 | 33.2 | 0.9 | 5.5 |
| 120 | 228.1 | 0.6 | 1.4 | 163.6 | 0.6 | 1.8 | 118.0 | 0.7 | 2.3 | 93.1 | 0.7 | 2.8 | 74.3 | 0.7 | 3.3 | 60.2 | 0.8 | 3.8 | 49.5 | 0.8 | 4.4 | 41.1 | 0.9 | 5.0 | 34.6 | 0.9 | 5.5 |
| 125 | 237.6 | 0.6 | 1.4 | 170.5 | 0.6 | 1.8 | 123.0 | 0.7 | 2.3 | 97.0 | 0.7 | 2.8 | 77.4 | 0.7 | 3.3 | 62.7 | 0.8 | 3.8 | 51.5 | 0.8 | 4.4 | 42.8 | 0.9 | 5.0 | 36.0 | 0.9 | 5.5 |
| 130 | 247.1 | 0.6 | 1.4 | 177.3 | 0.6 | 1.8 | 127.9 | 0.7 | 2.3 | 100.8 | 0.7 | 2.8 | 80.5 | 0.7 | 3.3 | 65.2 | 0.8 | 3.8 | 53.6 | 0.8 | 4.4 | 44.6 | 0.9 | 5.0 | 37.5 | 0.9 | 5.5 |
| 135 | 256.6 | 0.6 | 1.4 | 184.1 | 0.6 | 1.8 | 132.8 | 0.7 | 2.3 | 104.7 | 0.7 | 2.8 | 83.6 | 0.7 | 3.3 | 67.8 | 0.8 | 3.8 | 55.6 | 0.8 | 4.4 | 46.3 | 0.9 | 5.0 | 38.9 | 0.9 | 5.5 |
| 140 | 266.1 | 0.6 | 1.4 | 190.9 | 0.6 | 1.8 | 137.7 | 0.7 | 2.3 | 108.6 | 0.7 | 2.8 | 86.7 | 0.7 | 3.3 | 70.3 | 0.8 | 3.8 | 57.7 | 0.8 | 4.4 | 48.0 | 0.9 | 5.0 | 40.4 | 0.9 | 5.5 |
| 145 | 275.6 | 0.6 | 1.4 | 197.7 | 0.6 | 1.8 | 142.6 | 0.7 | 2.3 | 112.5 | 0.7 | 2.8 | 89.8 | 0.7 | 3.3 | 72.8 | 0.8 | 3.8 | 59.8 | 0.8 | 4.4 | 49.7 | 0.9 | 5.0 | 41.8 | 0.9 | 5.5 |
| 150 | 285.1 | 0.6 | 1.4 | 204.6 | 0.6 | 1.8 | 147.5 | 0.7 | 2.3 | 116.4 | 0.7 | 2.8 | 92.9 | 0.7 | 3.3 | 75.3 | 0.8 | 3.8 | 61.8 | 0.8 | 4.4 | 51.4 | 0.9 | 5.0 | 43.2 | 0.9 | 5.5 |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second:
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 12 of 14

**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"**

**Grade 6.00 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 10.6 | 0.5 | 1.3 | 7.3 | 0.6 | 1.8 | 5.3 | 0.6 | 2.3 | 4.0 | 0.7 | 2.8 | 2.9 | 0.8 | 3.2 | | | | | | | | | | | | |
| 10 | 21.1 | 0.5 | 1.3 | 14.7 | 0.6 | 1.8 | 10.9 | 0.6 | 2.3 | 8.4 | 0.7 | 2.8 | 6.6 | 0.7 | 3.2 | 5.3 | 0.8 | 3.8 | 4.2 | 0.8 | 4.3 | | | | | | |
| 15 | 31.6 | 0.5 | 1.3 | 22.1 | 0.6 | 1.8 | 16.3 | 0.6 | 2.3 | 12.7 | 0.6 | 2.7 | 10.1 | 0.7 | 3.3 | 8.2 | 0.7 | 3.8 | 6.6 | 0.8 | 4.3 | 5.4 | 0.9 | 4.9 | 4.3 | 1.0 | 5.5 |
| 20 | 42.1 | 0.5 | 1.3 | 29.5 | 0.6 | 1.8 | 21.7 | 0.6 | 2.3 | 17.0 | 0.6 | 2.7 | 13.6 | 0.7 | 3.2 | 11.1 | 0.7 | 3.7 | 9.0 | 0.8 | 4.3 | 7.4 | 0.8 | 4.9 | 6.1 | 0.9 | 5.5 |
| 25 | 52.7 | 0.5 | 1.3 | 36.8 | 0.6 | 1.8 | 27.1 | 0.6 | 2.3 | 21.2 | 0.6 | 2.8 | 17.0 | 0.7 | 3.2 | 13.9 | 0.7 | 3.8 | 11.3 | 0.8 | 4.3 | 9.3 | 0.8 | 4.9 | 7.8 | 0.9 | 5.5 |
| 30 | 63.2 | 0.5 | 1.3 | 44.2 | 0.6 | 1.8 | 32.5 | 0.6 | 2.3 | 25.4 | 0.6 | 2.8 | 20.4 | 0.7 | 3.2 | 16.6 | 0.7 | 3.8 | 13.7 | 0.8 | 4.3 | 11.3 | 0.8 | 4.9 | 9.4 | 0.9 | 5.5 |
| 35 | 73.7 | 0.5 | 1.3 | 51.6 | 0.6 | 1.8 | 38.0 | 0.6 | 2.3 | 29.7 | 0.6 | 2.8 | 23.8 | 0.7 | 3.2 | 19.4 | 0.7 | 3.8 | 16.0 | 0.8 | 4.3 | 13.4 | 0.8 | 4.9 | 11.1 | 0.9 | 5.5 |
| 40 | 84.2 | 0.5 | 1.3 | 58.9 | 0.6 | 1.8 | 43.4 | 0.6 | 2.3 | 33.9 | 0.6 | 2.8 | 27.2 | 0.7 | 3.3 | 22.2 | 0.7 | 3.8 | 18.3 | 0.8 | 4.3 | 15.3 | 0.8 | 4.9 | 12.7 | 0.9 | 5.5 |
| 45 | 94.8 | 0.5 | 1.3 | 66.3 | 0.6 | 1.8 | 48.8 | 0.6 | 2.3 | 38.2 | 0.6 | 2.8 | 30.7 | 0.7 | 3.3 | 24.9 | 0.7 | 3.8 | 20.6 | 0.8 | 4.3 | 17.2 | 0.8 | 4.9 | 14.5 | 0.9 | 5.4 |
| 50 | 105.3 | 0.5 | 1.3 | 73.6 | 0.6 | 1.8 | 54.2 | 0.6 | 2.3 | 42.4 | 0.6 | 2.8 | 34.1 | 0.7 | 3.3 | 27.7 | 0.7 | 3.8 | 22.8 | 0.8 | 4.3 | 19.1 | 0.8 | 4.9 | 16.1 | 0.9 | 5.4 |
| 55 | 115.8 | 0.5 | 1.3 | 81.0 | 0.6 | 1.8 | 59.7 | 0.6 | 2.3 | 46.6 | 0.6 | 2.8 | 37.5 | 0.7 | 3.3 | 30.5 | 0.7 | 3.8 | 25.1 | 0.8 | 4.3 | 21.0 | 0.8 | 4.9 | 17.7 | 0.9 | 5.4 |
| 60 | 126.4 | 0.5 | 1.3 | 88.4 | 0.6 | 1.8 | 65.1 | 0.6 | 2.3 | 50.9 | 0.6 | 2.8 | 40.9 | 0.7 | 3.3 | 33.3 | 0.7 | 3.8 | 27.4 | 0.8 | 4.3 | 22.9 | 0.8 | 4.9 | 19.3 | 0.9 | 5.4 |
| 65 | 136.9 | 0.5 | 1.3 | 95.7 | 0.6 | 1.8 | 70.5 | 0.6 | 2.3 | 55.1 | 0.6 | 2.8 | 44.3 | 0.7 | 3.3 | 36.0 | 0.7 | 3.8 | 29.7 | 0.8 | 4.3 | 24.8 | 0.8 | 4.9 | 20.9 | 0.9 | 5.4 |
| 70 | 147.4 | 0.5 | 1.3 | 103.1 | 0.6 | 1.8 | 75.9 | 0.6 | 2.3 | 59.3 | 0.6 | 2.8 | 47.7 | 0.7 | 3.3 | 38.8 | 0.7 | 3.8 | 32.0 | 0.8 | 4.3 | 26.7 | 0.8 | 4.9 | 22.5 | 0.9 | 5.4 |
| 75 | 158.0 | 0.5 | 1.3 | 110.5 | 0.6 | 1.8 | 81.3 | 0.8 | 2.3 | 63.6 | 0.8 | 2.8 | 51.1 | 0.7 | 3.3 | 41.6 | 0.7 | 3.8 | 34.3 | 0.8 | 4.3 | 28.6 | 0.8 | 4.9 | 24.1 | 0.9 | 5.4 |
| 80 | 168.5 | 0.5 | 1.3 | 117.8 | 0.6 | 1.8 | 86.8 | 0.6 | 2.3 | 67.8 | 0.6 | 2.8 | 54.5 | 0.7 | 3.3 | 44.3 | 0.7 | 3.8 | 36.5 | 0.8 | 4.3 | 30.5 | 0.8 | 4.9 | 25.7 | 0.9 | 5.5 |
| 85 | 179.0 | 0.5 | 1.3 | 125.2 | 0.6 | 1.8 | 92.2 | 0.6 | 2.3 | 72.0 | 0.6 | 2.8 | 57.9 | 0.7 | 3.3 | 47.1 | 0.7 | 3.8 | 38.8 | 0.8 | 4.3 | 32.4 | 0.8 | 4.9 | 27.3 | 0.9 | 5.5 |
| 90 | 189.6 | 0.5 | 1.3 | 132.6 | 0.6 | 1.8 | 97.6 | 0.6 | 2.3 | 76.3 | 0.6 | 2.8 | 61.3 | 0.7 | 3.3 | 49.9 | 0.7 | 3.8 | 41.1 | 0.8 | 4.3 | 34.3 | 0.8 | 4.9 | 28.9 | 0.9 | 5.5 |
| 95 | 200.1 | 0.5 | 1.3 | 139.9 | 0.6 | 1.8 | 103.0 | 0.6 | 2.3 | 80.5 | 0.6 | 2.8 | 64.7 | 0.7 | 3.3 | 52.6 | 0.7 | 3.8 | 43.4 | 0.8 | 4.3 | 36.2 | 0.8 | 4.9 | 30.5 | 0.9 | 5.5 |
| 100 | 210.6 | 0.5 | 1.3 | 147.3 | 0.6 | 1.8 | 108.5 | 0.6 | 2.3 | 84.8 | 0.6 | 2.8 | 68.1 | 0.7 | 3.3 | 55.4 | 0.7 | 3.8 | 45.7 | 0.8 | 4.3 | 38.1 | 0.8 | 4.9 | 32.1 | 0.9 | 5.5 |
| 105 | 221.1 | 0.5 | 1.3 | 154.6 | 0.6 | 1.8 | 113.9 | 0.6 | 2.3 | 89.0 | 0.6 | 2.8 | 71.5 | 0.7 | 3.3 | 58.2 | 0.7 | 3.8 | 47.9 | 0.8 | 4.3 | 40.0 | 0.8 | 4.9 | 33.7 | 0.9 | 5.5 |
| 110 | 231.7 | 0.5 | 1.3 | 162.0 | 0.6 | 1.8 | 119.3 | 0.6 | 2.3 | 93.2 | 0.6 | 2.8 | 74.9 | 0.7 | 3.3 | 60.9 | 0.7 | 3.8 | 50.2 | 0.8 | 4.3 | 41.9 | 0.8 | 4.9 | 35.3 | 0.9 | 5.5 |
| 115 | 242.2 | 0.5 | 1.3 | 169.4 | 0.6 | 1.8 | 124.7 | 0.6 | 2.3 | 97.5 | 0.6 | 2.8 | 78.3 | 0.7 | 3.3 | 63.7 | 0.7 | 3.8 | 52.5 | 0.8 | 4.3 | 43.8 | 0.8 | 4.9 | 36.9 | 0.9 | 5.5 |
| 120 | 252.7 | 0.5 | 1.3 | 176.7 | 0.6 | 1.8 | 130.2 | 0.6 | 2.3 | 101.7 | 0.6 | 2.8 | 81.7 | 0.7 | 3.3 | 66.5 | 0.7 | 3.8 | 54.8 | 0.8 | 4.3 | 45.7 | 0.8 | 4.9 | 38.5 | 0.9 | 5.5 |
| 125 | 263.3 | 0.5 | 1.3 | 184.1 | 0.6 | 1.8 | 135.6 | 0.6 | 2.3 | 106.0 | 0.6 | 2.8 | 85.1 | 0.7 | 3.3 | 69.3 | 0.7 | 3.8 | 57.1 | 0.8 | 4.3 | 47.6 | 0.8 | 4.9 | 40.1 | 0.9 | 5.5 |
| 130 | 273.8 | 0.5 | 1.3 | 191.5 | 0.6 | 1.8 | 141.0 | 0.6 | 2.3 | 110.2 | 0.6 | 2.8 | 88.5 | 0.7 | 3.3 | 72.0 | 0.7 | 3.8 | 59.4 | 0.8 | 4.3 | 49.5 | 0.8 | 4.9 | 41.7 | 0.9 | 5.5 |
| 135 | 284.3 | 0.5 | 1.3 | 198.8 | 0.6 | 1.8 | 146.4 | 0.6 | 2.3 | 114.4 | 0.6 | 2.8 | 91.9 | 0.7 | 3.3 | 74.8 | 0.7 | 3.8 | 61.6 | 0.8 | 4.3 | 51.4 | 0.8 | 4.9 | 43.3 | 0.9 | 5.5 |
| 140 | 294.9 | 0.5 | 1.3 | 206.2 | 0.6 | 1.8 | 151.8 | 0.6 | 2.3 | 118.7 | 0.6 | 2.8 | 95.3 | 0.7 | 3.3 | 77.6 | 0.7 | 3.8 | 63.9 | 0.8 | 4.3 | 53.3 | 0.8 | 4.9 | 44.9 | 0.9 | 5.5 |
| 145 | 305.4 | 0.5 | 1.3 | 213.6 | 0.6 | 1.8 | 157.3 | 0.6 | 2.3 | 122.9 | 0.6 | 2.8 | 98.7 | 0.7 | 3.3 | 80.3 | 0.7 | 3.8 | 66.2 | 0.8 | 4.3 | 55.2 | 0.8 | 4.9 | 46.5 | 0.9 | 5.5 |
| 150 | 315.9 | 0.5 | 1.3 | 220.9 | 0.6 | 1.8 | 162.7 | 0.6 | 2.3 | 127.1 | 0.6 | 2.8 | 102.1 | 0.7 | 3.3 | 83.1 | 0.7 | 3.8 | 68.5 | 0.8 | 4.3 | 57.1 | 0.8 | 4.9 | 48.1 | 0.9 | 5.5 |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second:
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 13 of 14

**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D), AND V2 FOR RETARDANCE "C"**

**Grade 8.00 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 12.0 | 0.5 | 1.3 | 8.5 | 0.5 | 1.7 | 6.2 | 0.5 | 2.2 | 4.6 | 0.6 | 2.7 | 3.7 | 0.6 | 3.2 | 2.9 | 0.7 | 3.6 | | | | | | | | | |
| 10 | 24.1 | 0.5 | 1.3 | 16.9 | 0.5 | 1.7 | 12.6 | 0.5 | 2.2 | 9.6 | 0.6 | 2.7 | 7.8 | 0.6 | 3.2 | 6.3 | 0.6 | 3.7 | 5.1 | 0.7 | 4.2 | 4.2 | 0.8 | 4.8 | 3.2 | 0.9 | 5.3 |
| 15 | 36.1 | 0.5 | 1.3 | 25.3 | 0.5 | 1.7 | 18.9 | 0.5 | 2.2 | 14.4 | 0.6 | 2.7 | 11.8 | 0.6 | 3.2 | 9.7 | 0.6 | 3.7 | 7.9 | 0.7 | 4.2 | 6.5 | 0.7 | 4.8 | 5.4 | 0.8 | 5.3 |
| 20 | 48.1 | 0.5 | 1.3 | 33.8 | 0.5 | 1.7 | 25.2 | 0.5 | 2.2 | 19.2 | 0.6 | 2.7 | 15.8 | 0.6 | 3.2 | 12.9 | 0.6 | 3.7 | 10.7 | 0.7 | 4.2 | 8.8 | 0.7 | 4.8 | 7.4 | 0.8 | 5.3 |
| 25 | 60.1 | 0.5 | 1.3 | 42.2 | 0.5 | 1.7 | 31.5 | 0.5 | 2.2 | 24.0 | 0.6 | 2.7 | 19.7 | 0.6 | 3.2 | 16.2 | 0.6 | 3.7 | 13.4 | 0.7 | 4.2 | 11.2 | 0.7 | 4.7 | 9.3 | 0.8 | 5.3 |
| 30 | 72.1 | 0.5 | 1.3 | 50.6 | 0.5 | 1.7 | 37.8 | 0.5 | 2.2 | 28.8 | 0.6 | 2.7 | 23.6 | 0.6 | 3.2 | 19.4 | 0.6 | 3.7 | 16.1 | 0.7 | 4.2 | 13.5 | 0.7 | 4.8 | 11.3 | 0.7 | 5.3 |
| 35 | 84.1 | 0.5 | 1.3 | 59.1 | 0.5 | 1.7 | 44.1 | 0.5 | 2.2 | 33.6 | 0.6 | 2.7 | 27.6 | 0.6 | 3.2 | 22.6 | 0.6 | 3.7 | 18.7 | 0.7 | 4.2 | 15.7 | 0.7 | 4.8 | 13.3 | 0.7 | 5.3 |
| 40 | 96.2 | 0.5 | 1.3 | 67.5 | 0.5 | 1.7 | 50.4 | 0.5 | 2.2 | 38.4 | 0.6 | 2.7 | 31.5 | 0.6 | 3.2 | 25.8 | 0.6 | 3.7 | 21.4 | 0.7 | 4.2 | 17.9 | 0.7 | 4.8 | 15.2 | 0.7 | 5.3 |
| 45 | 108.2 | 0.5 | 1.3 | 76.0 | 0.5 | 1.7 | 56.7 | 0.5 | 2.2 | 43.2 | 0.6 | 2.7 | 35.4 | 0.6 | 3.2 | 29.0 | 0.6 | 3.7 | 24.1 | 0.7 | 4.2 | 20.2 | 0.7 | 4.8 | 17.1 | 0.7 | 5.3 |
| 50 | 120.2 | 0.5 | 1.3 | 84.4 | 0.5 | 1.7 | 63.0 | 0.5 | 2.2 | 48.0 | 0.6 | 2.7 | 39.4 | 0.6 | 3.2 | 32.3 | 0.6 | 3.7 | 26.8 | 0.7 | 4.2 | 22.4 | 0.7 | 4.8 | 19.0 | 0.7 | 5.3 |
| 55 | 132.2 | 0.5 | 1.3 | 92.8 | 0.5 | 1.7 | 69.3 | 0.5 | 2.2 | 52.8 | 0.6 | 2.7 | 43.3 | 0.6 | 3.2 | 35.5 | 0.6 | 3.7 | 29.4 | 0.7 | 4.2 | 24.7 | 0.7 | 4.8 | 20.9 | 0.7 | 5.3 |
| 60 | 144.2 | 0.5 | 1.3 | 101.3 | 0.5 | 1.7 | 75.6 | 0.5 | 2.2 | 57.6 | 0.6 | 2.7 | 47.2 | 0.6 | 3.2 | 38.7 | 0.6 | 3.7 | 32.1 | 0.7 | 4.2 | 26.9 | 0.7 | 4.8 | 22.8 | 0.7 | 5.3 |
| 65 | 156.3 | 0.5 | 1.3 | 109.7 | 0.5 | 1.7 | 81.8 | 0.5 | 2.2 | 62.4 | 0.6 | 2.7 | 51.2 | 0.6 | 3.2 | 41.9 | 0.6 | 3.7 | 34.8 | 0.7 | 4.2 | 29.1 | 0.7 | 4.8 | 24.7 | 0.7 | 5.3 |
| 70 | 168.3 | 0.5 | 1.3 | 118.2 | 0.5 | 1.7 | 88.1 | 0.5 | 2.2 | 67.2 | 0.6 | 2.7 | 55.1 | 0.6 | 3.2 | 45.2 | 0.6 | 3.7 | 37.5 | 0.7 | 4.2 | 31.4 | 0.7 | 4.8 | 26.6 | 0.7 | 5.3 |
| 75 | 180.3 | 0.5 | 1.3 | 126.6 | 0.5 | 1.7 | 94.4 | 0.5 | 2.2 | 72.0 | 0.6 | 2.7 | 59.0 | 0.6 | 3.2 | 48.4 | 0.6 | 3.7 | 40.1 | 0.7 | 4.2 | 33.6 | 0.7 | 4.8 | 28.5 | 0.7 | 5.3 |
| 80 | 192.3 | 0.5 | 1.3 | 135.0 | 0.5 | 1.7 | 100.7 | 0.5 | 2.2 | 76.8 | 0.6 | 2.7 | 63.0 | 0.6 | 3.2 | 51.6 | 0.6 | 3.7 | 42.8 | 0.7 | 4.2 | 35.9 | 0.7 | 4.8 | 30.3 | 0.7 | 5.3 |
| 85 | 204.3 | 0.5 | 1.3 | 143.5 | 0.5 | 1.7 | 107.0 | 0.5 | 2.2 | 81.6 | 0.6 | 2.7 | 66.9 | 0.6 | 3.2 | 54.9 | 0.6 | 3.7 | 45.5 | 0.7 | 4.2 | 38.1 | 0.7 | 4.8 | 32.2 | 0.7 | 5.3 |
| 90 | 216.4 | 0.5 | 1.3 | 151.9 | 0.5 | 1.7 | 113.3 | 0.5 | 2.2 | 86.4 | 0.6 | 2.7 | 70.8 | 0.6 | 3.2 | 58.1 | 0.6 | 3.7 | 48.1 | 0.7 | 4.2 | 40.3 | 0.7 | 4.8 | 34.1 | 0.7 | 5.3 |
| 95 | 228.4 | 0.5 | 1.3 | 160.3 | 0.5 | 1.7 | 119.6 | 0.5 | 2.2 | 91.2 | 0.6 | 2.7 | 74.8 | 0.6 | 3.2 | 61.3 | 0.6 | 3.7 | 50.8 | 0.7 | 4.2 | 42.6 | 0.7 | 4.8 | 36.0 | 0.7 | 5.3 |
| 100 | 240.4 | 0.5 | 1.3 | 168.8 | 0.5 | 1.7 | 125.9 | 0.5 | 2.2 | 96.0 | 0.6 | 2.7 | 78.7 | 0.6 | 3.2 | 64.5 | 0.6 | 3.7 | 53.5 | 0.7 | 4.2 | 44.8 | 0.7 | 4.8 | 37.9 | 0.7 | 5.3 |
| 105 | 252.4 | 0.5 | 1.3 | 177.2 | 0.5 | 1.7 | 132.2 | 0.5 | 2.2 | 100.8 | 0.6 | 2.7 | 82.6 | 0.6 | 3.2 | 67.8 | 0.6 | 3.7 | 56.2 | 0.7 | 4.2 | 47.1 | 0.7 | 4.8 | 39.8 | 0.7 | 5.3 |
| 110 | 264.4 | 0.5 | 1.3 | 185.7 | 0.5 | 1.7 | 138.5 | 0.5 | 2.2 | 105.6 | 0.6 | 2.7 | 86.6 | 0.6 | 3.2 | 71.0 | 0.6 | 3.7 | 58.8 | 0.7 | 4.2 | 49.3 | 0.7 | 4.8 | 41.7 | 0.7 | 5.3 |
| 115 | 276.5 | 0.5 | 1.3 | 194.1 | 0.5 | 1.7 | 144.8 | 0.5 | 2.2 | 110.4 | 0.6 | 2.7 | 90.5 | 0.6 | 3.2 | 74.2 | 0.6 | 3.7 | 61.5 | 0.7 | 4.2 | 51.5 | 0.7 | 4.8 | 43.6 | 0.7 | 5.3 |
| 120 | 288.5 | 0.5 | 1.3 | 202.5 | 0.5 | 1.7 | 151.1 | 0.5 | 2.2 | 115.2 | 0.6 | 2.7 | 94.4 | 0.6 | 3.2 | 77.4 | 0.6 | 3.7 | 64.2 | 0.7 | 4.2 | 53.8 | 0.7 | 4.8 | 45.5 | 0.7 | 5.3 |
| 125 | 300.5 | 0.5 | 1.3 | 211.0 | 0.5 | 1.7 | 157.4 | 0.5 | 2.2 | 120.0 | 0.6 | 2.7 | 98.4 | 0.6 | 3.2 | 80.7 | 0.6 | 3.7 | 66.9 | 0.7 | 4.2 | 56.0 | 0.7 | 4.8 | 47.4 | 0.7 | 5.3 |
| 130 | 312.5 | 0.5 | 1.3 | 219.4 | 0.5 | 1.7 | 163.7 | 0.5 | 2.2 | 124.8 | 0.6 | 2.7 | 102.3 | 0.6 | 3.2 | 83.9 | 0.6 | 3.7 | 69.5 | 0.7 | 4.2 | 58.3 | 0.7 | 4.8 | 49.3 | 0.7 | 5.3 |
| 135 | 324.5 | 0.5 | 1.3 | 227.9 | 0.5 | 1.7 | 170.0 | 0.5 | 2.2 | 129.6 | 0.6 | 2.7 | 106.2 | 0.6 | 3.2 | 87.1 | 0.6 | 3.7 | 72.2 | 0.7 | 4.2 | 60.5 | 0.7 | 4.8 | 51.2 | 0.7 | 5.3 |
| 140 | 336.6 | 0.5 | 1.3 | 236.3 | 0.5 | 1.7 | 176.3 | 0.5 | 2.2 | 134.4 | 0.6 | 2.7 | 110.2 | 0.6 | 3.2 | 90.3 | 0.6 | 3.7 | 74.9 | 0.7 | 4.2 | 62.7 | 0.7 | 4.8 | 53.1 | 0.7 | 5.3 |
| 145 | 348.6 | 0.5 | 1.3 | 244.7 | 0.5 | 1.7 | 182.6 | 0.5 | 2.2 | 139.2 | 0.6 | 2.7 | 114.1 | 0.6 | 3.2 | 93.6 | 0.6 | 3.7 | 77.6 | 0.7 | 4.2 | 65.0 | 0.7 | 4.8 | 55.0 | 0.7 | 5.3 |
| 150 | 360.6 | 0.5 | 1.3 | 253.2 | 0.5 | 1.7 | 188.9 | 0.5 | 2.2 | 144.0 | 0.6 | 2.7 | 118.0 | 0.6 | 3.2 | 96.8 | 0.6 | 3.7 | 80.2 | 0.7 | 4.2 | 67.2 | 0.7 | 4.8 | 56.9 | 0.7 | 5.3 |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second

Depth "D" does not include allowance for freeboard or settlement

Table GS-4 Parabolic Grass Swale Design Sheet 14 of 14

**V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"**

**Grade 10.00 Percent**

| Q CFS | V1=2.0 | | | V1=2.5 | | | V1=3.0 | | | V1=3.5 | | | V1=4.0 | | | V1=4.5 | | | V1=5.0 | | | V1=5.5 | | | V1=6.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 | T | D | V2 |
| 5 | 13.3 | 0.4 | 1.3 | 9.4 | 0.5 | 1.7 | 6.8 | 0.5 | 2.2 | 5.3 | 0.5 | 2.6 | 4.1 | 0.6 | 3.2 | 3.4 | 0.6 | 3.6 | 2.6 | 0.7 | 4.1 | | | | | | |
| 10 | 26.6 | 0.4 | 1.3 | 18.7 | 0.5 | 1.7 | 13.8 | 0.5 | 2.2 | 10.9 | 0.5 | 2.6 | 8.5 | 0.6 | 3.2 | 7.1 | 0.6 | 3.6 | 5.9 | 0.6 | 4.1 | 4.9 | 0.7 | 4.7 | 4.0 | 0.7 | 5.3 |
| 15 | 39.9 | 0.4 | 1.3 | 28.0 | 0.5 | 1.7 | 20.7 | 0.5 | 2.2 | 16.3 | 0.5 | 2.6 | 12.8 | 0.6 | 3.2 | 10.9 | 0.6 | 3.6 | 9.0 | 0.6 | 4.1 | 7.5 | 0.6 | 4.7 | 6.3 | 0.7 | 5.2 |
| 20 | 53.2 | 0.4 | 1.3 | 37.4 | 0.5 | 1.7 | 27.6 | 0.5 | 2.2 | 21.7 | 0.5 | 2.7 | 17.0 | 0.6 | 3.2 | 14.5 | 0.6 | 3.6 | 12.1 | 0.6 | 4.1 | 10.2 | 0.6 | 4.6 | 8.5 | 0.7 | 5.2 |
| 25 | 66.5 | 0.4 | 1.3 | 46.7 | 0.5 | 1.7 | 34.5 | 0.5 | 2.2 | 27.1 | 0.5 | 2.7 | 21.3 | 0.6 | 3.2 | 18.1 | 0.6 | 3.6 | 15.1 | 0.6 | 4.1 | 12.7 | 0.6 | 4.7 | 10.8 | 0.7 | 5.2 |
| 30 | 79.8 | 0.4 | 1.3 | 56.1 | 0.5 | 1.7 | 41.4 | 0.5 | 2.2 | 32.5 | 0.5 | 2.7 | 25.5 | 0.6 | 3.2 | 21.7 | 0.6 | 3.6 | 18.1 | 0.6 | 4.1 | 15.2 | 0.6 | 4.7 | 12.9 | 0.7 | 5.2 |
| 35 | 93.1 | 0.4 | 1.3 | 65.4 | 0.5 | 1.7 | 48.3 | 0.5 | 2.2 | 37.9 | 0.5 | 2.7 | 29.8 | 0.6 | 3.2 | 25.3 | 0.6 | 3.6 | 21.1 | 0.6 | 4.1 | 17.8 | 0.6 | 4.7 | 15.1 | 0.7 | 5.2 |
| 40 | 106.4 | 0.4 | 1.3 | 74.7 | 0.5 | 1.7 | 55.2 | 0.5 | 2.2 | 43.3 | 0.5 | 2.7 | 34.0 | 0.6 | 3.2 | 29.0 | 0.6 | 3.6 | 24.1 | 0.6 | 4.1 | 20.3 | 0.6 | 4.7 | 17.2 | 0.7 | 5.2 |
| 45 | 119.7 | 0.4 | 1.3 | 84.1 | 0.5 | 1.7 | 62.1 | 0.5 | 2.2 | 48.8 | 0.5 | 2.7 | 38.3 | 0.6 | 3.2 | 32.6 | 0.6 | 3.6 | 27.2 | 0.6 | 4.1 | 22.8 | 0.6 | 4.7 | 19.4 | 0.7 | 5.2 |
| 50 | 133.0 | 0.4 | 1.3 | 93.4 | 0.5 | 1.7 | 69.0 | 0.5 | 2.2 | 54.2 | 0.5 | 2.7 | 42.5 | 0.6 | 3.2 | 36.2 | 0.6 | 3.6 | 30.2 | 0.6 | 4.1 | 25.4 | 0.6 | 4.7 | 21.5 | 0.7 | 5.2 |
| 55 | 146.3 | 0.4 | 1.3 | 102.8 | 0.5 | 1.7 | 75.9 | 0.5 | 2.2 | 59.6 | 0.5 | 2.7 | 46.8 | 0.6 | 3.2 | 39.8 | 0.6 | 3.6 | 33.2 | 0.6 | 4.1 | 27.9 | 0.6 | 4.7 | 23.7 | 0.7 | 5.2 |
| 60 | 159.6 | 0.4 | 1.3 | 112.1 | 0.5 | 1.7 | 82.8 | 0.5 | 2.2 | 65.0 | 0.5 | 2.7 | 51.0 | 0.6 | 3.2 | 43.4 | 0.6 | 3.6 | 36.2 | 0.6 | 4.1 | 30.5 | 0.6 | 4.7 | 25.9 | 0.7 | 5.2 |
| 65 | 172.9 | 0.4 | 1.3 | 121.4 | 0.5 | 1.7 | 89.7 | 0.5 | 2.2 | 70.4 | 0.5 | 2.7 | 55.3 | 0.6 | 3.2 | 47.1 | 0.6 | 3.6 | 39.2 | 0.6 | 4.1 | 33.0 | 0.6 | 4.7 | 28.0 | 0.7 | 5.2 |
| 70 | 186.2 | 0.4 | 1.3 | 130.8 | 0.5 | 1.7 | 96.6 | 0.5 | 2.2 | 75.8 | 0.5 | 2.7 | 59.5 | 0.6 | 3.2 | 50.7 | 0.6 | 3.6 | 42.2 | 0.6 | 4.1 | 35.5 | 0.6 | 4.7 | 30.2 | 0.7 | 5.2 |
| 75 | 199.5 | 0.4 | 1.3 | 140.1 | 0.5 | 1.7 | 103.5 | 0.5 | 2.2 | 81.2 | 0.5 | 2.7 | 63.8 | 0.6 | 3.2 | 54.3 | 0.6 | 3.6 | 45.2 | 0.6 | 4.1 | 38.1 | 0.6 | 4.7 | 32.3 | 0.7 | 5.2 |
| 80 | 212.8 | 0.4 | 1.3 | 149.5 | 0.5 | 1.7 | 110.5 | 0.5 | 2.2 | 86.7 | 0.5 | 2.7 | 68.0 | 0.6 | 3.2 | 57.9 | 0.6 | 3.6 | 48.3 | 0.6 | 4.1 | 40.6 | 0.6 | 4.7 | 34.5 | 0.7 | 5.2 |
| 85 | 226.1 | 0.4 | 1.3 | 158.8 | 0.5 | 1.7 | 117.4 | 0.5 | 2.2 | 92.1 | 0.5 | 2.7 | 72.3 | 0.6 | 3.2 | 61.5 | 0.6 | 3.6 | 51.3 | 0.6 | 4.1 | 43.1 | 0.6 | 4.7 | 36.6 | 0.7 | 5.2 |
| 90 | 239.4 | 0.4 | 1.3 | 168.1 | 0.5 | 1.7 | 124.3 | 0.5 | 2.2 | 97.5 | 0.5 | 2.7 | 76.5 | 0.6 | 3.2 | 65.2 | 0.6 | 3.6 | 54.3 | 0.6 | 4.1 | 45.7 | 0.6 | 4.7 | 38.8 | 0.7 | 5.2 |
| 95 | 252.7 | 0.4 | 1.3 | 177.5 | 0.5 | 1.7 | 131.2 | 0.5 | 2.2 | 102.9 | 0.5 | 2.7 | 80.8 | 0.6 | 3.2 | 68.8 | 0.6 | 3.6 | 57.3 | 0.6 | 4.1 | 48.2 | 0.6 | 4.7 | 40.9 | 0.7 | 5.2 |
| 100 | 266.0 | 0.4 | 1.3 | 186.8 | 0.5 | 1.7 | 138.1 | 0.5 | 2.2 | 108.3 | 0.5 | 2.7 | 85.0 | 0.6 | 3.2 | 72.4 | 0.6 | 3.6 | 60.3 | 0.6 | 4.1 | 50.7 | 0.6 | 4.7 | 43.1 | 0.7 | 5.2 |
| 105 | 279.3 | 0.4 | 1.3 | 196.2 | 0.5 | 1.7 | 145.0 | 0.5 | 2.2 | 113.7 | 0.5 | 2.7 | 89.3 | 0.6 | 3.2 | 76.0 | 0.6 | 3.6 | 63.3 | 0.6 | 4.1 | 53.3 | 0.6 | 4.7 | 45.2 | 0.7 | 5.2 |
| 110 | 292.6 | 0.4 | 1.3 | 205.5 | 0.5 | 1.7 | 151.9 | 0.5 | 2.2 | 119.2 | 0.5 | 2.7 | 93.5 | 0.6 | 3.2 | 79.6 | 0.6 | 3.6 | 66.4 | 0.6 | 4.1 | 55.8 | 0.6 | 4.7 | 47.4 | 0.7 | 5.2 |
| 115 | 305.9 | 0.4 | 1.3 | 214.9 | 0.5 | 1.7 | 158.8 | 0.5 | 2.2 | 124.6 | 0.5 | 2.7 | 97.8 | 0.6 | 3.2 | 83.3 | 0.6 | 3.6 | 69.4 | 0.6 | 4.1 | 58.3 | 0.6 | 4.7 | 49.5 | 0.7 | 5.3 |
| 120 | 319.2 | 0.4 | 1.3 | 224.2 | 0.5 | 1.7 | 165.7 | 0.5 | 2.2 | 130.0 | 0.5 | 2.7 | 102.0 | 0.6 | 3.2 | 86.9 | 0.6 | 3.6 | 72.4 | 0.6 | 4.1 | 60.9 | 0.6 | 4.7 | 51.7 | 0.7 | 5.3 |
| 125 | 332.5 | 0.4 | 1.3 | 233.5 | 0.5 | 1.7 | 172.6 | 0.5 | 2.2 | 135.4 | 0.5 | 2.7 | 106.3 | 0.6 | 3.2 | 90.5 | 0.6 | 3.6 | 75.4 | 0.6 | 4.1 | 63.4 | 0.6 | 4.7 | 53.8 | 0.7 | 5.3 |
| 130 | 345.8 | 0.4 | 1.3 | 242.9 | 0.5 | 1.7 | 179.5 | 0.5 | 2.2 | 140.8 | 0.5 | 2.7 | 110.5 | 0.6 | 3.2 | 94.1 | 0.6 | 3.6 | 78.4 | 0.6 | 4.1 | 66.0 | 0.6 | 4.7 | 56.0 | 0.7 | 5.3 |
| 135 | 359.1 | 0.4 | 1.3 | 252.2 | 0.5 | 1.7 | 186.4 | 0.5 | 2.2 | 146.2 | 0.5 | 2.7 | 114.8 | 0.6 | 3.2 | 97.7 | 0.6 | 3.6 | 81.4 | 0.6 | 4.1 | 68.5 | 0.6 | 4.7 | 58.1 | 0.7 | 5.3 |
| 140 | 372.4 | 0.4 | 1.3 | 261.6 | 0.5 | 1.7 | 193.3 | 0.5 | 2.2 | 151.7 | 0.5 | 2.7 | 119.0 | 0.6 | 3.2 | 101.3 | 0.6 | 3.6 | 84.4 | 0.6 | 4.1 | 71.0 | 0.6 | 4.7 | 60.3 | 0.7 | 5.3 |
| 145 | 385.7 | 0.4 | 1.3 | 270.9 | 0.5 | 1.7 | 200.2 | 0.5 | 2.2 | 157.1 | 0.5 | 2.7 | 123.3 | 0.6 | 3.2 | 105.0 | 0.6 | 3.6 | 87.5 | 0.6 | 4.1 | 73.6 | 0.6 | 4.7 | 62.5 | 0.7 | 5.3 |
| 150 | 399.0 | 0.4 | 1.3 | 280.2 | 0.5 | 1.7 | 207.1 | 0.5 | 2.2 | 162.5 | 0.5 | 2.7 | 127.5 | 0.6 | 3.2 | 108.6 | 0.6 | 3.6 | 90.5 | 0.6 | 4.1 | 76.1 | 0.6 | 4.7 | 64.6 | 0.7 | 5.3 |

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

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# Filter Strip (FS)

## Practice Description

A filter strip is a wide belt of vegetation designed to provide infiltration, intercept sediment and other pollutants, and reduce stormwater flow and velocity. Filter strips are similar to grassed swales except that they are designed to intercept overland sheet flow (not channel flow). They cannot treat high velocity flows. Surface runoff must be evenly distributed across the filter strip. Vegetation may consist of existing cover that is preserved and protected or be planted to establish the strip. Once a concentrated flow channel forms in the filter strip, the filter strip is no longer effective. This practice applies on construction sites and other disturbed areas.

## Planning Considerations

Filter strips provide their maximum benefit when established as early as possible after disturbances begin. This concept should receive strong consideration during the scheduling of practices to be installed. In some instances, the existing vegetation may be preserved to serve as a filter strip.

Filter strips should be strategically located on the contour to reduce runoff, and increase infiltration. They should be situated downslope from the disturbed site and where runoff water enters environmentally sensitive areas.

Overland flow entering filter strips should be primarily sheet flow. All concentrated flow should be dispersed prior to entering the filter strip.

Flow length should be based on slope percent and length, predicted amount and particle size distribution of sediment delivered to the filter strip, density and height of the filter strip vegetation, and runoff volume.

The slope of the drainage area above a filter strip should be greater than 1% but less than 10%. The ratio of the drainage area to the filter strip area should be less than 10:1. The minimum width of an effective filter strip is 15 feet.

Existing vegetation may be used if it meets stand density and height requirements and has uniform flow through the existing vegetation. The existing vegetation strip must be on a contour to be effective.

Site preparation for filter strips requires that the filter strip be placed on the contour. Variation in placement on the contour should not exceed a 0.5% longitudinal (perpendicular to the flow length) gradient.

All soil amendments should be applied according to a soil test recommendation for the planned vegetation.

The vegetation for filter strips must be permanent herbaceous vegetation of a single species or a mixture of grasses or legumes, which have stiff stems and a high stem density near the ground surface. Stem density should be such that the stem spacing does not exceed 1".

## Design Criteria

### *Installation (preservation of existing vegetation)*

Designate the areas for preserving vegetation on the design plan map.

Indicate in the plan that the designated areas will be fenced or flagged and will not be disturbed. This includes avoiding surface disturbances that affect sheet flow of stormwater runoff and not storing debris from clearing and grubbing, and other construction waste material in the filter strips during construction.

### *Installation (planting)*

*Site Preparation*
If the upper edge of the filter strip does not have a level edge, remove any obstructions and grade the upper edge of the filter strip so that runoff evenly enters the filter strip.
Fill and smooth any rills and gullies that exist over the filter strip area to ensure that overland flow will discharge across the filter strip along a smooth surface

*Seedbed Preparation*
Grade and loosen soil to a smooth firm surface to enhance rooting of seedlings and reduce rill erosion. If existing, break up large clods and loosen compacted, hard or crusted soil surfaces with a disk, ripper, chisel, harrow or other tillage equipment. Avoid preparing the seedbed under excessively wet conditions.

For broadcast seeding and drilling, tillage should adequately loosen the soil to a depth of at least 6", alleviate compaction, and smooth and firm the soil for the proper placement of seed.

For no-till drilling, the soil surface does not need to be loosened unless the site has surface compaction. If compaction exists, the area should be chiseled across the slope to a depth of at least 6".

### *Applying Soil Amendments*

*Liming*
Follow soil test recommendation. If a soil test is not available, use 2 tons/acre of ground agricultural lime on clayey soils (approximately 90 lbs/1000 $ft^2$) and 1 ton/acre on sandy soils (approximately 45 lbs/1000 $ft^2$). Exception: If the cover is tall fescue and clover, use the 2 tons/acre rate (90 lbs/1000 $ft^2$) on both clayey and sandy soils.

Spread the specified amount of lime and incorporate into the top 6" of soil after applying fertilizer.

*Fertilizing*
Apply fertilizer at rates specified in the soil test recommendation. In the absence of soil tests, use the following as a guide:

Grass alone: 8-24-24 or equivalent - 400 lbs/acre (9.2 lbs/1000 $ft^2$). When vegetation has emerged to a stand and is growing, 30 to 40 lbs/acre (0.8 lb/1000 $ft^2$) of additional nitrogen fertilizer should be applied.

Grass-Legume Mixture: 8-24-24 or equivalent-400 lbs/acre (9.2 lbs/1000 $ft^2$). When vegetation has emerged to a stand and is growing, 30 to 40 lbs (0.8 lb/1000 $ft^2$) of additional nitrogen fertilizer should be applied.

Legume alone: 0-20-20 or equivalent-500 lbs/acre (11.5 lbs/1000 $ft^2$).

Incorporate lime and fertilizer to a minimum depth of at least 6" or more by disking or chiseling on slopes of up to 3:1.

### *Planting*

Select adapted species from Figure FS-1 and Table FS-1.

Apply seed uniformly using a cyclone seeder, drill seeder, cultipacker seeder or hydroseeder.

When using a drill seeder, plant grasses and legumes ¼" to ½" deep. Calibrate equipment in the field.

When planting by methods other than a drill seeder or hydroseeder, cover seed by raking, or dragging a chain, brush or mat. Then firm the soil lightly with a roller. Seed can also be covered with hydro-mulched wood fiber and tackifier. Legumes

require inoculation with nitrogen-fixing bacteria to ensure good growth. Purchase inoculum specific for the seed and mix with seed prior to planting.

Table FS-1 Commonly Used Plants for Permanent Cover

| Species | Seeding Rates/Ac PLS[1] | North | Central | South |
|---|---|---|---|---|
| | | Seeding Dates | | |
| **Bahiagrass, Pensacola** | 40 lbs | -- | Mar 1-July 1 | Feb 1-Nov 1[1] |
| **Bermudagrass, Common** | 10 lbs | Apr 1-July 1 | Mar 15-July 15 | Mar 1-July 15 |
| **Bahiagrass, Pensacola Bermudagrass, Common** | 30 lbs 5 lbs | -- | Mar 1-July 1 | Mar 1-July 15 |
| **Bermudagrass, Hybrid (Lawn Types)** | Solid Sod | Anytime | Anytime | Anytime |
| **Bermudagrass, Hybrid (Lawn Types)** | Sprigs 1/sq ft | Mar 1-Aug 1 | Mar 1-Aug 1 | Feb 15 - Sep 1 |
| **Fescue, Tall** | 40-50 lbs | Sep 1-Nov 1 | Sep 1-Nov 1 | -- |
| **Sericea** | 40-60 lbs | Mar 15-July 15 | Mar 1-July 15 | Feb 15 -July 15 |
| **Sericea & Common Bermundagrass** | 40 lbs 10 lbs | Mar 15 -July 15 | Mar 1-July 15 | Feb 15-July 15 |
| **Switchgrass, Alamo** | 4 lbs | Apr 1-Jun 15 | Mar 15-Jun 15 | Mar 15-Jun 15 |

[1] PLS means pure live seed and is used to adjust seeding rates. For example, to plant 10 lbs of a species with germination of 80% and with purity of 90%, PLS = 0.8 x 0.9 = 72%, 10 PLS = 10/0.72 = 13.9 lbs

[2] A late fall planting of Bahiagrass should include 45 lbs./ac. of small grain to provide cover during winter months.

*Mulching*

Cover approximately 75% of the surface with the specified mulch materials. Crimp, tack or tie down straw mulch with netting. Mulching is extremely important for successful seeding (See Mulching practice for more details).

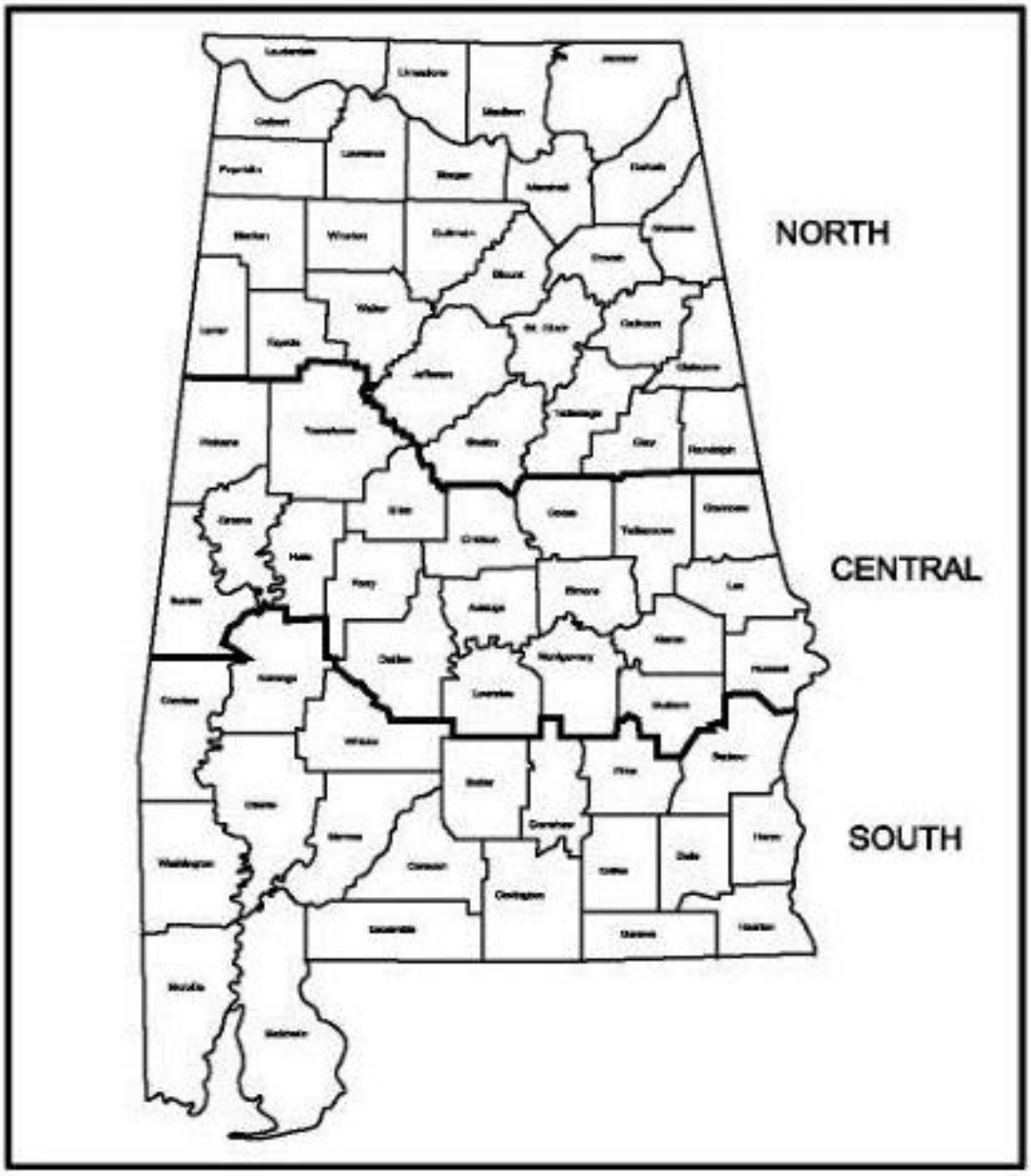


Figure FS-1 Geographical Areas for Species Adaptation and Seeding Dates

*Note: Site conditions related to soils and aspect in counties adjacent or close to county boundaries may justify adjustments in planting dates by qualified design professionals.*

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# Sediment Barrier (SB)

## Practice Description

A sediment barrier is a temporary structure used across a landscape mostly on the contour to reduce the quantity of sediment that is moving downslope. The most commonly used barrier is a silt fence (a geotextile fabric that is trenched into the ground and attached to supporting posts and possibly reinforced with a wire fence or polypropylene netting). Other barrier materials could include sand bags, wattles, and various man-made materials and devices that can be used in a similar manner as a silt fence.

This practice applies where sheet and rill erosion occurs on small disturbed areas. Barriers intercept runoff from upslope to form ponds that temporarily store runoff and allow sediment to settle out of the water and remain on the construction site.

## Planning Considerations

Sediment barriers may be used on developing sites. It is important that they be installed on the contour so that flow will not concentrate and cause overtopping due to lack of storage capacity. It is also important that the ends of sediment barriers are turned upslope to prevent runoff from bypass around the ends of the barrier. Prevention of scouring, erosion, and undermining at and under sediment barriers is also of upmost importance to ensure maximum impoundment capabilities.

The most commonly used sediment barriers are silt fences and manufactured sediment logs (often referred to as wattles or sediment retention fiber rolls). Manufactured sediment logs should be installed according to manufacturer's recommendations.

The success of silt fences depends on a proper installation (on the contour with each end turned up slope) that causes the fence to develop maximum efficiency of sediment trapping. Silt fences should be carefully installed to meet the intended purpose. Silt fences are effective at trapping coarse sediment but do not effectively reduce turbidity as water passes through the geotextile fabric.

A silt fence is specifically designed to retain sediment transported by sheet flow from disturbed areas, while allowing water to pass through the fence. Water flow through the silt fence often decreases over time as silts and trash "blind" or seal the geotextile fabric. Silt fences should be installed to be stable under the flows expected from the site. Generally, silt fences should not be installed across streams, ditches, waterways, or other concentrated flow areas. When properly designed and installed, silt fence can be used as a Check Dam (See Check Dam).

Silt fences are composed of geotextile (i.e., woven and non-woven) supported between steel or wooden posts. Silt fences are commercially available with geotextile attached to the post and can be rolled out and installed by driving the post into the ground. This type of silt fence is simple to install, but more expensive than some other installations. Silt fences must be trenched in at the bottom to prevent runoff from undermining the fence and developing rills under the fence. Locations with high runoff flows or velocities should use either a wire or polypropylene net reinforcement. In addition, decreasing the spacing between support posts will improve the structural integrity of the silt fence in these areas.

Design professionals should consider specifying an "off-set" trench installation. This involves a conventional 6 in. x 6 in. trench to bury the geotextile with the posts and wire installed 6 in. downslope of the trench. The wire is on top of the ground surface and not in a trench. This installation has proven to have less potential for undermining than any installation tested at the Auburn University Erosion and Sediment Control Test Facility.

A rather recent innovation that is still being tested and refined is referred to as a "sediment retention barrier with flocculant." It is used to introduce flocculant to turbid runoff causing flocculation. A sediment retention barrier should only be used in conjunction with effective erosion and sediment control practices upstream that have removed sediment and turbidity as much as possible without chemical additive. The measure consists of a double row of netting on the contour that allows runoff to easily pass through. Material such as jute is secured to the ground between the rows of netting and adjacent to the downslope row. Loose straw is placed between the rows (see Figure SB-1). An approved flocculant powder is added at a designed rate to all the jute and in layers within the straw. The measure is located upstream of sediment control (sediment basin, sediment trap, or sediment barrier) which will pond, allow for flocs to settle, and capture flocs prior to runoff leaving the site. Design professionals should get details needed to design this measure from a research professional or a qualified industry representative.

Figure SB-1 Sediment Retention Barrier

## Design Criteria (for silt fence)

Silt fence installations are normally limited to situations in which only sheet or overland flow is expected because the practice cannot pass the volumes of water generated by channelized flows. Silt fences are normally constructed of synthetic fabric (geotextile) and the life is expected to be the duration of most construction projects. Silt fence geotextile should conform to the property requirements found in AASHTO M288 shown in Table SB-1 as follows:

Table SB-1 Silt Fence Geotextile Fabric Requirements per AASHTO M288

| Requirement | Test Methods | Units | Type A supported fence | Type B unsupported fence |
|---|---|---|---|---|
| Grab Strength | ASTM | | | |
| Machine Direction | D4632/D4632M | N | 400 | 550 |
| X-Machine Direction | | | 400 | 450 |
| Permittivity | ASTM D4491 | $sec^{-1}$ | 0.05 | 0.05 |
| Apparent Opening Size | ASTM D4751 | mm | 0.60 max avg roll value | 0.60 max avg roll value |
| Ultraviolet stability (retained strength) | ASTM D4355/4355M | % | 70% after 500 h of exposure | 70% after 500 h of exposure |

Note: ALDOT has an approved products list for geotextile

The drainage area behind the silt fence should not exceed ¼ acre per 100 linear feet of silt fence for non-reinforced fence and ½ acre per 100 feet of reinforced silt fence. When all runoff from the drainage area is to be stored behind the fence (i.e. there is no stormwater disposal system in place) the maximum slope length behind the fence should not exceed those shown in Table SB-2.

Table SB-2 Slope Limitations for Silt Fence

| Land Slope (Percent) | Maximum Slope Length Above Fence (Feet) |
|---|---|
| <2 | 100 |
| 2 to 5 | 75 |
| 5 to 10 | 50 |
| 10 to 20* | 25 |
| >20 | 15 |

*In areas where the slope is greater than 10%, a flat area length of 10 feet between the toe of the slope to the fence should be provided.

*Type A Silt Fence*

Type A fence shall be a minimum of 24" and not more than 32" above ground with wire reinforcements and is used on sites needing the highest degree of protection by a silt fence. The wire reinforcement is necessary because this type of silt fence is used for the highest flow situations and has almost 3 times the flow rate as Type B silt fence. Wire fence should be made of 14-gauge wire with 6 in. x 6 in. openings (Note: ALDOT wire spacing may differ). Type A silt fence should be used where runoff flows or velocities are particularly high or where slopes exceed a vertical height of 10 feet. Staked tie backs on each end of a Type A silt fence may be necessary to prevent overturning. Tie backs should also be used at points of possible concentration and overtopping if site conditions do not allow for the silt fence to be installed on the contour.

Provide a riprap splash pad with a geotextile underlay or other outlet protection device for any point where flow may overtop the silt fence.

The silt fence should be installed as shown in Figure SB-2. Maximum post spacing is 10 ft. In situations where runoff flows parallel with the silt fence when in perimeter control applications, 10 ft. spacing is adequate. J-hooks should also be considered for long parallel flow scenarios to slow flow velocity and create areas of impoundments, thereby reducing scour potential under the silt fence. For the portion of the silt fence that creates the J-hook impoundment area, the post spacing should be reduced to 5 ft. to support the hydrostatic loads. For all installations that intercept flow perpendicularly to the slope causing a concentrated impoundment, the maximum post spacing should be reduced to 5 ft. Materials for posts, post size, and fasteners are shown in Tables SB-3 and SB-4. Do not use "light weight" steel posts commonly found at building supply stores. Details for overlap of Type A silt fence is available from The Alabama Department of Transportation construction drawings.

Geotextile silt fence material should be looped over each post and the top of the wire to prevent sagging. A "hog ring" attachment should be made each 2 feet along the top of the wire.

Table SB-3 Post Size for Silt Fence

| | Minimum Length | Type of Post | Size of Post |
|---|---|---|---|
| **Type A** | 5' | Steel "T" Post | 1.25 lb./ft. min. |
| **Type B** | 4' | Soft Wood<br>Oak<br>Steel | 3" diameter or 2X4<br>1.5" X 1.5"<br>1.25 lb./ft. min. |

Table SB-4 Wood Post Fasteners for Silt Fence

| | Gauge | Crown | Legs | Staples/Post |
|---|---|---|---|---|
| **Wire Staples** | 17 min. | ¾" wide | ½" long | 5 min. |
| | **Gauge** | **Length** | **Button Heads** | **Nail/Post** |
| **Nails** | 14 min. | 1" | ¾" long | 4 min. |

*Type B Silt Fence*

This 36" wide geotextile fabric should be used on developments where the life of the project is short (6 months or less) and there is less need for protection from a silt fence.

The silt fence should be installed as shown in Figure SB-3. Post spacing is either 4 ft. or 6 ft. based on geotextile elongation % (see note on Figure SB-3). Materials for posts and fasteners are shown in Tables SB-3 and SB-4. Details for overlap of the silt fence and fastener placement are shown in Figure SB-4.

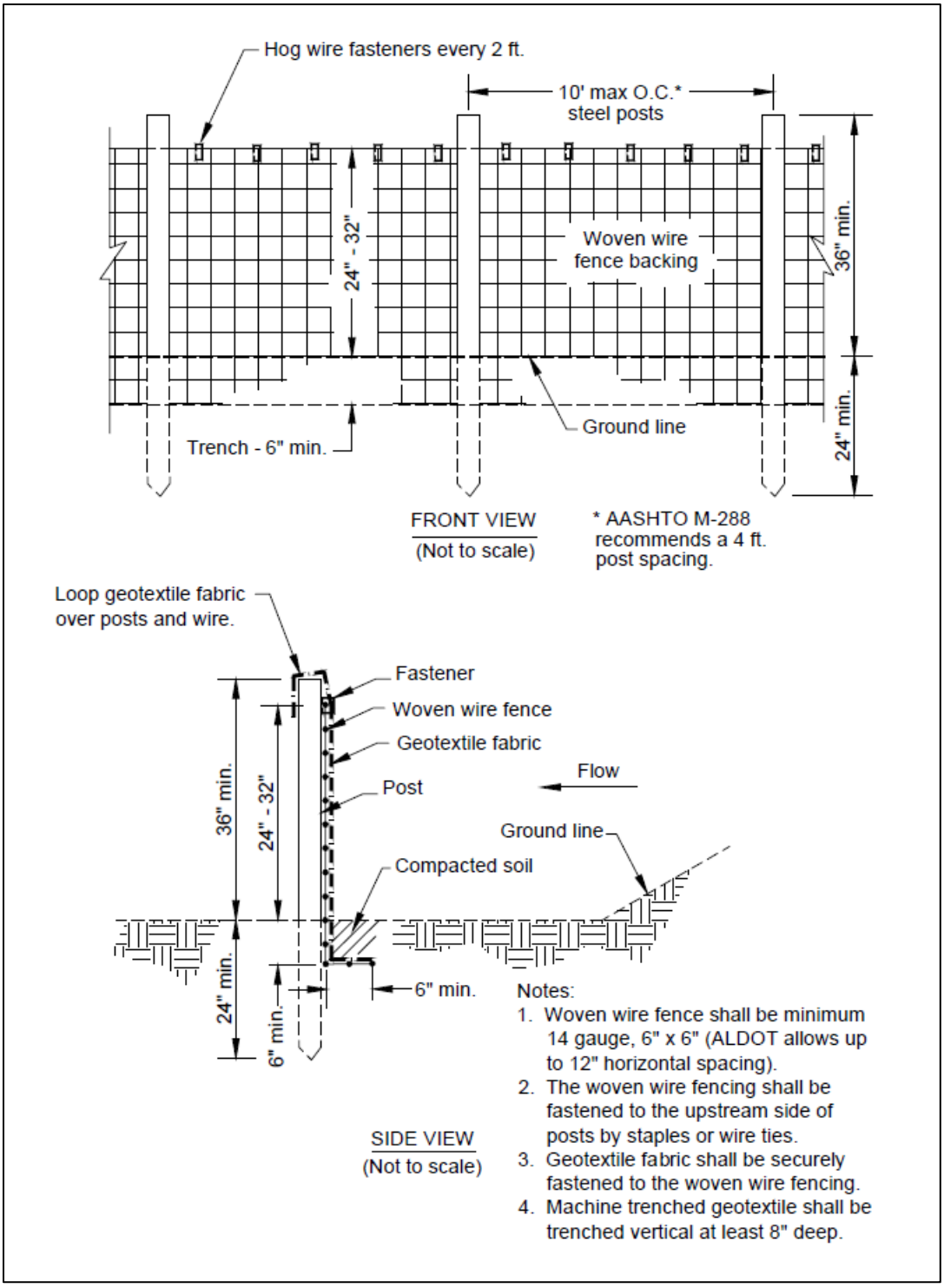


Figure SB-2 Silt Fence-Type A
(For post material requirements see Tables SB-3 and SB-4)

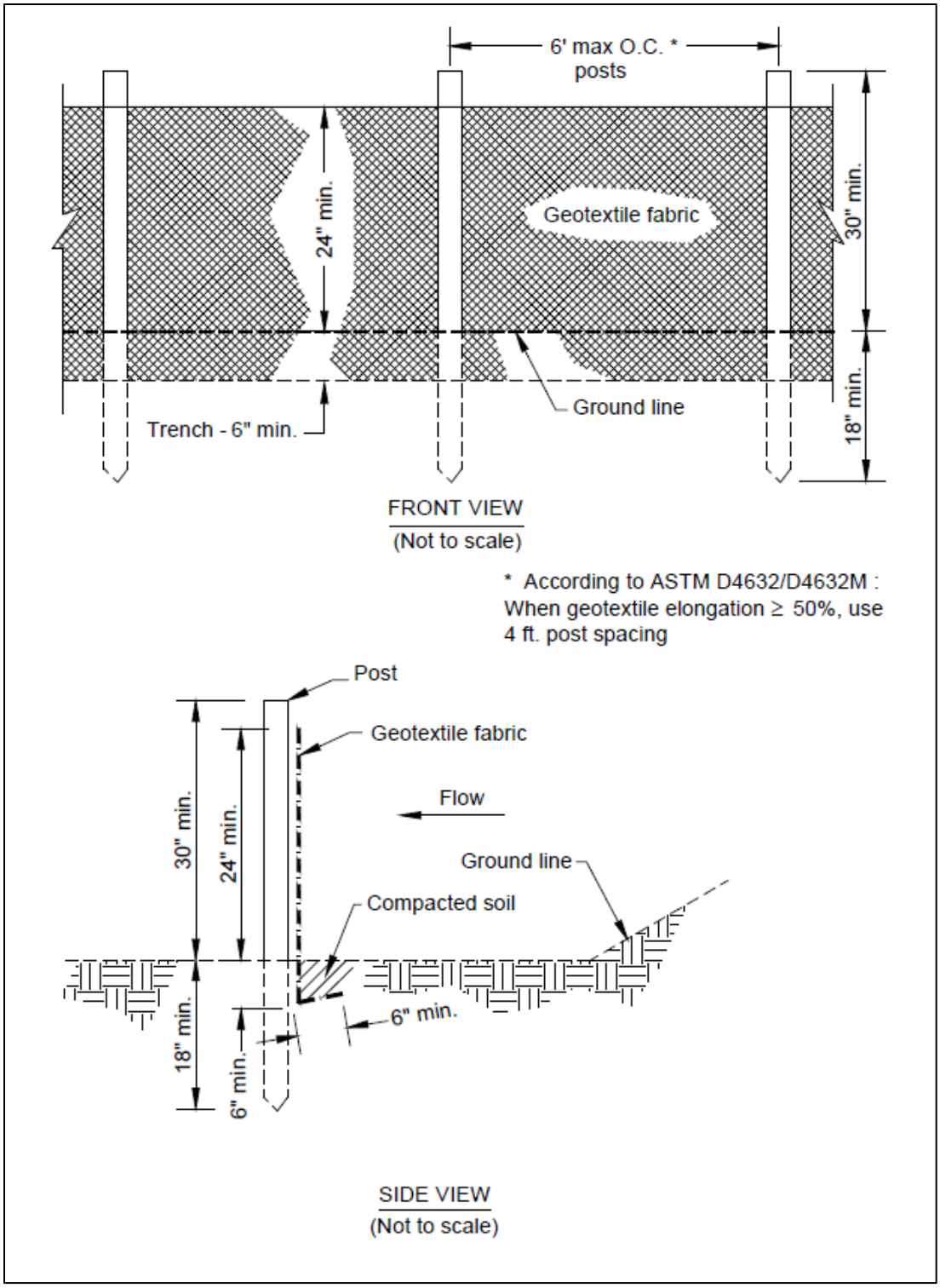


Figure SB-3 Silt Fence - Type B

(1) For post material requirements see Tables SB-3 and SB-4

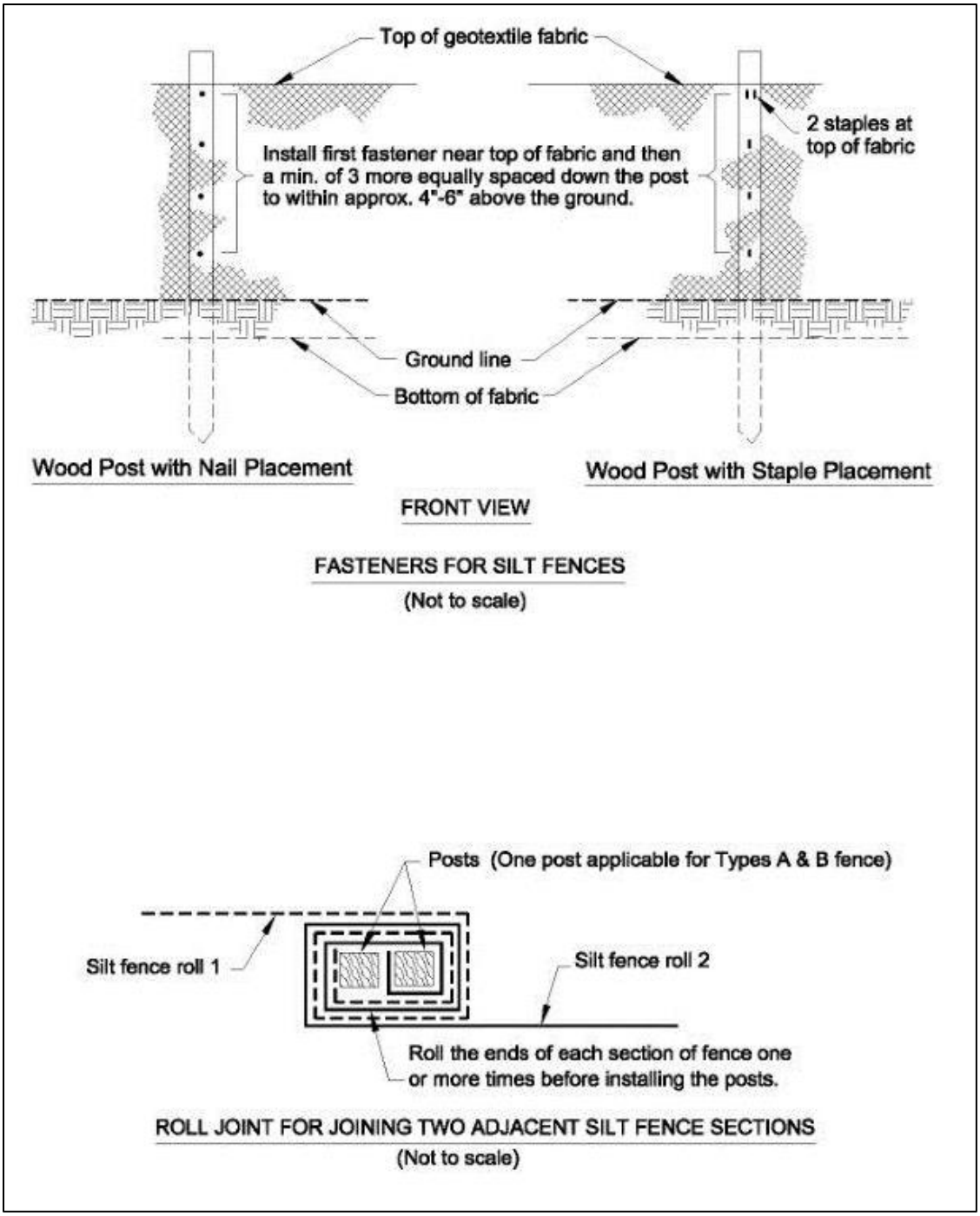


Figure SB-4 Silt Fence Installation Details

# Sediment Trap (ST)

## Practice Description

A sediment trap is a temporary catch basin used for intercepting and detaining small amounts of sediment to prevent it from leaving the construction site. This practice applies within disturbed areas with very small drainage basins that are subject to sheet erosion or in minor swales. Various materials may be used for sediment traps and include straw bales, sand bags, wattles, and various man-made materials and devices.

## Planning Considerations

*Note: Straw bales are the only sediment trap material covered in this handbook.*

In certain situations, straw bales can be used as an alternative to silt fence for trapping sediment. The practice should only be used to trap sediment for a short duration from very small drainage areas. Straw bales comparatively low flow rate should be considered before choosing to use this practice. Ponding above the bales can occur rapidly due to the low flow rate. Overtopping and bypass of the bales can cause significant damage to the site. Additional measures should be used if turbidity leaving the site served by this practice is an issue.

## Design Criteria

*Drainage Area*

For disturbed areas subject to sheet erosion the drainage area should be restricted to ¼ acre per 100 feet of trap. The slope length behind the trap should be restricted according to Table ST-1.

Table ST-1 Criteria for Straw or Hay Bale Placement

| Land Slope (Percent) | Maximum Slope Length Above Bale (Feet) |
|---|---|
| **<2** | 75 |
| **2 to 5** | 50 |
| **5 to 10** | 35 |
| **10 to 20** | 20 |
| **>20** | 10 |

*Bale Size*

Bales should be 14” x 18” x 36”.

*Anchors*

Two 36” long (minimum) 2” x 2” hardwood stakes should be driven through each bale after the bales are properly entranced. Alternate anchors can be 2 pieces of no.4 steel rebar, 36” long (minimum). See Figure ST-1 for details on proper installation of straw bales.

*Effective Life*

Straw and hay bales have a relatively short period of usefulness and should not be used if the project duration is expected to exceed 3 months. Bale placement should result in the twine or cord being on the side and not the bottom of the bale.

*Location*

This practice should be used on nearly level ground and be placed at least 10 feet from the toe of any slope. The barrier should follow the land contour. The practice should never be used in live streams or in swales where there is a possibility of washout. The practice should also not be used in areas where rock or hard surfaces prevent the full and uniform anchoring of the bales.

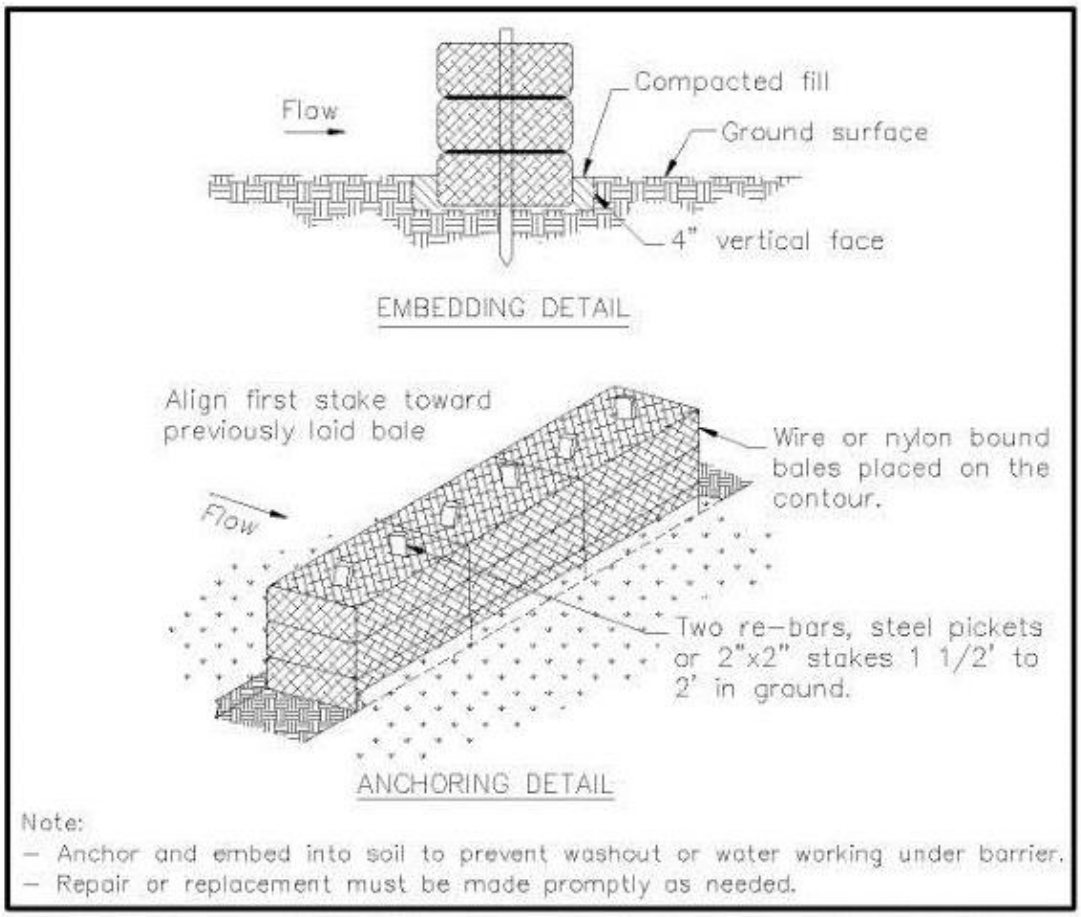


Figure ST-1 Anchoring Technique for Straw Bales

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# ATTACHMENT G-4

# CONSTRUCTION ACTIVITY LOG SHEETS

- Corrective Action Log
- Construction Best Management Practices Plan Amendment Log
- Grading and Stabilization Activities Log
- Rainfall Documentation and Observations Log
- Construction Stormwater Inspection Report and BMP Certification
- Construction Stormwater Noncompliance Notification Report

## *Corrective Action Log*

Project Name: Corrective Measures Implementation RSA-122/183, Former Lewisite Manufacturing Plants, Operable Units 5 and 6
CBMPP Contact:

| Inspection Date | Inspector Name(s) | Description of BMP Deficiency | Corrective Action Needed (including planned date/responsible person) | Date Action Taken/Responsible person |
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## *CBMPP Amendment Log*

Project Name: Corrective Measures Implementation RSA-122/183, Former Lewisite Manufacturing Plants, Operable Units 5 and 6
CBMPP Contact:

| Amendment No. | Description of Amendment | Date of Amendment | Amendment Prepared by [Name(s) and Title] |
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## *Grading and Stabilization Activities Log*

Project Name: Corrective Measures Implementation RSA-122/183, Former Lewisite Manufacturing Plants, Operable Units 5 and 6
CBMPP Contact:

| Date Grading Activity Initiated | Description of Grading Activity | Date Grading Activity Ceased (Indicate Temporary or Permanent) | Date When Stabilization Measures are Initiated | Description of Stabilization Measure(s) and Location(s) |
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