ARIZONA NEMO

Arid Southwest Best Management Practices (BMPs) For the Control of Nonpoint Source Pollution

A Manual for Land Use Decision Makers

Water Resources Research Center

ADEQ Arizona Department of Environmental Quality

The University of Arizona. Arizona's First University.

Arizona Cooperative Extension

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Community volunteers implementing BMP
Photo courtesy of ADEQ Streambank Plan

www.ArizonaNEMO.com

Written and prepared by:
Steven S. Amesbury, Jonathan Burnett, Carie Deatherage, Renee Johns, Channah Rock, Terry Spouse, James C. Summerset, and Kristine Uhlman.
University of Arizona
Tucson, Arizona
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Water Resources Research Center
University of Arizona
350 N. Campbell Avenue
Tucson, Arizona 85721
www.cals.arizona.edu/azwater

Implementation of BMP
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Community volunteers evaluating BMP
Photo courtesy of AWPF Grant Projects

Statement of Purpose

This document is an introduction for the general public, land owners and policy makers, to learn practical techniques, referred to as "Best Management Practices" (BMP). These practices will help you control and protect your local water resources from "nonpoint source" pollution.

You will become acquainted with pollutants such as metals, sedimentation, nutrients and pathogens that are common constituents of nonpoint pollution in the "Arid Southwest". You will come to understand how these pollutants could have a negative impact on water quality in your communities which could lead to the violation of the Clean Water Act as enforced by the Environmental Protection Agency (EPA); as well as, jeopardize the economic stability of land productivity and the health of livestock.

This document will list and describe Best Management Practices suitable to control nonpoint source pollutants, based on land use classification, load reduction mechanisms and desired benefits. It will guide you through the steps to:

- Determine the source of the pollution problem;
- Select a solution;
- Prepare for implementation of the BMPs;
- Implementation of the BMPs;
- Monitor your project(s);
- Evaluating the performance of your project(s); and
- Identify post BMP installation adaptive management options.

You will be provided, as well, with web site links and other of sources of information to further assist you with your project(s).

The goal is to equip you with the technical tools necessary to control and protect your precious water resources from the negative impacts of nonpoint source pollution. If not protected, the contamination of these resources could jeopardize the economic sustainability of land productivity and the health and safety of our drinking water.

Arizona NEMO is integrating watershed management and planning emphasizing the linkages between water supply and water quality with research-based, professional education engaging stakeholders to foster better land-use decisions and protect our water resources. For more information visit NEMO's website at: www.ArizonaNEMO.com.

Index: Best Management Practices in Alphabetical Order

*Engineering level is explained in section 2.5 (table 1) on pages 14-16

Chapter 1: Introduction – Nonpoint Source Pollution in Arizona

1.1 Nonpoint Source Pollution

In order to maintain a high standard of water quality in the Arid Southwest, water must be analyzed for chemical, biological and physical characteristics, and not just judged by its taste, odor or clarity. Although these terms are adequate for a "good or bad" standard, they fall far short of distinguishing quality standard drinking water from good recreational swimming and fishing water. This is due in large part to the increased impact of "Nonpoint Source" pollution (NPS); NPS is pollution that has no single point of origin but is an accumulative source that is derived from the many dispersed areas and activities of our daily lives **(**pollutants are byproducts of natural and human-created activities). Unlike "point source" pollution that is from a single identifiable source, such as a sewage discharge pipe which is "permit" regulated by the National Pollutant Discharge Elimination System (NPDES) and by Arizona Pollutant Discharge Elimination System (AZPDES) on a state level. NPS pollution comes from many diffused sources, and is frequently carried by winds, rains and snowmelt runoff over and through the ground and deposited into your lakes, rivers, wetlands, and even to underground sources of drinking water. These pollutants include (but not limited to):

Flowing stream in the Agua Fria watershed
Photo courtesy of NEMO

• Excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas;

• Oil, grease, and toxic chemicals from urban runoff and energy production;

• Sediment from improperly managed construction sites, crop and forest lands, and eroding stream banks;

• Salt from irrigation practices;

• Metals from acid drainage from abandoned mines; and,

• Bacteria and nutrients from livestock, pet wastes, and faulty septic systems.

Every two years, the Arizona Department of Environmental Quality (ADEQ) provides a comprehensive report on the status of surface water quality that identifies impaired waters and pollutants causing impairments to fulfill the requirements of Clean Water Act sections 305(b) and 303(d). The most current report can be downloaded from the ADEQ website at: www.azdeq.gov/environ/water/assessment/assess.html .

The ADEQ ambient ground water basin reports can also be downloaded from their website at: www.azdeq.gov/environ/water/assessment/ambient.html#studies.

In Arizona the pollutants most likely to be causing impairment to its streams are: metals, suspended sediment, nutrients and pathogens. In lakes, two pollutant groups are of major concern: nutrients and mercury. Ground water pollutants can be contributed to the following categories:

1) Natural deposition: arsenic, fluoride, radio-chemicals, and total dissolved solids (TDS)

2) Agriculture crop production and animal feeding operations: nitrates, bacteria and TDS;

3) Septic systems when inadequate: nitrate and bacteria;

4) Commercial and industry users of solvents: volatile organic compounds (VOCs);

5) Underground storage facilities (e.g. gas stations): Petroleum products; and

6) Mining metals: sulfate, radio-chemicals, metals and TDS.

Livestock in stream

Photo courtesy of ADEQ Streambank

Road crossing stream

Photo courtesy of ADEQ NPS

Volunteers removing trash from desert

Potential groundwater contamination is generally controlled through ADEQ's Aquifer Protection Permit requirements which requires anyone owning or operating a facility that discharges a pollutant directly to an aquifer, to the land surface, or to the vadose zone (the area between an aquifer and the land surface) in such a manner that there is a *"reasonable probability"* that the pollutant will reach an aquifer. Facilities that meet this characterization must obtain an Aquifer Protection Permit (A.R.S. R18-9-101 through

403). For more information on permit requirements http://www.azdeq.gov/environ/water/permits/app.html.

In Arizona and nationally, surface water quality assessments have demonstrated that most water quality impairments are due to pollutant loadings from NPS. These pollutants if not controlled, will contaminate your water resources to the point that they will jeopardize the economic stability of your farm land productivity and health of your ranch livestock, as well as the domestic health and safety of your drinking waters.

1.2 Land Uses – Major Contributors of NPS

In the State of Arizona, land use is the major contributor to NPS; some of those uses are farming, ranching, abandon mines, and urban (impervious surface) runoff.

Farming:

There are more than one million acres of land devoted to agriculture in the state. The heavy use of nutrient fertilizers (nitrogen and phosphorus) in farming contributes to the growth of algae and pathogenic organisms in water bodies. Irrigation of agriculture is the largest consumer of water in the state, and the negative impacts appear in the form of salinization of soil and water "consumptive" use (a term used for water which is lost after its use, rather than immediately returned to its source for reuse). In Arizona, the salinization of soil as well as both ground and surface waters is made worse when water used in flood irrigation evaporates and increases the concentration of salt. Salinization of soil is detrimental because it causes habitat degradation, depressed populations of native plants and animals, and desertification when salinity becomes too great. Some surface waters and groundwaters of the Southwest are naturally saline due to leaching from the surrounding rocks, but irrigation practices have increased the amount of salt.

Farming irrigation channel
Photo courtesy of NEMO

The methodology of irrigating to supplement natural precipitation or to protect crops against freezing or wilting causes water quality problems. In arid areas like Arizona, infrequent rainfall does not flush residues deep into the soil. Excessive irrigation can

then concentrate residues such as pesticides, nutrients, disease carrying microorganisms, selenium, and salts (total dissolved solids) in the top layer of soil. Irrigation return flows from the fields will carry these concentrated residues into the canals that frequently provide the water for irrigation and possibly back to connecting surface water.

Ranching:

Watersheds are impacted by over grazing which may result in loss of native vegetation, increased sheet flow, soil and stream channel erosion. Elevated turbidity levels harm aquatic and wildlife when streams, do not meet water quality standards.

Livestock grazing near streambank
Photo courtesy of NEMO

Large parts of Arizona are used for grazing; some 1,000 grazing allotments occur on public lands. The grazing livestock as well as wildlife are drawn to water and to the surrounding riparian vegetation in an arid climate. Their grazing can contribute sediment and animal wastes containing nutrients (nitrogen and phosphorus) and disease causing organisms (bacteria) to surface waters. Soil disruption and reduction in natural vegetative cover associated with gazing can increase the erosion of lowland stream channels and upland range. Overgrazing can expose soils, increase erosion, encourage invasion by non-native plants, destroy fish habitat, and reduce the filtration of sediment necessary for building streambanks, wet meadows, and floodplains.

Abandoned Mines:

Arizona's Department of Mines and Mineral Resources declares that Arizona is the number one mining state with the largest value of non-fuel mineral production in the United States. Two subsets of mines should be considered: active mines and inactive mines. An inactive mine has not been abandoned, but is not operating. The State Mine Draft dated August 2009, documented that the Inspector's office had inventoried over 10,000 abandoned mines (owners walked away, deceased, sold for taxes or repossessed by the State), of the estimated 100,000 inactive mines in Arizona. For

Copper in tributary to Mineral Creek
Photo courtesy of ADEQ NPS Plan

a copy of the report visit their website at: www.asmi.state.az.us/faq.asp.

In 2007, Arizona listed 187 companies with 402 active mines operating in the state. www.admmr.state.az.us/Info/mining_update2007.pdf.

Prior to when environmental regulations were put into place (1980), mines physically altered lands on a large-scale, creating pits this collected water after rain events. Mine operators used explosives underground resulting in ground water contamination and flowing adits. Abandoned mine workings, tailings piles, and overburden stockpiles, when exposed to water and oxygen cause an increase in acidity and metals leached from the soil and rock into the stream channels (during rain events); resulting in an elevated concentrations of dissolved minerals in the water column. Additionally, acid mine drainage result in the oxidation of sulfides from metalliferous mine spoils that lead to the leaching of large quantities of cations, e.g. Fe^{2+}, Mn^{2+} Pb^{2+} Cu^{2+} Zn^{2+} (Rodriguez et al. 2008). This oxidation decreases the pH levels in water and the surrounding soils that come in contact with the water. An environment of “low biotic integrity” is created which is harsh for organisms that are sensitive to extreme changes (Rodriguez et al. 2008).

Active mines are operating mines, licensed and therefore under compliance. Any pollution from these mines would come from the mineralized soils found in the mining areas.

Urban Runoff:

Urban areas contain impervious surfaces such as, pavement, sidewalks, and roof tops which prevent rain water from percolating into the soil. This increases the amount of water runoff that cause land erosion and stream bank deterioration in urban areas. Urban pavement can also be a source of grease and oils from automobiles and a variety of pollutants spilled on the pavement from domestic and industrial uses. These pollutants make their way into your water resources and endanger the water quality.

Drainage from industrial dumpster
Photo courtesy of ADEQ NPS Program

Flood water in Sabino Canyon in 2005 after fire on Mount Lemmon

For more in depth information on NPS and special conditions in Arizona that contributes to NPS visit ADEQ website at:
http://www.azdeq.gov/environ/water/watershed/download/final5.pdf

Chapter 2: Best Management Practices for the control of NPS

This document is an introduction for the general public, land owners and policy makers, to learn practical techniques, referred to as “Best Management Practices” (BMP) which are defined as structural, vegetative, and managerial conservation practices that will reduce and prevent the detachment, transport and delivery of “Nonpoint Source” (NPS) pollution to surface water and groundwater. Practices are defined as actions taken by a landowner or managers to reduce pollutant loads from NPS.

2.1 Best Management Practices

Through this document you will become acquainted with BMPs suitable to control NPS pollution in Arizona and the “Arid Southwest”. The BMPs are designed based on land use classification, load reduction mechanisms and desired benefits; section 2.5 (table 1) lists BMPs based on their engineering intensity/management levels, with each level defined; and section 2.6 (table 2) lists the BMPs based on the pollutant(s) that need to be remedied and/or controlled. The BMP implementation sheets will provide you with descriptions of the:

Volunteers implementing BMP
Photo courtesy of NEMO

- Best Management Practice (BMP);
- Load reduction mechanism;
- Land use classification;
- Additional benefits;
- Potential treatment areas;
- Alternative management measures;
- Permitting requirements;
- Estimated time for load reduction;
- Planning and implementation of the BMPs; and,
- Sources of additional information.

Ratings of low, medium and high are given to the categories of:

Load Reduction Potential: This section qualitatively describes the potential reduction of pollutant(s) loading by implementation of the practice. The actual load reduction is dependent on the extent of the practice and the existing pollutant loading levels.

Expected Maintenance: qualitatively describes the expected maintenance costs related to the practice.

Estimated Cost:

- Low – $0 – $1,000
- Medium – $1,000 – $5,000
- High – $10,000 +

The BMP implementation sheet also includes pictures and/or detailed drawings to aid in the visualization and implementation of the BMPs.

In general, practices described in this document are meant to be implemented in areas immediately adjacent to the stream channel or water body. However, many of the treatments can be utilized effectively in uplands and other areas. It should be noted that while practices are effective when used separately, an implementation strategy utilizing two or more complimentary practices generally provides better results. Any strategy for reducing pollutant loads should work to eliminate the underlying causes of the pollution as well as the identified source. For example, stream bank erosion is often caused by a reduction in woody vegetation and/or the result of intensive livestock or wildlife grazing. Revegetation of the eroding banks without addressing the underlying grazing management issues would reduce the ultimate success of the project. Additional benefits from the implementation of these practices will include (but not limited to) the following:

- Prevent the erosion of land, soil, and loss of native vegetation in watersheds;
- Minimize damage to roads, buildings, and utilities located adjacent to streams and rivers;
- Maintain the capacity of the stream channel and control unwanted meander of streams and rivers;
- Reduce sediment loads (soil that is transported and deposited) to streams and rivers; and,
- Protect and improve streams and rivers for recreational use, and for fish and wildlife habitat.

2.2 Evaluation Criteria

When selecting a BMP(s) for implementation, first identify the most significant pollutant sources. These sources may include over grazing, areas of soil disturbance, stream erosion, agricultural practices, mining practices, and other resource management and use. Table 2 links sources directly to specific practices.

POTENTIAL TREATMENT AREAS

The choice of practices to address the pollutant sources described above is dependent on the area to be treated. Treatment areas can be divided into two broad categories:

- Streamside which refers to the active channel and floodplain of the waterbody; and,
- Adjacent lands which can further be divided by uses into agricultural, ranching and developed.

Streamside describes the area that includes the channel, floodplain, and riparian corridor of a stream or waterbody. The area is dominated by riparian plant species and is exposed to disturbance from moderate, frequent flood events. Practices within this area include streambank protection, riparian habitat enhancement and channel stabilization.

Adjacent Agricultural/Ranch Lands include those lands devoted to growing of crops and/or livestock. These areas maybe adjacent to affected waterbodies. Pollution may take the form of unconstrained runoff of excess nutrients or wastes, sediments eroded from bare soils or fallow fields, or pollutants transported through subsurface flows.

Adjacent Developed Lands are areas near or adjacent to affected waterbodies. Development may take the form of rural or urban housing, industrial facilities, bare or disturbed areas, or streets and other impervious surfaces. Pollution sources are created by runoff of pollutants from these areas.

Specific costs for practices vary widely by region and over time. As a result, costs are not provided in the implementation sheet, rather a rating of high, medium and low is offered. However, the engineering intensity/management level or level of technical complexity is described for each practice on the implementation sheets. In general, costs are relative to the technical complexity. Management practices are generally the least costly while those that require intense engineering are the most costly. It should be kept in mind that the implementation of practices based on cost along may not be the most cost-effective approach. Other factors such as load reduction potential, estimated time for load reduction, and maintenance costs can be equally important. Table 1 links engineering intensity/management levels to specific practices.

2.3 Implementation

When planning, briefly summarize the technical considerations necessary for successful implementation of each practice. It should be noted that detailed planning considerations for all practices

Community volunteers implementing BMP
Photo courtesy of ADEQ Streambank Plan

are beyond the scope of this document. However, following the suggested engineering intensity/maintenance levels (discussed in section 2.5) will aide you in at this stage; practices in levels 100 & 200 (Passive and Active Management) can often be implemented directly by the landowner. Level 300 (Mild Engineering) practices can often be implemented by landowners with guidance from an experienced technician. Professional assistance in design and implementation is generally necessary in Levels 400 – 500 (Moderate and Intense Engineering.

Many of the practices described on the implementation sheets involve the use of vegetation to reduce pollution loads. It is recommended that native plant species be utilized whenever possible, especially near the stream. To be successful, plant species must be installed in zones that meet specific needs of soil moisture and disturbance regime. The following zone descriptions shown in figure 1 are adapted from "Riparian Planting Zones in the Intermountain West," NRCS (Hoag. Etal, 2001).

2.4 Riparian Planting Zones

Dry Wash: streams in the Southwest, and make up 94% of stream miles in Arizona. Given their vast extent, ephemeral and intermittent streams are crucial to the overall health of a watershed, providing a wide array of functions including forage, cover, nesting, and movement corridors for wildlife. Because of the relatively higher moisture content in dryland streams, vegetation and wildlife abundance and diversity is higher than in the surrounding uplands. Ephemeral and intermittent streams provide the same hydrologic functions as perennial streams by moving water, nutrients, and sediment through the watershed. When functioning properly, dryland streams provide many of the same services as perennial riparian-wetland areas, such as landscape hydrologic connections; stream energy dissipation during high-water flows that reduces erosion and improves water quality; surface and subsurface water storage and exchange; groundwater recharge and discharge; sediment transport, storage, and deposition aiding in floodplain maintenance and development; nutrient cycling; wildlife habitat and movement/migration; support for vegetation communities that help stabilize stream banks and provide wildlife services; and water supply and water quality filtering (Levick, L., D. Goodrich, M. Hernandez, D. J. SEMMENS, J. Stromberg, R. LEIDY, M. Apodaca, P. Guertin, M. Tluczek, AND W. G. KEPNER, 2007).

***Toe Zone*:** The Toe Zone is located at or below the elevation of stream base flow. Generally, this is the zone of highest stresses and the most erosion and is critical to successful treatment of streambank erosion. In perennial streams the zone rarely supports woody species and is generally colonized by wetland plants with a tolerance for very wet soil conditions.

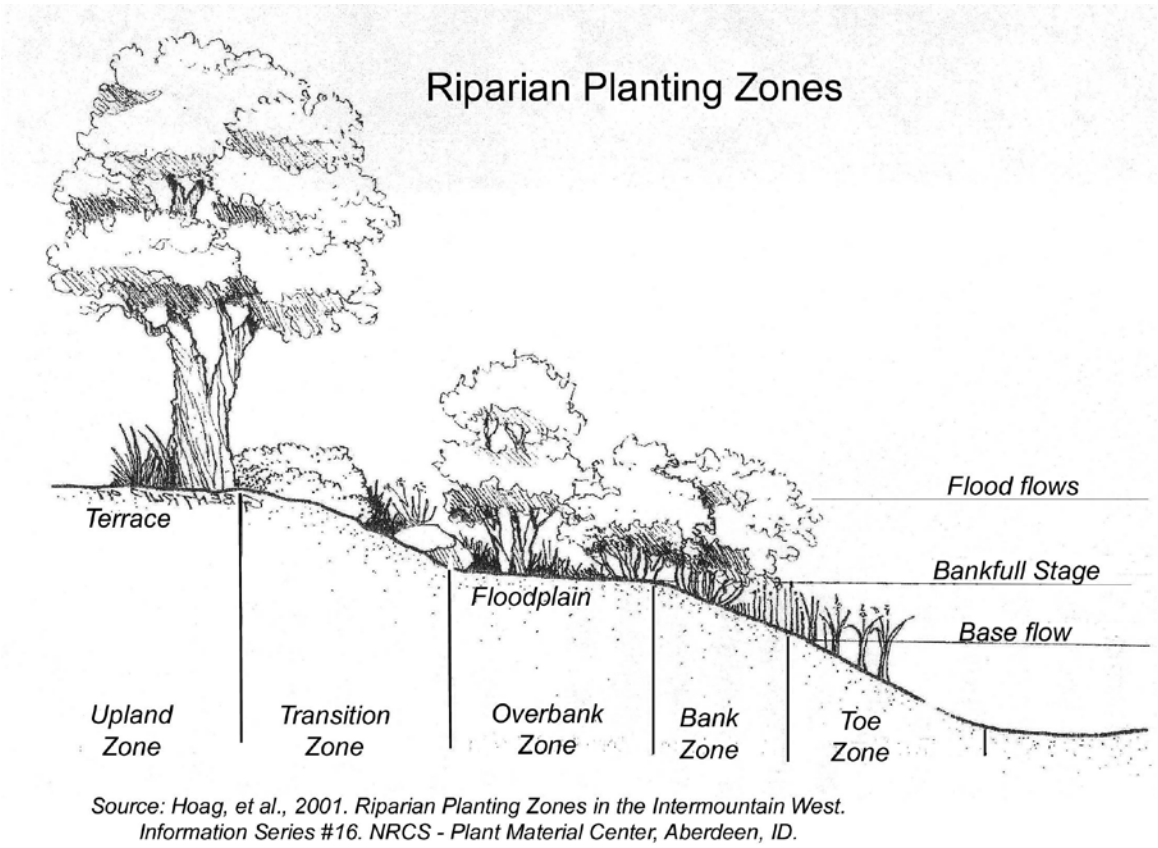
***Bank Zone*:** The Bank Zone is the area between stream baseflow water elevation and the bank full\ discharge elevation. It is less erosive than the toe zone but is still exposed to erosive river currents, wind generated waves, wet and dry cycles, and freezing or thawing cycles. The bank zone is generally vegetated with early seral (ecological progression such as form withered to dry) or colonizing herbaceous (herblike having the texture and color of an ordinary foliage leaf) species, flexible stemmed willows, and low shrub species.

***Overbank Zone*:** The Overbank Zone is located between the bank full stage elevation and the overbank elevation. It is relatively flat and often has layered soils. Because it is periodically flooded, usually about every 2-5 years, the zone is exposed to erosive water currents. Vegetation in the overbank zone should be flood tolerant. Shrubby willows, cottonwoods, birch, and other species with flexible stems will predominate here.

Larger shrub type willows will generally occur on the higher end of the riparian zone. Cottonwoods and tree type willows may survive well at the higher end of the zone. Species that have large inflexible stems should not be part of the planting plan in the lower parts of this zone as they can cause significant disruption to the stream dynamics.

***Transition Zone*:** The Transition Zone is located between overbank elevation and upland elevation. This zone is less often subjected to erosive water currents except during high water events. Species in this zone are not extremely flood or inundation tolerant. This is the zone where larger tree species are typically found.

***Upland Zone*:** The Upland Zone is found outside the riparian area and is dominated by more drought tolerant upland species.



Source: Hoag, et al., 2001. Riparian Planting Zones in the Intermountain West. Information Series #16. NRCS - Plant Material Center, Aberdeen, ID.

Figure 1. Riparian Planting Zones

Lakes/Urban Lakes

According to the Environmental Protection Agency (1986), half of the 1,000 estimated lakes in America are classified as either eutrophic or hyper-eutrophic. However, of the 3,700 urban lakes evaluated by the Environmental Protection Agency (1980), the percentages of urban lakes that are eutrophic or hyper-eutrophic exceed 80%. This is due to the fact that urban watersheds produce higher unit area phosphorus loads from stormwater runoff, compared to other watersheds. In addition, most urban watersheds produce significant secondary phosphorus loads from a diverse range of sources including municipal wastewater discharges, failing septic systems and sewage overflows. Urban lakes also have many unique internal phosphorus sources such as foul droppings, boat sewage and sediment release. Given such high phosphorus loads, it does not take much uncontrolled development in the watershed of an urban lake to quickly accelerate the eutrophication process. For example, stormwater runoff from watershed development begins to exceed background phosphorus loads at 4%, 17% and 40% impervious cover for forested, rural and agricultural watersheds, respectively. However, these thresholds can be approximately doubled if stormwater treatment

practices and better site design are effectively applied across the watershed (Tom Schueler and Jon Simpson).

On each BMP implementation sheet the proper riparian planting zone for the BMP is located in the planning and implementation section.

2.5 Table 1: Best Management Practices Engineering Intensity/Maintenance Levels

Definitions of Engineering Intensity/Management Levels and BMPs in the category:

Level 100: ***Passive Engineering*** includes practices that can generally be implemented by volunteers without significant training efforts, or can be implemented by the land owner following brief instructions. Examples of passive engineering practices would include changes in timing and extent of irrigation, changes in type or amount of fertilizer, restricted or rotational grazing, and appropriate abandonment of roads or other disturbed areas.

PASSIVE MANAGEMENT Examples
100 – Lake Weed Removal
100 - Construction Site Management
100 - Grazing Management
100 - Irrigation Water Management
100 - Nutrient Management
100 - Pest Management
100 - Residue Management

Level 200: ***Active Engineering*** describes practices that can generally be implemented directly by a volunteer, land owner, or site manager. However, these practices typically require some conceptual design to improve or update infrastructure, and may include the need to measure locations and distances. Examples of active management include fencing, creation of buffer strips, and establishment of vegetation.

ACTIVE MANAGEMENT Examples
200 - Cover Crop
200 - Exotic Removal
200 - Fencing
200 - Filter Strip
200 - Mulching
200 - Pole/Post Planting
200 - Seeding
200 - Waste Utilization

Level 300: ***Mild Engineering*** practices are those that not only require active efforts but also assistance from appropriate technical and licensed professional resources. Technical resources could include University Extension Service, Natural Resource Conservation Service, and other agency or private practitioners. Licensed professionals may include a land surveyor, Professional Engineer (PE), and/or Registered Geologist (RG) or soils professional. Practices included in this category include a variety of bioengineering activities, such as reduction of stream bank erosion, road grading, and irrigation tailwater recovery.

MILD ENGINEERING Examples
300 – Lake Aeration
300 - Brush Layer
300 - Brush Mattress
300 - Brush Revetment
300 - Brush Trench
300 - Erosion Control Fabric
300 - Fiberschines/Biologs
300 - Silt Fence
300 - Sloped Drain
300 - Strawbale Barrier
300 - Terrace
300 - Vertical Bundle
300 - Watering Facility
305 - Willow Fascines

Level 400: ***Moderate Engineering*** practices entail a greater risk of failure without appropriate technical expertise. These practices typically are more expensive and require the mobilization of specialized equipment, such as drilling rigs or back hoes, will require design and installation by a licensed or registered professionals, and may require permitting. Practices include structural bank protection, structural gully stabilization, off-channel water sources such as wells, and design and installation of more efficient irrigation systems.

MODERATE ENGINEERING Examples
400 - Detention Basin
400 - Grade Stabilization Structure
400 - Irrigation Land Leveling
400 - Irrigation Pipeline
400 - Irrigation System, Drip
400 - Irrigation System, Sprinkler
400 - Irrigation System, Surface
400 - Irrigation System, Tailwater Recovery
400 - Road Stabilization
400 - Rock Vane/Barb
400 - Rock Weir
400 - Toe Rock

Level 500: ***Intense Engineering*** practices require significant engineering and other technical expertise in both design and construction to ensure success. These practices are generally most expensive and have a significant risk of failure if not implemented correctly, and will require licensed engineering and permitting. Heavy equipment will likely be required, increasing the cost of mobilization, and data collection/analysis may be necessary to appropriately ‘size’ the practice, such as in culvert design. Practices

include diversion dams and other primary in-stream structures, grade stabilization structures in large stream channels, and construction of waste storage or treatment lagoons.

INTENSE ENGINEERING Examples
500 - Lake Dredging
500 - Constructed Wetland
500 - Cross-Vane Weir Diversion
500 - Rock RipRap
500 - Stream Channel Stabilization

*****The implementation of these BMPs requires land access/permission from the land owner(s). Some federal and state lands allow BMPs on their lands with permits issued by the appropriate agencies.

2.6 Table 2: Best Management Practices by Pollutant

Example BMP	Heavy Metals	Nutrients & Pathogens	Sediment	Selenium	Page
Brush Layer		x	x	x	19
Brush Mattress		x	x	x	21
Brush Revetment		x	x	x	23
Brush Trench		x	x	x	25
Constructed Wetland		xx	x	x	27
Construction Site Management	x	x	x		29
Cover Crop		xx	x	x	31
Cross-Vane Weir Diversion			x		33
Detention Basin	x	xx		x	35
Erosion Control Fabric		x	x	x	37
Exotic Removal		x	x		39
Fencing		x	x		41
Fiberschines/Biologs		x	x	x	43
Filter Strips	x	xx	x	x	45
Grade Stabilization Structure		x	x	x	47
Grazing Management		xx	x		49
Irrigation Land Leveling		x	x	x	51
Irrigation Pipeline		x	x	x	53
Irrigation System, Drip		x	x	x	55
Irrigation System, Sprinkler		x	x	x	57
Irrigation System, Surface		x	x	x	59
Irrigation System, Tailwater Recovery		x	x	x	61
Irrigation Water Management		x	x	x	63
Lake Aeration		x			65
Lake Dredging		x	x		67
Lake Weed Removal		x			69
Mulching		x	x		71
Nutrient Management		x			73
Pole/Post Planting		x	x	x	75
Residue Management		x	x	x	77
Road Stabilization		x	x	x	79
Rock RipRap		x	x	x	81

Example BMP	Heavy Metals	Nutrients & Pathogens	Sediment	Selenium	Page
Rock Vane/Barb		x	x	x	83
Rock Weir		x	x		85
Seeding		x	x	x	87
Silt Fence		x	x	x	89
Sloped Drain		x	x	x	91
Strawbale Barrier		x	x	x	93
Stream Channel Stabilization			x		95
Terrace		x	x		97
Toe Rock		x	x	x	99
Vertical Bundle		x	x	x	101
Waste Utilization		xx	x		103
Watering Facility		xx	x	x	105
Willow Fascines		x	x	x	107

XX = BMP is suitable for the control of Pathogens (microorganisms), as well as Nutrients.

Brush Layer

POLLUTANTS ADDRESSED: Sediments, Nutrients and Organics, Salinity

DESCRIPTION:
This technique uses bundles of willow cuttings (Salix spp.) in buried trenches along the slope of an eroding streambank.

LOAD REDUCTION MECHANISM:

Organics/Nutrients Management - Nutrients and organics in water flowing across the land are taken up by plants before they reach the stream.
Sediment Reduction - Dense matrix of willow roots provides cohesion for sediment, reducing erosion.
Salinity Reduction – Dissolved salts are taken up by plants.

LAND USE CLASSIFICATION:
Agricultural and grazing lands where nutrients and organic materials may be carried into adjacent streams

Urban areas where organic pollutants may be released and where impervious surfaces increase runoff

ADDITIONAL BENEFITS:
Rooted plants protect bank from erosion.
Brush layer promotes development of riparian plant and animal communities along streambank.

POTENTIAL TREATMENT AREAS:
Stream banks

ALTERNATIVE MANAGEMENT MEASURES:
Pole/Post Planting
Vertical Bundle
Willow Fascines
Brush or Tree Revetment

PERMITTING REQUIREMENTS:
As required under Sections 404 and 401 of the Clean Water Act.

Contact county regional flood control district.

Brush Layer

POLLUTANTS ADDRESSED: Sediments, Nutrients and Organics, Salinity

Level 300: MODERATE ENGINEERING

LOAD REDUCTION POTENTIAL:

○LOW ◉MEDIUM ○HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

○LOW ◉ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. Coyote willow (Salix exigua) is a particularly good species for this method because of its' dense root system. Seep willow (*Baccharis salicifolia*) is another useful species that is widely available.

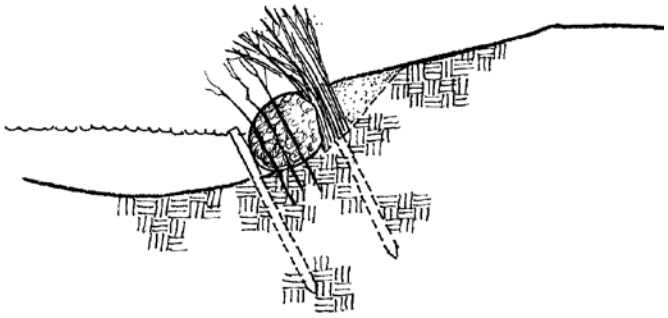
2. If this method is used in a highly erodible area, some protection should be placed in front of the wattles to prevent scour. Analysis and calculations of forces will provide guidance for suitable toe protection. In some cases, brush revetment or fiberschines may be adequate, while other situations may require rock. If no other protection is used, the wattle should be 12 to 24 inches in diameter.

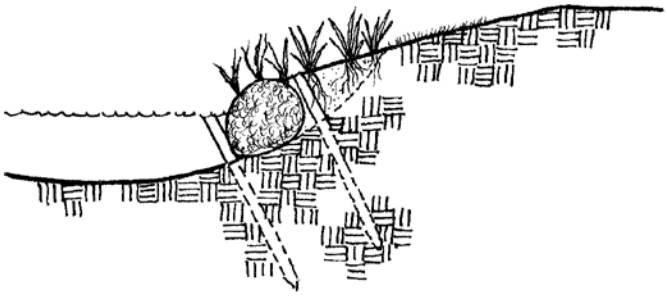
3. Another variation of this technique is to cover the wattles with erosion control fabric to prevent the soil from being washed away from the wattles. Secure the fabric under the first wattle. Poles can be planted into the permanent water table between the wattles. The following illustration also shows the use of a rock toe to prevent scour.

4. Rooting hormones and fertilizers do not significantly improve success for the cost of the materials.

5. Never disturb the site unnecessarily. Remember the goal is to stabilize a site. The less it is disturbed, the easier it will be to restore.

Riparian Planting Zone: Toe Zone





Brush Mattress

POLLUTANTS ADDRESSED: Sediments, Nutrients and Organics, Salinity

DESCRIPTION:
A brush mattress is a mat of live branches of willow or similar tree species placed along the slope of an eroding stream bank to reduce erosion and to filter surface water flowing into the stream. To hold the mattress in place, the lower end is placed in a trench and anchored by bundles of cuttings (fascines). Further stability is achieved by securing the mattress to the stream bank with a grid of ropes tied to wooden stakes. Over time, branches will take root and provide long-term bank protection.

LOAD REDUCTION MECHANISM:

Organics/Nutrients Management - Nutrients and organics in water flowing across the land are taken up by plants before they reach the stream.
Sediment Reduction - Dense matrix of willow roots provides cohesion for sediment, reducing erosion.
Salinity Reduction – Dissolved salts are taken up by plants.

LAND USE CLASSIFICATION:
Agricultural and grazing lands where nutrients and organic materials may be carried into adjacent streams. Urban areas where organic pollutants may be released and where impervious surfaces increase runoff.

ADDITIONAL BENEFITS:
Rooted plants protect bank from erosion.
Brush mattresses help maintain natural channel configuration.

POTENTIAL TREATMENT AREAS:
Stream banks

ALTERNATIVE MANAGEMENT MEASURES:
Pole/Post Planting
Vertical Bundle
Willow Fascines
Brush or Tree Revetment

PERMITTING REQUIREMENTS:
As required under Sections 404 and 401 of the Clean Water Act.

Contact county regional flood control district.

Brush Mattress

POLLUTANTS ADDRESSED: Sediments, Nutrients and Organics, Salinity

Level 300: MODERATE ENGINEERING

LOAD REDUCTION POTENTIAL:

○LOW ◉MEDIUM ○HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

○LOW ◉ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

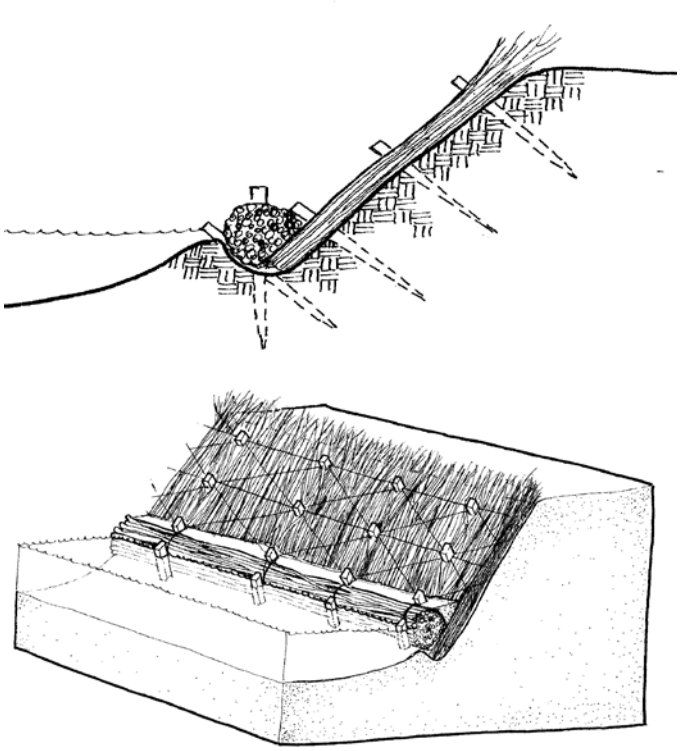
1. This technique works best on stream slopes no steeper than 2H:1V.

2. Brush mattresses can be washed out by strong flooding events, so the flow regime of the stream should be known.
3. Use branches from native species to avoid introducing invasive plants to the riparian community. Gathering of live branches should not damage other ecosystems.
4. Prepare the slope of the stream bank by clearing away large debris. Do not, however, remove woody debris from the stream channel because this provides important fish habitat.
5. Excavate a horizontal trench, 8 to 12 inches deep, at the toe (bottom) of the stream bank along the length of the area to be treated.
6. Place willow cuttings in the trench. Make sure the cut ends reach the bottom of the trench. Spread the cuttings along the face of the slope until a thickness of 4 to 6 inches is achieved.
7. Pound a grid of 36-inch long wooden stakes into the mattress 3 to 4 feet apart. Use longer stakes in less cohesive soil. Secure the brush mattress by using 3/8-inch rope. Tie the cord in horizontal runs and then diagonally between each row of stakes. After tying the mattress, drive the stakes further into the ground to compress the mattress tightly against the stream bank.

8. Construct a bundle of branches (a fascine) the length of the area to be treated. Place the fascine across the base of the mattress in the trench.

9. Backfill around the fascine and mattress by using material excavated from the trench, making sure to work soil between the branches. Use buckets of water to wash the soil down into the stems. Key the upstream end of the mattress and fascine into the stream bank to prevent high flows from getting behind the mattress. It is a good idea to protect this area with a revetment, large rocks, or tree trunks.

Riparian Planting Zone: Toe Zone



Brush Revetment

POLLUTANTS ADDRESSED: Sediments, Nutrients and Organics, Salinity

DESCRIPTION:
Brush or trees are secured to the stream bank to slow excessive erosion by diverting the current away from the bank's edge. The revetment material does not need to sprout. It is expected that the seeds of native trees will lodge in the brush revetment and sprout, producing more permanent protection for the stream bank.

LOAD REDUCTION MECHANISM:

Organics/Nutrients Management - Nutrients and organics in water flowing across the land are taken up by plants before they reach the stream.
Sediment Reduction – Tree branches slow the stream flow and provide stream bank protection, reducing erosion.
Salinity Reduction – Dissolved salts are taken up by plants.

LAND USE CLASSIFICATION:
Agricultural and grazing lands where nutrients and organic materials may be carried into adjacent streams.

Urban areas where organic pollutants may be released and where impervious surfaces increase runoff.

ADDITIONAL BENEFITS:
Provides fish habitat

POTENTIAL TREATMENT AREAS:
Stream Banks

ALTERNATIVE MANAGEMENT MEASURES:
Control Fabric Vertical
Bundles
Post/pole Planting
Seeding Erosion
Brush Mattress

PERMITTING REQUIREMENTS:
As required under Sections 404 and 401 of the Clean Water Act.

Contact county regional flood control district.

Brush Revetment

POLLUTANTS ADDRESSED: Sediments, Nutrients and Organics, Salinity

Level 300: MODERATE ENGINEERING

LOAD REDUCTION POTENTIAL:

○LOW ◉MEDIUM ○HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

○ LOW ◉MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. Installation of brush or tree revetment can usually be accomplished at any time during the year. However, for safety reasons avoid high water periods.
2. Native plant species should be used to avoid spreading invasive exotic species.
3. Typically, the trunks of the revetment should be placed between the annual low and high water levels. In areas of extreme fluctuation in water levels, it may be necessary to place a second revetment at the high water line to prevent scouring behind the revetment during flood events.
4. It is critical that the revetment extend upstream and downstream at least 1 to 3 tree lengths past the eroded area being treated to prevent flows from getting behind the revetment. Key the upstream and downstream ends of the revetment into the bank and reinforce with additional brush or rock. These endpoints are the sections most likely to fail, and they require substantial protection.
5. Avoid disturbing the site unnecessarily. The goal is to stabilize the site, and the less it is disturbed, the easier it will be to restore.
6. Plant live willows or other quickly sprouting species behind the revetment to provide permanent cover and roots.
7. Installation of brush or tree revetment can usually be accomplished at any time during the year. However, for safety reasons avoid high water periods.
8. Native plant species should be used to avoid spreading invasive exotic species.
9. Typically, the trunks of the revetment should be placed between the annual low and high water levels. In areas of extreme fluctuation in water levels, it may be necessary to place a second revetment at the high water line to prevent scouring behind the revetment during flood events.
10. It is critical that the revetment extend upstream and downstream at least 1 to 3 tree lengths past the eroded area being treated to prevent flows from getting behind the revetment. Key the upstream and downstream ends of the revetment into the bank and reinforce with additional brush or rock. These endpoints are the sections most likely to fail, and they require substantial protection.
11. Avoid disturbing the site unnecessarily. The goal is to stabilize the site, and the less it is disturbed, the easier it will be to restore.
    Plant live willows or other quickly sprouting species behind the revetment to provide permanent cover and roots.

Riparian Planting Zone: Toe Zone.

Drawing Courtesy of ADEQ
Streambank Stabilization Plan 2005

Brush Trench

POLLUTANTS ADDRESSED: Sediments, Nutrients and Organics, Salinity

DESCRIPTION:
Bundles of willow cuttings (or cuttings of other available species) are placed in a buried trench along the top of an eroding stream bank. The roots of the sprouting cuttings will provide stream bank stability and the living fence will filter pollutants and sediment from the water.

LOAD REDUCTION MECHANISM:

Organics/Nutrients Management- Willow fence filters surface water runoff before it enters the stream.

Sediment Reduction- Stream banks are stabilized by the dense matrix of roots.

Salinity Reduction- Plants take up salts from the water.

LAND USE CLASSIFICATION:
Agricultural and grazing lands where nutrients and organic materials may be carried into adjacent streams.

Urban areas where organic pollutants may be released and where impervious surfaces increase runoff.

ADDITIONAL BENEFITS:
Plants protect stream bank from erosion

POTENTIAL TREATMENT AREAS:
Stream Banks

ALTERNATIVE MANAGEMENT MEASURES:
Brush Mattress
Brush Revetment
Filter Strip
Mulching
Silt Fence
Seeding

PERMITTING REQUIREMENTS:
As required under Sections 404 and 401 of the Clean Water Act.

Contact county regional flood control district.

Brush Trench

POLLUTANTS ADDRESSED: Sediments, Nutrients and Organics, Heavy Metals

Level 300: MODERATE ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

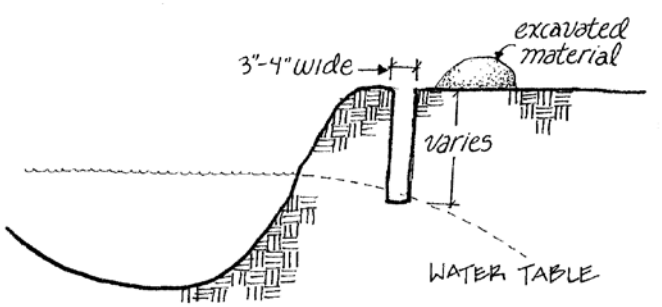
○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

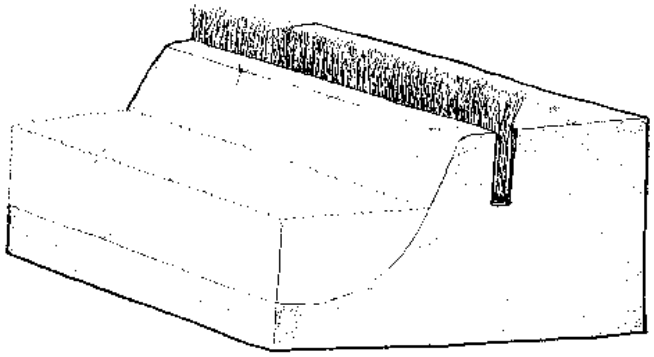
EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

○ LOW ◉ MEDIUM ○ HIGH





PLANNING AND IMPLEMENTATION:

1. Select plant species with dense root systems (such as coyote willow - *Salix exigua*) to bind the soil together securely.

2. Use native species to avoid spreading invasive exotics. Gathering of live branches should not damage other ecosystems.

3. Determine the availability of moisture for the cuttings. Either the cuttings will have to reach the capillary fringe of the permanent water table or there will need to be sufficient overland runoff or bank seepage to sustain the willows.

4. Determine whether toe protection is necessary. In some cases, a brush revetment or fiberschine may be adequate, while other situations may require rock.

5. Give careful attention to both endpoints of the treatment to prevent flows from getting behind the trench. Tying into existing features on site such as trees or rocks or utilizing additional brush or rock are some possible solutions.

6. Do not disturb the site unnecessarily -- the goal is to stabilize the site. The less it is disturbed, the easier it will be to restore.

Riparian Planting Zone: Bank Zone.

Constructed Wetland

POLLUTANTS ADDRESSED: Nutrients and Organics, Pathogens, Salinity, Sediments

DESCRIPTION:
A constructed wetland provides many valuable environmental services. This living vegetation barrier can significantly reduce a variety of pollutants in surface waters. Constructing such a wetland is, however, a complex undertaking, requiring significant engineering expertise.

LOAD REDUCTION MECHANISM:

Organics/Nutrients Management- Nutrients in overland flow and stream water are taken up by wetland plants and absorbed by wetland soils.
Pathogen Reduction- Vegetation filters microorganisms out of the water.
Salinity Reduction- Vegetation absorbs dissolved salts from the water.
Sediment Reduction – The dense vegetation slows water flowing through it and traps suspended sediments.

LAND USE CLASSIFICATION:
Disturbed Areas
Agricultural and Ranch Lands

ADDITIONAL BENEFITS:
Provides low maintenance wastewater treatment.
Facilitates groundwater recharge.
Helps to maintain stream flow during dry periods.
Provides habitat for native wetland species

POTENTIAL TREATMENT AREAS:
Streambanks
Agricultural lands
Developed lands

ALTERNATIVE MANAGEMENT MEASURES:
Pole/Post Planting
Brush Trench
Seeding
Irrigation Water Management

PERMITTING REQUIREMENTS:
Requirements vary by location. A permit under Section 404 and 401 of the Clean Water Act will be necessary. If discharge is involved an AZDPES permit may be required.
Contact county regional flood control district.

Constructed Wetland

POLLUTANTS ADDRESSED: Nutrients and Organics, Pathogens, Salinity, Sediments and metals

Level 500: INTENSE ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. Construct treatment wetlands, as a rule, on uplands and outside floodplains in order to avoid damage to natural wetlands and other aquatic resources, unless pretreated effluent can be used to restore degraded systems.

2. Consider the role of treatment wetlands within the watershed (e.g., potential water quality impacts, surrounding land uses and relation to local wildlife corridors).

3. Closely examine site-specific factors, such as soil suitability, hydrology, vegetation, and presence of endangered species or critical habitat, when determining an appropriate location for the project in order to avoid unintended consequences, such as bioaccumulation or destruction of critical habitat.

4. Use water control measures that will allow easy response to changes in water quantity, quality, depth and flow.

5. Create and follow a long-term management plan that includes regular inspections, monitoring and maintenance.

Riparian Planting Zone: Base flow/Toe Zone

SOURCES OF ADDITIONAL INFORMATION:

Design manual: Constructed wetland and aquatic plant system for municipal treatment, EPA 1988**.** http://epa.gov/wetlands/pdf/design.pdf.

Brookhaven National Laboratory Technology Fact Sheet: Wetlands Restoration/Constructed Wetlands. http://www.bnl.gov/erd/Peconic/Factsheet/Wetlands.pdf.

Construction Site Management

POLLUTANTS ADDRESSED: Sediments, Nutrients and Organics, Heavy Metals

DESCRIPTION:
Construction site management involves a set of planning and implementation activities which must be put into operation before, during, and after a construction project is carried out. Guidance on the development of an appropriate plan, known as a "stormwater pollution prevention plan" (SWPPP), can be obtained from the US EPA document cited below. The ultimate goal of any SWPPP is to protect rivers, lakes, wetlands, and coastal waters that could be affected by the construction project. Practices include appropriate handling of pollutants and special or hazardous wastes which could be released. Effective erosion control measures should be implemented throughout the construction site.

LOAD REDUCTION MECHANISM:
Organics/Nutrients Management- Oversight by managers to make sure precautions is followed.
Sediment Reduction- Oversight by managers to make sure precautions is followed.
Heavy Metal Reduction- Oversight by managers to make sure precautions is followed.

LAND USE CLASSIFICATION:
Disturbed areas
Industrial/mining areas
Urban areas

ADDITIONAL BENEFITS:
Educated workers not likely to mishandle or misuse equipment or hazardous wastes.

POTENTIAL TREATMENT AREAS:
Construction sites
Developed lands

ALTERNATIVE MANAGEMENT MEASURES:
Straw bale barrier
Silt fence
Erosion control fabric
Detention basin

PERMITTING REQUIREMENTS:
A general construction and/or grading permit will be required.
Contact county regional flood control district.

SOURCES OF ADDITIONAL INFORMATION:

ADEQ's stormwater construction permits page for additional information:
http://www.azdeq.gov/environ/water/permits/stormwatr.html.

Construction Site Management

POLLUTANTS ADDRESSED: Sediments, Nutrients and Organics, Heavy Metals

Level 100: PASSIVE MANAGEMENT

LOAD REDUCTION POTENTIAL:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

Photo courtesy of ADEQ
NPS Plan 2005

Photo courtesy of ADEQ NPS Plan 2005

PLANNING AND IMPLEMENTATION:
Erosion Control and Minimizing the Impact of Construction:

1. Minimize disturbed area and protect natural features and soil
2. Phase construction activity
3. Control stormwater flowing onto and through the project
4. Stabilize soils promptly
5. Protect slopes

Sediment Controls:

1. Protect storm drain inlets
2. Establish perimeter controls
3. Retain sediment on-site and control dewatering practices
4. Establish stabilized construction exits
5. Inspect and maintain controls

Riparian Planting Zone: Upland Zone.

Cover Crop

POLLUTANTS ADDRESSED: Sediments, Salinity, and Pathogens

DESCRIPTION:
Temporarily seeding an area to establish vegetative cover is one of the most effective, and least expensive, methods of reducing erosion. This approach might not be appropriate on steep slopes, when vegetation cannot be established quickly enough to control erosion during a storm event, or when additional activities might occur soon in the area. Seeding can also add richness and organic material to the soil, improve the physical structure of the soil, and increase infiltration and aeration.

LOAD REDUCTION MECHANISM:

Pathogens- Crop plants filter out and trap pathogens, preventing them from reaching water bodies.

Sediment Reduction- Crop plants reduce wind, water, and rill erosion.

Salinity- Plant roots absorb dissolved salts

LAND USE CLASSIFICATION:
Disturbed areas
Agricultural areas

LAND USE CLASSIFICATION:
Disturbed areas
Agricultural areas

ADDITIONAL BENEFITS:
Cover crops can enrich the soil with organic matter and nutrients

POTENTIAL TREATMENT AREAS:
Agricultural lands

ALTERNATIVE MANAGEMENT MEASURES:
None

PERMITTING REQUIREMENTS:
None

Cover Crop

POLLUTANTS ADDRESSED: Sediments, Salinity, and Pathogens

Level 300: ACTIVE MANAGEMENT

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

Cover crop such as cereal grasses, mustards and/or legumes are grown for their biomass, which is incorporated into the soil without harvest. As such, cover crops are considered a type of conservation practice that is used to provide ground cover during the rainy season. Cover crop growth serves to improve water penetration and infiltration, slow surface water runoff, and reduce erosion. Cover crops can also build soil fertility and improve soil structure. In addition, cover crops can capture residual soil nitrogen and reduce nutrient runoff and leaching.

Cover crop types include legumes such as bell beans, peas and vetch, mustards, and cereals such as barley, oats and rye. Specially formulated mixes that include both cereals and legumes may also be planted.

1. The cover crop should be terminated as late in the year as feasible to maximize plant growth and to prepare the seedbed for the subsequent crop.

2. Deep-rooted species can bring deeper nutrients into surface soil layers.

3. Avoid cover crop species that attract potentially damaging insects.

4. Cover crops may be used to improve site conditions for establishment of perennial species.

Riparian Planting Zone: Upland Zone

SOURCES OF ADDITIONAL INFORMATION:

ATTRA, Overview of Cover Crops and Green Manures
http://attra.ncat.org/attra-pub/PDF/covercrop.pdf.

AWQA, Cost Studies Publication: Annually Planted Cover Crops.
http://www.awqa.org/pubs/CostEstimates/PlantedCoverCrop.pdf.

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Cross-Vane Weir Diversion

POLLUTANTS ADDRESSED: Sediments

DESCRIPTION:
The cross-vane weir is a diversion dam intended to channel water to an alternate waterway such as an irrigation canal, another stream, or a water spreading system. It is built in a V-shape and angled upstream.

LOAD REDUCTION MECHANISM:

Sediment Reduction - Diverts stream flow while maintaining the transport of flood waters and sediments. The geometry increases flow and velocity in the center of the river maintaining sediment transport.

LAND USE CLASSIFICATION:
Disturbed areas
Agricultural lands
Grazing lands

ADDITIONAL BENEFITS:
The weir helps stabilizes the stream channel.

POTENTIAL TREATMENT AREAS:
Streams

ALTERNATIVE MANAGEMENT MEASURES:
Grazing Management
Water Facilities
Irrigation Water Management
Irrigation Pipeline

PERMITTING REQUIREMENTS:
Permits are required under Sections 404 and 401 of the Clean Water Act.

Water diversions are based on a water right administered by state and/ or federal agencies. Contact ADWR for additional information.

Cross-Vane Weir Diversion

POLLUTANTS ADDRESSED: Sediments

Level 500: INTENSE ENGINEERING

LOAD REDUCTION POTENTIAL:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

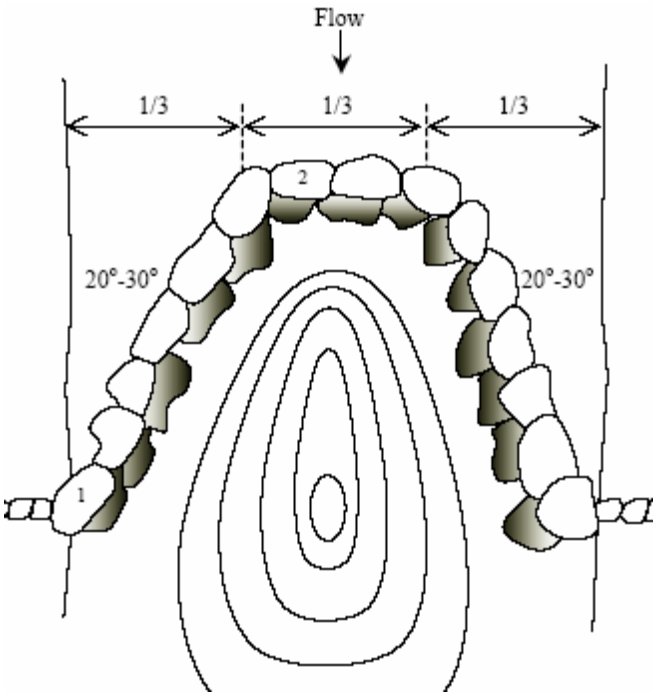
○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED COST:

○ LOW ○ MEDIUM ◉ HIGH



The effects of this practice on water quantity, water quality, and the environment should be considered during the planning process.

Some effects to be considered are:

1. Effects on the water budget, on volume and rate of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Effects of the use of diverted waters for irrigation.
3. Effects on the original watercourse, on the newly constructed watercourse, and on the area where the water is being diverted to and from.
4. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances carried by runoff.
5. Effects on the natural migration of fish.

Riparian Planting Zone: Base flow.

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PLANNING AND IMPLEMENTATION:

Detention Basin

POLLUTANTS ADDRESSED: Heavy Metals, Nutrients and Organics, Salinity, Sediments

DESCRIPTION:
A detention basin is a constructed basin designed to collect and temporarily store water or waterborne debris or sediment.

LOAD REDUCTION MECHANISM:

Heavy Metal Reduction – Improves water quality by filtering pollutants from collected runoff using a combination of microbial soil processes, infiltration, evaporation, and plant uptake.

Nutrients/Organics Management- - see above

Salinity Reduction – see above

Sediment Reduction – Suspended sediments settle within the basin.

LAND USE CLASSIFICATION:
Disturbed areas
Agricultural lands
Urban areas

ADDITIONAL BENEFITS:
Flood protection

POTENTIAL TREATMENT AREAS:
Agricultural lands
Developed lands

ALTERNATIVE MANAGEMENT MEASURES:
Brush trench
Silt fence
Straw bale barrier
Sloped drain

PERMITTING REQUIREMENTS:
Requirements vary by location. A permit under Section 404 and 401 of the Clean Water Act may be necessary. Contact county regional flood control district.

Note: Retention Basins are not allowed in Arizona under ADWR rules.
http://www.azwater.gov/azdwr/default.aspx.

Detention Basin

POLLUTANTS ADDRESSED: Heavy Metals, Nutrients and Organics, Salinity, Sediments

Level 500: INTENSE ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

Effects on water quantity to be considered:

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.
2. Effects on downstream flows and aquifers that would affect other water uses and users.
3. Effects on volume of discharge flow on the environmental, social, and economic conditions.
4. Effects on the water table downstream and the results of changes of vegetative growth.
5.

Effects on water quality to be considered:

1. Effects on erosion, movement of sediment, pathogens, and soluble and sediment-attached substances that could be carried by runoff.
2. Effects on the visual quality of onsite and downstream water resources.
3. Effects of construction and early establishment of protective vegetation on the surface and ground water.
4. Effects on wetlands and water-related wildlife habitats.

Riparian Planting Zone: Upland Zone and Flood flows areas.

Photo courtesy of ADEQ NPS Plan

Erosion Control Fabric

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

DESCRIPTION:
Erosion control fabric can be used to prevent erosion on slopes, banks, or floodplains until vegetation can be established. Wood cuttings and native plants can be planted in the fabric, and seeds can be placed underneath the fabric. By the time the fabric decomposes, planted vegetation will be ready to stabilize the streambank.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- Plants will take up nutrients in the water.

Salinity Reduction- Plants will take up dissolved salts in the water.

Sediment Reduction – The fabric reduces soil erosion until the planted vegetation can provide long-term protection.

LAND USE CLASSIFICATION:
Agricultural lands
Grazing lands

ADDITIONAL BENEFITS:
Plants prevent bank from erosion

POTENTIAL TREATMENT AREAS:
Agricultural Lands
Developed Lands
Stream Side

ALTERNATIVE MANAGEMENT MEASURES:
Brush Layers
Brush Trench
Toe Rock
Willow Fascines
Willow Pole Planting

PERMITTING REQUIREMENTS:
None if applied by hand or away from streams or wetlands.

Contact county regional flood control district.

Erosion Control Fabric

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

Level 300: MILD ENGINEERING

LOAD REDUCTION POTENTIAL:

○LOW ○MEDIUM ◉HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. An important step with this technique is to ensure the upstream and downstream ends of the erosion control blanket are well keyed into the bank to prevent high flows from pulling the blanket out. Cobble should be placed in the key trenches to prevent the fabric from being pulled out.

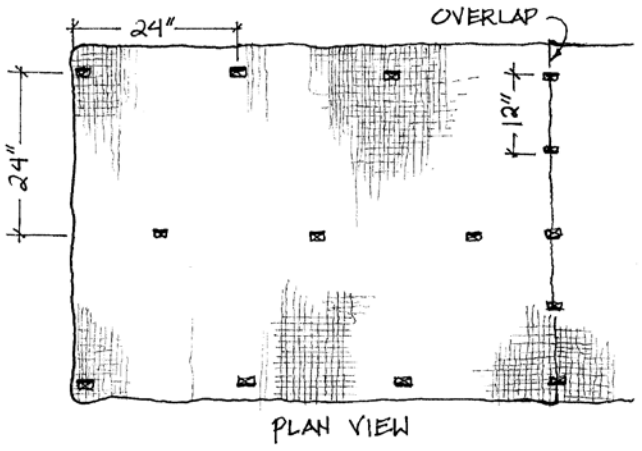
2. Another important step is where the fabric overlaps; it should be shingled away from the direction of the current to prevent flows from pulling at the fabric.

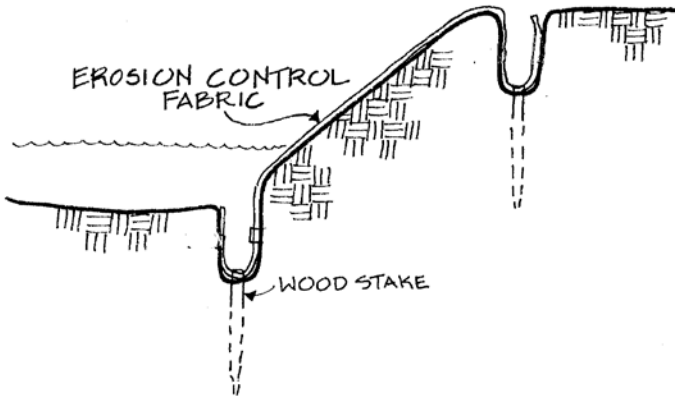
3. Never disturb the site unnecessarily. Remember the goal is to stabilize a site. The less it is disturbed, the easier it will be to restore.

4. If the area is grazed, restrict livestock from treated areas to allow the eroded section of streambank to heal. Exclosure fences are the most efficient means to accomplish this goal. Managers should resist the temptation to put the exclosure fences at the high water line. The exclosure areas should include enough of the riparian zone to allow the stream to shift naturally over time.

5. If the area is farmed, a riparian buffer strip should be established and maintained. A buffer strip on both sides of the stream should be set aside to allow for natural riparian vegetation and stream function. A wider buffer strip is strongly encouraged and will yield greater benefits.

Riparian Planting Zone: Bank Zone and Toe Zone.





Exotic Removal

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments

DESCRIPTION:
The predominant streamside exotic plant species in Arizona are various species of saltcedar (tamarisk). These trees were introduced originally for erosion control, but they have had undesirable consequences (high water use, deleterious impacts on native species), and their removal is now recommended.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- Native plant species that replace exotics will take up nutrients from overland and instream water flows.

Sediment Reduction – Once native plants have replaced the exotic species, their roots will stabilize stream banks, reducing erosion and the production of sediment.

LAND USE CLASSIFICATION:
Agricultural lands
Grazing lands
Disturbed areas
Riparian areas in lakes and streams.

ADDITIONAL BENEFITS:
Native plants cover and protect soil.
There may be a reduction in water loss through reduced evapotranspiration .
Native plants can provide more natural habitat for native wildlife.

POTENTIAL TREATMENT AREAS:
Streamside riparian areas

ALTERNATIVE MANAGEMENT MEASURES:
Fencing
Grazing Management
Mulching
Pole/Post Planting
Seeding

PERMITTING REQUIREMENTS:
None, unless practice takes place near stream, or wetland. In these cases permits under Section 404 and 401 of the Clean Water Act may be required.

Contact county regional flood control district.

Exotic Removal

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments

Level 200: ACTIVE MANAGEMENT

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

For mechanical treatment methods, plans and specifications will include types of equipment and any modifications necessary to enable the equipment to adequately complete the job.

Also included should be:

1. Dates of treatment Operating instructions.
2. Techniques or procedures to be followed.

For chemical treatment methods, plans and specifications will include:

1. Herbicide name.
2. Rate of application or spray volumes.
3. Acceptable dates of application.
4. Mixing instructions (if applicable).
5. Any special application techniques, timing considerations, or other factors that must be considered to ensure the safest, most effective application of the herbicide.
6. Reference to label instructions.

For biological treatment methods, plans and specifications will include:

1. Kind of biological agent or grazing animal to be used.
2. Timing, duration, and intensity of grazing or browsing.
3. Desired degree of grazing or browsing use for effective control of target species.
4. Maximum allowable degree of use on desirable non-target species.
5. Special precautions or requirements when using insects or plants as control agents.

Riparian Planting Zone: Upland Zone

Photo Courtesy of NEMO

Fencing

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments

DESCRIPTION:
Stream protection with fencing involves the fencing of narrow strips of land along streams to exclude livestock, people, and wildlife. The fenced areas may be planted with trees or grass, but are typically not wide enough to act as streamside buffers. As a result of streamside fencing, remote watering and stream crossings must be provided.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- Exclusion of livestock and wildlife from riparian areas will prevent their wastes from contaminating stream waters.
Sediment Reduction – Fencing will also prevent livestock from trampling and destroying riparian vegetation which will reduce erosion and sediment production.

LAND USE CLASSIFICATION:

Grazing lands

ADDITIONAL BENEFITS:
Native vegetation will be able to recover from grazing damage.

POTENTIAL TREATMENT AREAS:
Grazing lands
Riparian areas

ALTERNATIVE MANAGEMENT MEASURES:
Grazing Management
Watering Facility

PERMITTING REQUIREMENTS:
Generally none

Fencing

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments

Level 200: ACTIVE MANAGEMENT

LOAD REDUCTION POTENTIAL:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

A wide variety of fencing is available. However, fencing material and construction quality should always designed and installed to assure the fence will meet the intended purpose and longevity requirements of the project.

The standard fence is constructed of either barbed or smooth wire suspended by posts with support structures. Other types include woven wire for small animals, electric fence as a cost efficient alternative, and suspension fences which are designed with heavy but widely spaced posts and support structures.

Things to consider when planning a fence include the following:

1. For ease of maintenance purposes avoid as much irregular terrain as possible.

2. Wildlife movement needs should be considered.

3. State and local laws may apply to boundary fences.

4. Consider livestock handling, watering and feeding requirements when locating fences.

5. Consider soil erosion potential and feasibility of fence construction when planning fences on steep or irregular terrain.

Riparian Planting Zone: Upland Zone and Flood flow

Photo courtesy of NEMO

Fiberschines/Biologs

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments, Salinity

DESCRIPTION:
The material used is a coconut-fiber roll product (fiberschine) used to stabilize the stream bank at the base of the slope. Plant cuttings are planting into thefiberschine and just behind it as well. When the fiberschine decomposes, plants will have rooted, stabilizing the stream bank.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management - Vegetation planted in the fiberschine will take up nutrients from the water.

Salinity Reduction - Plant s will also absorb dissolved salts.

Sediment Reduction - Vegetation roots will stabilize stream bank.

LAND USE CLASSIFICATION:
Disturbed areas
Agricultural lands
Grazing lands

ADDITIONAL BENEFITS:
Growing riparian vegetation will provide streambank stability and habitat for wildlife.

POTENTIAL TREATMENT AREAS
Streamsides

ALTERNATIVE MANAGEMENT MEASURES:
Brush Layer
Brush Mattress
Brush Trench
Pole Plantings
Willow Fascines

PERMITTING REQUIREMENTS:
None if installed by hand.

Contact county regional flood control district.

Fiberschines/Biologs

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments, Salinity

Level 300: MILD ENGINEERING

LOAD REDUCTION POTENTIAL:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

○ LOW ◉ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. Installation of the fiberschine can usually be accomplished throughout the year. High water periods should be avoided for safety reasons.

2. The fiberschine should extend upstream and downstream past the eroded area being treated to prevent flows from getting behind the fiberschine.

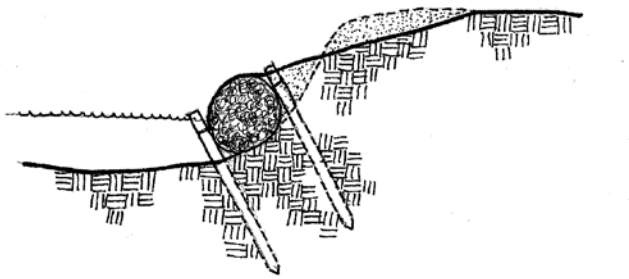
3. Analysis and calculations may reveal that additional toe protection is necessary. In many cases, rock may be appropriate if placed properly. Improperly placed rock can result in erosion problems on the opposite streambank as well as downstream.

4. Be sure to key the upstream and downstream end of the fiberschine into the streambank and secure it with some hard materials such as tree trunks or large rocks.

5. If this method is used in a highly erodible area and bank shaping is not possible, a tiered fiberschine technique may be necessary. Three fiberschines of different diameters are often used but various numbers and combinations of sizes can be used.

6. Never disturb the site unnecessarily. Remember the goal is to stabilize a site. The less it is disturbed the easier it will be to restore.

Riparian Planting Zone: Toe and Bank Zones**.**



Filter Strip

POLLUTANTS ADDRESSED: Heavy Metals, Nutrients and Organics, Pathogens, Salinity, Sediment

DESCRIPTION:
A filter strip is a vegetation barrier between different types of land, such as crop lands, grazing lands, forested lands, and disturbed lands. The most common BMP for urban lakes in Arizona.

LOAD REDUCTION MECHANISM:

Metal Reduction – Metals are absorbed by vegetation and microorganisms living in the filter strip**.**
Nutrients/Organics Management – Nutrients are taken up by organisms living in the filter strip.
Pathogen Reduction – Pathogens are filtered out of the water passing across the filter strip.
Sediment Reduction – Filter strips stabilize sediments, preventing them from washing into streams.
Salinity Reduction – Vegetation can take up dissolved salts.

LAND USE CLASSIFICATION:
Agricultural lands
Construction sites
Mining areas
Recreation areas

ADDITIONAL BENEFITS:
Vegetation provides a habitat for wildlife.

POTENTIAL TREATMENT AREAS:
Agricultural lands
Developed lands

ALTERNATIVE MANAGEMENT MEASURES:
Exotic removal
Fencing
Seeding

PERMITTING REQUIREMENTS:

Contact county regional flood control district.

Filter Strip

POLLUTANTS ADDRESSED: Heavy Metals, Nutrients and Organics, Pathogens, Salinity, Sediments

Level 200: ACTIVE MANAGEMENT

LOAD REDUCTION POTENTIAL:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. Filter strips should be strategically located to reduce runoff, and increase infiltration and ground water recharge throughout the watershed.
2. Filter strips for the single purposes of wildlife/beneficial insect habitat or to enhance watershed function should be strategically located to intercept contaminants thereby enhancing the water quality of the watershed.
3. To avoid damage to the filter strip consider using vegetation that is somewhat tolerant to herbicides used in the upslope crop rotation.
4. Consider using this practice to enhance the conservation of declining species of wildlife, including those that are threatened or endangered.
5. Consider using this practice to protect National Register listed or eligible (significant) archaeological and traditional cultural properties from potential damaging contaminants.
6. Filter strip size should be adjusted to a greater flow length to accommodate harvest and maintenance equipment.

Riparian Planting Zone: Upland Zone and Flood flows.

Photo courtesy Of ADEQ Streambank Stabilization Plan

Photo courtesy Of ADEQ Streambank Stabilization Plan

Grade Stabilization Structure

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

DESCRIPTION:
Rock, alone or combined with brush or biologs, is used to control the grade and head cutting in natural and artificial channels, preventing the formation or advance of gullies.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- If brush or biologs are used, plants will take up excess nutrient runoff.

Salinity Reduction- If brush or biologs are used, plants will take up dissolved salts from water runoff.

Sediment Reduction – Grade stabilization structures can reduce slope erosion thus reducing the amount of sediments carried into streams.

LAND USE CLASSIFICATION:
Grazing lands
Agricultural lands
Cleared areas
Urban areas

ADDITIONAL BENEFITS:
Rocks, brush, and biologs provide habitat for small wildlife species.

POTENTIAL TREATMENT AREAS:
Streamside

ALTERNATIVE MANAGEMENT MEASURES:
Brush Trench
Erosion Water Management
Irrigation Control Fabric

PERMITTING REQUIREMENTS:
ACOE 401 and 404 permits may be required.

Contact county regional flood control district.

Grade Stabilization Structure

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

Level 400: MODERATE ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

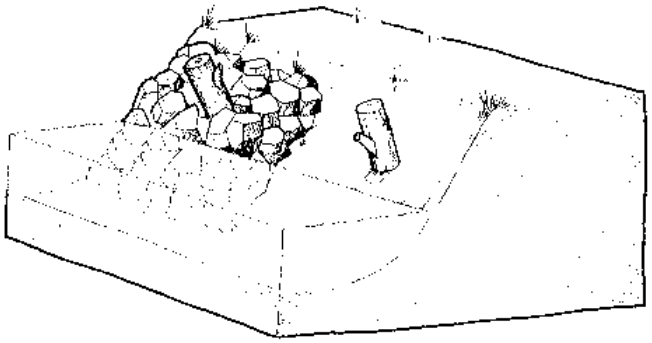
◉ LOW ○ MEDIUM ○ HIGH

Photo courtesy of AWPR 2007

PLANNING AND IMPLEMENTATION:

Grade stabilization structures are located so that the elevation of the inlet of the spillway is set at an elevation that will control upstream headcutting. A wide range of alternative types of structures are available for this practice and an intensive site investigation is required to plan and design an appropriate grade stabilization structure for a specific site.

Riparian Planting Zone: Toe & Bank Zones and Upland Zone



Grazing Management

POLLUTANTS ADDRESSED: Nutrients and Organics, Pathogens, Sediments

DESCRIPTION:
The focus of the grazing management measure is on the riparian zone, yet the control of erosion from range, pasture, and other grazing lands above the riparian zone is also encouraged. Application of this management measure will reduce the physical disturbance to sensitive areas and reduce the discharge of sediment, animal waste, nutrients, and chemicals to surface waters. This can be accomplished by exclusion from grazing, seasonal rotation, rest, or a combination of these measures.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- Proper management provides for healthy riparian plants, which have the ability to take up excess nutrients.

Sediment Reduction - Proper management provides for healthy riparian vegetation which stabilize the stream bank, reducing soil erosion.

Pathogen Reduction – Riparian plants can filter out potential pathogens before they reach the water body.

LAND USE CLASSIFICATION:
Agricultural areas
Grazing areas
Disturbed areas
Riparian corridors

ADDITIONAL BENEFITS:
Grazing management protects the viability of riparian plant communities which:
- preserves habitat for native species,
- stabilizes stream banks,
- helps to control flooding.

POTENTIAL TREATMENT AREAS:
Agricultural Lands
Streamside

ALTERNATIVE MANAGEMENT MEASURES:
Fencing
Watering Facility

PERMITTING REQUIREMENTS:
None

Grazing Management

POLLUTANTS ADDRESSED: Nutrients and Organics, Pathogens, Sediments

Level 100: PASSIVE MANAGEMENT

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. Removal of herbage will be in accordance with site production limitations, rate of plant growth, and the physiological needs of forage plants.
2. Manage kind of animal, animal number, grazing distribution, length of grazing periods, and timing of use to provide sufficient deferment from grazing during the growing period.
3. Protect soil, water, air, plant, and animal resources when locating livestock feeding, handling, and watering facilities.
4. Manage grazing animals to maintain adequate vegetative cover on sensitive areas (i.e. riparian, wetland, habitats of concern, karst areas).
5. Duration and intensity of grazing will be based on desired plant health and expected productivity of key forage species to meet management unit objectives.
6. Adjust grazing periods and/or stocking rates to meet the desired objectives for the plant communities and the associated resources, including the grazing animal.
7. Schedule livestock movements based on rate of plant growth, available forage and utilization, not calendar dates.
8. Periodic rest from grazing may be needed to maintain or restore the desired plant community following episodic events, such as wildfire or severe drought.
9. Maintain adequate ground cover and plant density to maintain or improve filtering capacity of the vegetation.
10. Minimize concentrated livestock areas to enhance nutrient distribution and improve or maintain ground cover.

Riparian Planting Zone: Toe & Bank Zones and Upland zone

Photo courtesy of ADEQ Streambank Stabilization Plan

Irrigation Land Leveling

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

DESCRIPTION:
Reshaping and leveling the surface of land to be irrigated allows for uniform and efficient application of surface irrigation water without significant erosion, loss of water quality, or damage to soil and crops from water logging.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management – Leveling of irrigated lands reduces overland water flow thus reducing transport of nutrients and organics to adjacent streams.

Salinity Reduction – Soil salts are not carried into adjacent waters by overland flow.

Sediment Reduction – Leveling the area to be irrigated results in a reduction in runoff, erosion, and suspended sediments in nearby surface water.

LAND USE CLASSIFICATION:
Agricultural land

ADDITIONAL BENEFITS:
None

POTENTIAL TREATMENT AREAS:
Agricultural lands

ALTERNATIVE MANAGEMENT MEASURES:
Cover Crop
Irrigation Water Management
Seeding

PERMITTING REQUIREMENTS:
A grading permit may be required, contact county regional flood control district.

Irrigation Land Leveling

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

Level 400: MODERATE ENGINEERING

LOAD REDUCTION POTENTIAL:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. In the design consider the excavation and fill material required for or obtained from such structures as ditches, ditch pads, and roadways. The appropriate yardage shall be included when balancing cuts and fills and determining borrow requirements.

2. Consider related structures and measures needed to control irrigation water and/or storm water runoff.

3. Consider crops, method of irrigation, soil intake rates, field slope, irrigation stream size and resulting deep percolation and runoff when determining or evaluating length of irrigation runs.

4. Consider related structures and measures needed to control irrigation water and/or storm water runoff.

5. Consider crops, method of irrigation, soil intake rates, field slope, irrigation stream size and resulting deep percolation and runoff when determining or evaluating length of irrigation runs.

6. Consider the depth of cuts and the resulting available plant rooting depths to saline soils and to shallow water tables.

7. In areas with sediment-laden irrigation water, consider increasing the required height of the water surface at the point of delivery.

8. Consider effects on irrigation efficiencies, especially on volumes and rates of runoff, infiltration, evapotranspiration and deep percolation.

9. Consider effects on water flows and aquifers, and the affect to other water uses and users.

10. Consider the effects on adjacent wetlands.

Riparian Planting Zone: Upland Zone and Flood flows.

SOURCES OF ADDITIONAL INFORMATION:

USDA, Irrigation Land Leveling:
Conservation Practice Standard, Irrigation Land Leveling prepared for the Natural Resources Conservation Service.
http://efotg.nrcs.usda.gov/references/public/NM/464.pdf

EPA; Management Measures for Agricultural Sources: Irrigation Water, 1982.
http://www.epa.gov/nps/MMGI/Chapter2/ch2-2f.html.

Irrigation Pipeline

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

DESCRIPTION:
An irrigation pipeline, consisting of pipes (of various materials), pumps, valves, and other appurtenance, allows the transfer of irrigation water underground rather than through open canals or ditches.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management - An underground pipeline confines irrigation water, controlling the spread of nutrients and organic pollutants.

Salinity Reduction - - An underground pipeline confines irrigation water, controlling the spread of salts.

Sediment Reduction – By reducing overground flows of irrigation water, an irrigation pipeline reduces soil erosion, thus reducing sediment transport.

LAND USE CLASSIFICATION:
Agricultural lands

ADDITIONAL BENEFITS:
An irrigation pipeline reduces water loss and protects water quality.

POTENTIAL TREATMENT AREAS:
Agricultural lands
Developed lands

ALTERNATIVE MANAGEMENT MEASURES:
Irrigation, Drip
Irrigation, Sprinkler

PERMITTING REQUIREMENTS:
None

Contact county regional flood control district.

Irrigation Pipeline

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

Level 400: MODERATE ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:
The design and installation of an irrigation system requires consideration of numerous variables, including the size of the area to be irrigated, the water requirements of the crops, the frequency of irrigation, optimal pump placement, energy costs for pump operation, maintenance requirements, and cost. Consultation with an irrigation engineer is recommended.

Riparian Planting Zone: Upland Zone and Flood flows.

SOURCES OF ADDITIONAL INFORMATION:

Farm Water Quality Management Practice, Irrigation Systems, Sprinkler, #442, prepared by the University of California Cooperative Extension, Natural Resources Conservation Service.
http://extension.oregonstate.edu/catalog/html/pnw/pnw290/

Irrigation System, Drip

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

DESCRIPTION:
A drip system brings water to the root zone of the plants by means of emitters, orifices, or porous tubing. The purpose of this technique is to efficiently and uniformly apply irrigation water and to maintain soil moisture for optimum plant growth.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- A drip irrigation system brings water directly to the plants roots, eliminating surface runoff.

Salinity Reduction- A drip irrigation system does not allow salt to accumulate in soils because water surface runoff is eliminated.

Sediment Reduction – Reduction in surface runoff reduces erosion and the production of suspended sediments.

LAND USE CLASSIFICATION:
Agricultural lands

ADDITIONAL BENEFITS:
Maintains soil moisture for optimum plant growth.

POTENTIAL TREATMENT AREAS:
Agricultural lands

ALTERNATIVE MANAGEMENT MEASURES:
Irrigation Pipeline
Irrigation Water Management

PERMITTING REQUIREMENTS:
none

Irrigation System, Drip

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

Level 400: MODERATE ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. Water quality is usually the most important consideration when determining whether a microirrigation system is feasible. Well and surface water often contains high concentrations of undesirable minerals (chemicals). Surface water can contain organic debris, algae, moss, bacteria, soil particles, etc. Well water can also contain sand.

2. Microirrigation can influence runoff and deep percolation by raising the soil moisture level and decreasing available soil water storage capacity, increasing the probability of runoff or percolation below the root zone from storm events. The movement of sediment, soluble chemicals, and sediment-attached substances carried by runoff may affect surface water quality. The movement of dissolved substances below the root zone may affect groundwater quality.

3. On systems where chemicals are injected, care shall be taken so the injected nutrients do not react with other chemicals in the irrigation water to cause precipitation and plugging.

4. Microirrigation will effect a change in plant growth and transpiration because of changes in the volume of soil water.

5. There may be a potential for development of saline seeps or other salinity problems resulting from increased infiltration near restrictive layers.

6. Field shape and slope frequently dictate the most economical lateral direction. Whenever possible, laterals should be laid downslope for slopes of less than 5% if lateral size reduction can be attained. For steeper terrain, lateral lines should be laid along the field contour and pressure compensating emitters should be specified or pressure control devices used along downslope laterals.

Riparian Planting Zone: Upland Zone and Flood flows.

SOURCES FOR ADDITIONAL INFORMATION:

TMDLs for Total Dissolved Solids in the Duchesne River Watershed, prepared for the US Environmental Protection Agency by the Utah Department of Environmental Quality, Division of Water Quality, and the NRCS New Jersey Irrigation Guide, prepared for the US Department of Agriculture, Natural Resources Conservation Service.
http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

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Irrigation System, Sprinkler

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

DESCRIPTION:
A sprinkler system brings water efficiently and uniformly to the plants by means of nozzles operated under pressure.

ADDITIONAL BENEFITS:
Sprinkler systems maintain adequate soil moisture for optimum plant growth without causing excessive water loss, erosion, and impairment of water quality.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- A sprinkler system spreads nutrients uniformly so that excessive amounts do not accumulate at various spots throughout the field.

Salinity Reduction – Because an optimal amount of irrigation water is applied to fields, the buid-up of salts is reduced.

Sediment Reduction – By applying the correct amount of water to the plants so that there is no surface runoff, sprinkler systems reduce sheet, gully and irrigation-induced erosion, reduced suspended sediments in surface water.

LAND USE CLASSIFICATION:
Agricultural lands

POTENTIAL TREATMENT AREAS:
Agricultural lands

ALTERNATIVE MANAGEMENT MEASURES:
Irrigation Pipeline
Irrigation Water Management

PERMITTING REQUIREMENTS:
None

Irrigation System, Sprinkler

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

Level 400: MODERATE ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. Sprinkler irrigation designs are based on an evaluation of the site considering soil, topography, water supply, energy supply, crops to be grown, labor requirements, and expected operating conditions.

2. Sprinkler irrigation systems are a better choice for sandy soils. Conversely, if the soils are very slowly permeable (clayey), the site may not be well adapted to sprinkler irrigation due to excessive runoff and erosion.

3. The net depth of application should be based on the available moisture capacity of the soil in the root zone of the crop irrigated or a lesser amount consistent with the land user's operation plan. The gross depth is be determined by using field application efficiencies consistent with the conservation of water resources.

4. The design rate of application should be within a range established by the minimum practical application rate under local climatic conditions and the maximum rate consistent with the intake rate of the soil and the conservation practices used on the land. If two or more sets of conditions are in the design area, the lowest maximum application rate for areas of significant size should apply.

5. A combination of sprinkler spacing, nozzle sizes, and operating pressure that most nearly provides the design application rate and distribution should be selected. The velocity of prevailing winds and other conditions must be considered.

Riparian Planting Zone: Upland Zone and Flood flows

SOURCES OF ADDITIONAL INFORMATION:

Conservation Practice Standard, Irrigation Land Leveling prepared for the Natural Resources Conservation Service.
http://www.ag.ndsu.edu/pubs/ageng/irrigate/ae91.pdf

Irrigation System, Surface

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

DESCRIPTION:
This is a system that efficiently distributes irrigation water directly to the point of application. Surface irrigation requires well designed furrows, borders, contour levees, contour ditches, or a subsurface apparatus.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- A properly designed surface irrigation system will reduce erosion and water loss, thereby reducing the transport of agricultural fertilizers and other organics into surface waters.

Salinity Reduction- Reduced erosion and water loss will reduce the transport of salts into surface waters.

Sediment Reduction – Similarly, reduction in erosion will reduce the transport of sediments into adjacent surface waters.

LAND USE CLASSIFICATION:
Agricultural lands

ADDITIONAL BENEFITS: None

POTENTIAL TREATMENT AREAS:
Agricultural Lands

ALTERNATIVE MANAGEMENT MEASURES:
Irrigation Land Leveling
Irrigation System, Tailwater
Irrigation Water Management

PERMITTING REQUIREMENTS:
None

Irrigation System, Surface

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

Level 400: MODERATE ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:
When planning a surface irrigation system, the following items should be considered, where applicable:

1. Effects of nutrients and pesticides and other dissolved substances on surface and ground water quality.
2. Effects of water level control on the salinity of soils, soil water or downstream water quality.
3. Effects of water levels on such soil nutrient processes as plant nitrogen use or denitrification.
4. Impact of salt leaching on system management and capacity requirements.

Implementation considerations include:

5. The water budget, especially volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
6. Plant growth and transpiration because of changes in the volume of soil water.
7. Downstream flows or aquifers that impact other water uses or users.
8. The volume of downstream flow that could have environmental, social, or economic impacts.
9. Field water table in providing a suitable rooting depth for anticipated land uses.
10. Erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.
11. Temperature of downstream waters.
12. Aquatic and wildlife communities, wetlands or water related wildlife habitats.
13. The visual quality of water resources.
14. Possible impacts on cultural resources.

Riparian Planting Zone: Upland Zone and Flood flows

ADDITIONAL SOURCES OF INFORMATION:

Conservation Practice Standard, Irrigation System, Surface and Subsurface, prepared by the Natural Resources Conservation Service.
http://www.ag.ndsu.edu/pubs/ageng/irrigate/ae91.pdf

Irrigation System, Tail Water Recovery

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

DESCRIPTION:
Tail water recovery systems captures water after it has been used to irrigate an agricultural field and directs it to a facility that can collect, store, and transport tail water to be reused for further irrigation.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- A properly designed tail water storage facility will provide adequate retention time for the breakdown of chemicals in the runoff waters.

Salinity Reduction- Pond sealers and liners are used to prevent high salinity water from entering subsurface and surface waters.

Sediment Reduction – Sediment settles out of the tail water while it is held in a storage facility.

LAND USE CLASSIFICATION:

Agricultural lands

POTENTIAL TREATMENT AREAS:
Agricultural Lands

ADDITIONAL BENEFITS
Reduction in surface water contaminants

ALTERNATIVE MANAGEMENT MEASURES:
Irrigation Land Leveling
Irrigation System, Drip
Irrigation Water Management

PERMITTING REQUIREMENTS:

Contact county regional flood control district.

Irrigation System, Tail water Recovery

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

Level 400: MODERATE ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED COST:

○ LOW ○ MEDIUM ◉ HIGH

PLANNING AND IMPLEMENTATION:

1. Irrigation systems should be designed to limit tailwater volumes to that needed for effective operation. This reduces the need or minimizes the size and capacity of collection, storage, and transportation facilities.

2. Changes in irrigation water management activities will be necessary to accommodate return flows.

3. Nutrient and pest management measures should be planned to limit chemical-laden tailwater as much as practical. Chemical-laden water can create a potential hazard to wildlife, especially waterfowl that are drawn to ponded water.

4. Irrigation systems should be designed to limit tailwater volumes to that needed for effective operation. This reduces the need or minimizes the size and capacity of collection, storage, and transportation facilities.

5. Changes in irrigation water management activities will be necessary to accommodate return flows.

6. Nutrient and pest management measures should be planned to limit chemical-laden tailwater as much as practical. Chemical-laden water can create a potential hazard to wildlife, especially waterfowl that are drawn to ponded water.

7. Protection of system components from storm events and excessive sedimentation should be considered. Downstream flows or aquifer recharge volumes dependent on runoff will be reduced. Existing wetland hydrology could be impacted by this practice.

Riparian Planting Zone: Upland Zone and Flood flows

SOURCES OF ADDITIONAL INFORMATION:

Conservation Practice Standard, Irrigation System, Surface and Subsurface, prepared by the Natural Resources Conservation Service.
http://www.ag.ndsu.edu/pubs/ageng/irrigate/ae91.pdf

Irrigation Water Management

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

DESCRIPTION:
Irrigation water management is the process of determining and controlling the volume, frequency, and application rate of irrigation water in a planned, efficient manner.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- Appropriate water management will apply water at rates that minimize transport of nutrients and chemicals to surface waters and ground water.
Salinity Reduction- Appropriate water management will apply water at rates that minimize transport of dissolved salts to surface waters and ground water.
Sediment Reduction – Appropriate water management will apply water at rates that minimize erosion and transport of sediments to surface waters.

LAND USE CLASSIFICATION:
Agricultural lands

ADDITIONAL BENEFITS:
Irrigation water management can result in reduced water costs, reduced water loss through evaporation, and soil conservation.

POTENTIAL TREATMENT AREAS:
Agricultural lands

ALTERNATIVE MANAGEMENT MEASURES:
Cover Crop
Mulching
Nutrient Management
Seeding

PERMITTING REQUIREMENTS:
Contact county regional flood control district.

Irrigation Water Management

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

Level 100: PASSIVE MANAGEMENT

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. Consideration should be given to managing precipitation effectiveness, crop residues, and reducing system losses.
2. Modify plant populations, crop and variety selection, and irrigated acres to match available or anticipated water supplies.
3. Consider potential for spray drift and odors when applying agricultural and municipal waste water.
4. Equipment modifications or soil amendments such as polyacrylamides and mulches should be considered to decrease erosion.
5. Consider the quality of water and the potential impact to crop quality and plant development.
6. Quality of irrigation water should be considered relative to its potential effect on the soil's physical and chemical properties, such as soil crusting, pH, permeability, salinity, and structure.
7. Avoid traffic on wet soils to reduce compaction.
8. Consider effects of irrigation water on wetlands, water related wildlife habitats, riparian areas, cultural resources, and recreation opportunities.
9. Management of nutrients and pesticides.
10. Schedule salt leaching events to coincide with low residual soil nutrients and pesticides.
11. Water should be managed in such a manner as to not drift or come in direct contact with surrounding electrical lines, supplies, devices, controls, or components that would cause shorts in the same or the creation of an electrical safety hazard to humans or animals.
12. Consideration must be given to electrical load control/ interruptible power schedules, repair and maintenance downtime, and harvest downtime.
13. Consider improving the irrigation system to increase distribution uniformity of irrigation water application.

Riparian Planting Zone: Upland Zone and Flood flows

SOURCES OF ADDITIONAL INFORMATION:

Farm Water Quality Management Practice, Irrigation Systems, Sprinkler, #442, prepared by the University of California Cooperative Extension, Natural Resources Conservation Service.
http://extension.oregonstate.edu/catalog/html/pnw/pnw290/

Lake Aeration

POLLUTANTS ADDRESSED: Phosphorus and Algal Blooms

DESCRIPTION:
Various systems are available to aerate lake either by injecting air, mechanically mixing or agitating the water, or even injecting pure oxgen.

LOAD REDUCTION MECHANISM:
Increase the dissolved oxygen content of the water and, in some case, nuisance algal blooms can be reduced or a shift to a less objectionable algae species can occur.

LAND USE CLASSIFICATION:
Agricultural and Ranch Lands
Disturbed Areas
Urban Lands

ADDITIONAL BENEFITS:
Increase fish and other aquatic animal habitat; improve the quality of domestic and industrial water supplies while decreasing treatment cost.

POTENTIAL TREATMENT AREAS:
Lakes in agricultural/ranch lands
Lakes in development lands

ALTERNATIVE MANAGEMENT MEASURES:
Pole/Post Planting
Vertical Bundle
Willow Fascines
Brush or Tree Revetment

PERMITTING REQUIREMENTS:
Requirements vary by location. A permit under sections 404 and 401 of the Clean Water Act and from AZDPS before the use of herbicides is used in a waterbody.

Contact county regional flood control district.

Lake Aeration

POLLUTANTS ADDRESSED: Phosphorus and Algal Blooms

Level 300: ACTIVE MANAGEMENT

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. To properly choice and design an artificial circulation system, it will depend on the lake management goals and the physical characteristics of the lake; example, if the system is under sized the mixing will be incomplete. If the lake is large, it may require several systems.

2. Avoid placing the air diffusers too near the bottom of the lake, this will help to stop stirring up the sediment and resuspending it in the lake. Also, avoid placing the air diffusers to far above the lake bottom; this will stop the creation of an anaerobic zone (without oxygen).

The Air-lift method exposes the water to the atmosphere where it obtains more oxygen.

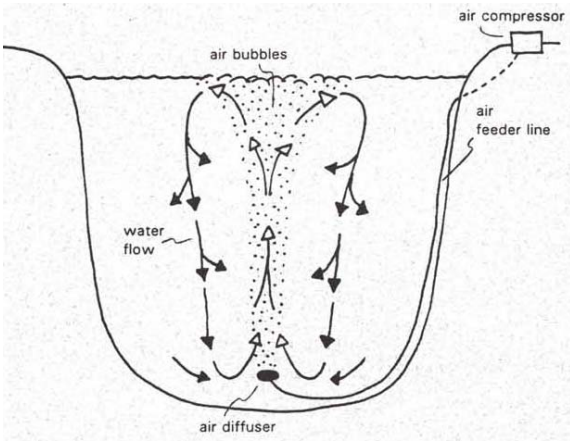

Photo courtesy of: Aquatic Plant Management - Manual Methods http://www.ecy.wa.gov/programs/wq/plants/management/aqua022.html.

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Riparian Planting Zone: Base flow/Toe Zone

Lake Dredging

POLLUTANTS ADDRESSED: Sediments, Nutrients and Organics, Salinity

DESCRIPTION:
Dredging is an excavation activity in which materials are recovered from beneath the water's surface. The purpose is generally to gather bottom sediment and either dispose it at a different location or to excavate the roots of nuisance weeds which concentrate nutrients. By removing these nutrients the cycle of lake eutrophization can be terminated.

LOAD REDUCTION MECHANISM:
Organics/Nutrients Management- Nutrients deposited in the lake by overland flow and stream waters, then absorbed by lake plants, are removed by dredging.

LAND USE CLASSIFICATION:
Agricultural and Ranch Lands
Disturbed Areas
Urban Lands

ADDITIONAL BENEFITS:
Open stream flow-lane and produce material to be used within-banks placement. It can be used to enhance or restore habitat. It is a method of weed reduction.

POTENTIAL TREATMENT AREAS:
Lakes in agricultural/ranch lands
Lakes in development lands

ALTERNATIVE MANAGEMENT MEASURES:
Pole/Post Planting
Vertical Bundle
Willow Fascines
Brush or Tree Revetment

PERMITTING REQUIREMENTS:
Requirements vary by location. A permit under sections 404 and 401 of the Clean Water Act, and/or county floodplain maybe required.

Contact county regional flood control district.

POLLUTANTS ADDRESSED: Sediments, Nutrients and Organics, Salinity

Level 500: INTENSE ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

○ LOW ○ MEDIUM ◉ HIGH

PLANNING AND IMPLEMENTATION:

Dredging requires a company that will work closely with your engineering team to utilize the right dredging equipment for your particular project. Each dredging project is different and therefore requires the equipment to be tailored for optimum project performance and a project feasibility studies, and cutter calculations are the professional assistance you will need.

Riparian Planting Zone: Base flow/Toe Zone

Photo courtesy of: Dredging Company, Inc
http://www.dscdredge.com/dredge-applications.htm.

Lake Weed Removal

POLLUTANTS ADDRESSED: milfoil, curly-leaf pondweed, hydrilla, water lilies, and algae

DESCRIPTION:
Many lakes are dominated by dense growths of aquatic weeds, because they are quite shallow, and influenced by nutrient rich bottom sediments. Lake management must resort to in-lake treatment practices such as harvesting, dredging, water level manipulations or applications of herbicides.

LOAD REDUCTION MECHANISM:
These species create dense beds of aquatic weeds that cause nuisance conditions for lake users, making it unpleasant to swim, hard to operate boats, and difficult to maintain open water areas.

LAND USE CLASSIFICATION:
Agricultural and Ranch Lands
Disturbed Areas
Urban Lands

ADDITIONAL BENEFITS:
Safe waterbodies for recreational activities.

POTENTIAL TREATMENT AREAS:
Lakes in agricultural/ranch lands
Lakes in development lands

ALTERNATIVE MANAGEMENT MEASURES:
Dredging, water level manipulations or applications of herbicides.

PERMITTING REQUIREMENTS:
Requirements vary by location. A permit under sections 404 and 401 of the Clean Water Act and from AZDPS before the use of herbicides is used in a waterbody.

Contact county regional flood control district.

Lake Weed Removal

POLLUTANTS ADDRESSED: milfoil, curly-leaf pondweed, hydrilla, water lilies, and algae

Level 100: PASSIVE ENGINEERING

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YEARS

EXPECTED

⦿ LOW ○

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PLANNING

1. Removal
removing e
and roots),
concern an
area away

2. In water
hand-pullin
requires no
although a
may be nee
packed or h

3. In deepe
accomplish
equipment
collection o

5. Aquatic weeds including invasive milfoil, curly-leaf pondweed, hydrilla, water lilies, algae and many more.

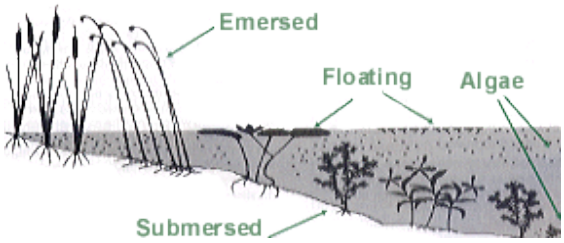


Photo courtesy of: Aquacide Company
White Bear Lake, Mn
http://www.killlakeweeds.com/index.cfm?fuseaction=dsp_weeds

Riparian Planting Zone: Base flow/Toe Zone

Mulching

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments

DESCRIPTION:
Mulch is used as a protective cover consisting of plant residue or other appropriate substances not naturally found on the site to the soil surface. Hay or crop residues are examples of mulches that are transported to a site.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- Mulching reduces runoff of soils as well as nutrients and organic matter on the soils.

Sediment Reduction – By reducing runoff, mulching reduces soil erosion and sediment production.

LAND USE CLASSIFICATION:
Agricultural lands
Residential areas
Mining lands

ADDITIONAL BENEFITS:
Mulching can reduce soil loss, conserve moisture, help control weeds, and add organic matter to soils.

POTENTIAL TREATMENT AREAS:
Agricultural lands
Residential yards
Construction sites
Mine sites

ALTERNATIVE MANAGEMENT MEASURES:
Construction Site Management
Grazing Management
Irrigation Water Management

PERMITTING REQUIREMENTS:
None

Mulching

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments

Level 200: ACTIVE MANAGEMENT

LOAD REDUCTION POTENTIAL:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. Consider the effects of mulching on evaporation, infiltration and runoff. Mulch material may affect microbial activity in the soil surface, increase infiltration, and decrease runoff, erosion and evaporation. Increased infiltration may increase nutrient and chemical transport below the root zone. The temperature of the surface runoff may also be lowered.

2. Mulched soil retains moisture, requires less watering and reduces the chance of water stress on plant materials. Mulch also minimizes evaporation from the soil surface and hence reduces losses from bare soil areas.

3. Mulch materials high in organic matter with a high water holding capacity and high impermeability to water droplets may adversely affect the water needs of plants.

4. Clear and infra-red transmissible (IRT) plastics have the greatest warming potential. They are transparent to incoming radiation and trap the longer wavelengths radiating from the soil. Black mulches are limited to warming soils by conduction only and are less effective.

5. Clear mulches allow profuse weed growth and may negate the benefits of soil warming. Black mulches provide effective weed control. Wavelength selective (IRT) blends the soil warming characteristics of clear mulch with the weed control ability of black mulch.

6. Consider potential toxic allopathic effects that mulch material may have on other organisms. Animal and plant pest species may be incompatible with the site.

7. Consider the potential for increased pathogenic activity within the applied mulch material.

8. Keep mulches 3 to 6 inches away from plant stems and crowns to prevent disease and pest problems. Deep mulch provides nesting habitat for groundburrowing rodents that can chew extensively on bark on tree trunk and/or tree roots. Light mulch applied after the first cold weather may prevent rodents from nesting.

Riparian Planting Zone: Upland Zone and Flood flows.

SOURCES OF ADDITIONAL INFORMATION:
Conservation Practice Standard, Mulching, prepared by the Natural Resources Conservation Service.
ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/484.pdf

Nutrient Management

POLLUTANTS ADDRESSED: Nutrients and Organics

DESCRIPTION:
Managing nutrients involves the budget and supply of nutrients for plant production. By utilizing the amount, placement, and timing of plant nutrients, it leads to optimum crop yields.

LOAD REDUCTION MECHANISM:
Nutrients/Organics Management- Properly managing manure or organic by-products minimizes agricultural nonpoint source pollution of surface and ground water resources.

LAND USE CLASSIFICATION:
Cropland Management

ADDITIONAL BENEFITS:
Maintains or improves; physical, chemical, and biological condition of soil.

Management of nutrients leads to less runoff in streams, which feed algae and can lower oxygen.

POTENTIAL TREATMENT AREAS:
Agricultural Lands

ALTERNATIVE MANAGEMENT MEASURES:
Irrigation Water Management

PERMITTING REQUIREMENTS:
Application of manure requires a land application permit from ADEQ.

Nutrient Management

POLLUTANTS ADDRESSED: Nutrients and Organics

Level 100: PASSIVE MANAGEMENET

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. In areas with an identified or designated nutrient-related water quality impairment, an assessment should be completed of the potential for nitrogen and/or phosphorus transport from the field. The Leaching Index (LI) and/or Phosphorus Index (PI), or other recognized assessment tools, may be used to make these assessments. The results of these assessments and recommendations may be discussed with the producer and included in the plan.
2. Plans developed to minimize agricultural nonpoint source pollution of surface or ground water resources shall include practices and/or management activities that can reduce the risk of nitrogen or phosphorus movement from the field.

Riparian Planting Zone: Upland Zone and Flood flows.

SOURCES OF ADDITIONAL INFORMATION:

Water Quality and Animal Feeding Operations in Arizona: A Producer's Notebook, prepared by the Concentrated Animal Feeding Operation Education Group for the University of Arizona Cooperative Extension, Natural Resources Conservation Service.
http://www.nrcs.usda.gov/technical/NRI/pubs/cnmp1f.pdf

Pole/Post Planting

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

DESCRIPTION:
Pole or post planting (sometimes called live staking) is a process for facilitating the regeneration of riparian vegetation by implanting live cuttings of native riparian species into eroded streambanks.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- Nutrients and organic pollutants are trapped and taken up by vegetation.

Salinity Reduction- Dissolved salts are absorbed by plants.

Sediment Reduction – Vegetation protects the streambank, reducing erosion and sediment production.

LAND USE CLASSIFICATION:
Agricultural land
Grazing land
Rural and urban areas

ADDITIONAL BENEFITS:
Vegetation provides wildlife habitat and enhances the aesthetics of the area.
Damage from erosion is reduced.

POTENTIAL TREATMENT AREAS:
Agricultural lands
Developed lands
Streamside

ALTERNATIVE MANAGEMENT MEASURES:
Brush Mattress
Brush Revetment
Brush Trench
Seeding
Vertical Bundle
Willow Fascines

PERMITTING REQUIREMENTS:
Generally none as long as stream banks are contoured by hand.

Contact county representative

Pole/Post Planting

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

Level 200: ACTIVE MANAGEMENT

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. Use locally adapted seed, seedlings or cuttings. Priority should be given to plant materials that have been selected and tested in tree/shrub improvement programs. All plant materials should comply with a minimum standard, such as the American Nursery and Landscape Association, Forest Service, or state approved nursery.

2. Plans for landscape and beautification plantings should consider foliage color, season and color of flowering, and mature plant height.

3. Where multiple species are available to accomplish the planned objective, consideration should be given to selecting species which best meet wildlife needs.

4. Tree/shrub arrangement and spacing should allow for and anticipate the need for future access lanes for purposes of stand management.

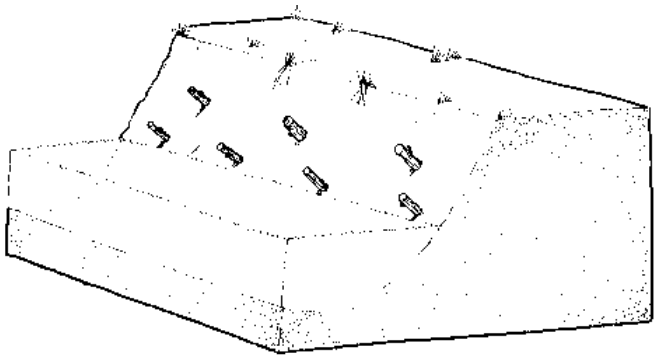
5. Residual chemical carryover should be evaluated prior to planting.

6. Species considered locally invasive or noxious should not be used.

7. Species used to treat waste should have fast growth characteristics, extensive root systems, capable of high nutrient uptake, and may produce wood/fiber products in short rotations.

8. For optimal carbon storage, select plant species that are adapted to the site to assure strong health and vigor and plant the full stocking rate for the site.

Riparian Planting Zone: Bank and Toe Zones.



Residue Management

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

DESCRIPTION:
Residue management is the management of the amount, orientation, and distribution of crop and other plant residue on the soil surface year round while growing crops. Various forms of residue management include no-till, strip till, mulch, ridge till, direct seeding, and seasonal residue management.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- Nutrients and organic matter derived from plant residues becomes incorporated into the soil rather than draining to adjacent waterways.

Salinity Reduction- Residue management stabilizes the soil, reduces erosion, and reduces the transport of soil salts to adjacent waterways.

Sediment Reduction – Residue management protects the soil from erosion by reducing mud splash and runoff.

ADDITIONAL BENEFITS:
Residue management practices reduce energy and time costs for farmers.
Moisture is conserved in the soil.
Soil compaction can be reduced.
Strategies manage available moisture to increase plant damage from freezing or desiccation.

LAND USE CLASSIFICATION:
Agricultural lands

POTENTIAL TREATMENT AREAS:
Agricultural lands

ALTERNATIVE MANAGEMENT MEASURES:
Cover Crop
Filter Strip
Mulching
Nutrient Management

PERMITTING REQUIREMENTS:
None

Residue Management

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

Level 100: PASSIVE MANAGEMENT

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. Removal of plant residue by baling or grazing may have a negative impact on resources. These activities should not be performed without full evaluation of impacts on other resources.

2. Production of adequate amounts of crop residue necessary for the proper functioning of this practice can be enhanced by selection of high residue producing crops and crop varieties, by the use of cover crops, and by adjustment of plant populations and row spacing. When planting in a low residue seedbed, completing tillage and planting in a single operation, or by performing primary tillage no more than three days before planting can minimize exposure to erosion; and in limited moisture areas, can conserve moisture for germination.

3. Leaving standing stubble taller than the six inch minimum will increase the amount of snow trapped. Leaving one or two rows of unharvested crop standing at intervals across the field can enhance the value of residue for wildlife habitat. Unharvested crop rows have the greatest value when they are adjacent to other cover types, such as grassy or brushy areas or woodland.

Riparian Planting Zone: Upland Zone and Flood flows.

SOURCES OF ADDITIONAL INFORMATION:

Soil Conservation Program, Agriculture in Montcalm County, Michigan.
http://www.montcalm.org/agriculture0030.asp

Road Stabilization

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

DESCRIPTION:
This management practices requires the use of rock, vegetation, and/or geotextiles to enhance the stabilization of roads and other embankments. Traditional stabilization relies on the use of expensive rock treatments. Other options are available that include the use of erosion control fabric, toe rock, and revegetation to stabilize banks.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- Stabilizing embankments reduces sediment inputs while preventing excessive stormwater from entering the adjacent stream, thus reducing inputs of nutrients and organic pollutants.

Salinity Reduction- The same process will also reduce inputs of salts.

Sediment Reduction – Embankment stabilization reduces erosion and the input of sediments to adjacent waterways.

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LAND USE CLASSIFICATION:
Agricultural lands
Grazing lands
Rural areas
Urban areas

ADDITIONAL BENEFITS:
Stabilizing embankments protects roads and other infrastructure.

POTENTIAL TREATMENT AREAS:
Agricultural lands
Developed lands
Streamside

ALTERNATIVE MANAGEMENT MEASURES:
Brush Mattress
Brush Revetment
Brush Trench
Erosion Control Fabric
Rock Riprap
Toe Rock

PERMITTING REQUIREMENTS:
Permits under Section 404 and 401 of the Clean Water Act are required if the bank is adjacent to a stream or wetland. A grading will be required from local county agency.

Contact county regional flood control district.

Road Stabilization

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

Level 400: MODERATE ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

Planning considerations include the height and slope of the bank, the climate, and the value of the road or infrastructure. In general, hardening the bank with rock riprap is the most costly approach. Often the installation of native plant materials can reduce erosion runoff and stabilize the soils. Erosion control cloth can be used to temporarily stabilize the bank until vegetation is established.

Photo courtesy of ADEQ Streambank Stabilization Plan

Riparian Planting Zone: Upland Zone and Flood flows.

Photo courtesy of ADEQ Streambank Stabilization Plan

Rock Rip Rap

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

DESCRIPTION:
Riprap consists of a layer of angular stone designed to protect and stabilize areas subject to erosion, slopes subject to seepage, or areas with poor soil structure. Riprap is used on streambanks where stream velocities are too great to successfully establish vegetative cover, on channel bottoms and slopes, stormwater structure inlets and outlets, slope drains, and shorelines.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management - By stabilizing banks, riprap reduces erosion and the transport of soil organics into adjacent stream waters.
Salinity Reduction – Transport of soil salts into adjacent waters is also reduced.
Sediment Reduction – Reduced bank erosion reduces the introduction of sediments into adjacent waters.

LAND USE CLASSIFICATION:
Agricultural land
Grazing land
Urban areas
Rural areas

POTENTIAL TREATMENT AREAS:
Agricultural lands
Developed lands
Streamside

ADDITIONAL BENEFITS:
Riprap protects infrastructure from erosion and loss.

ALTERNATIVE MANAGEMENT MEASURES:
Brush Mattress
Grazing Management
Road Stabilization
Rock Riprap
Toe Rock
Vertical Bundles

PERMITTING REQUIREMENTS:
Permits are required under Sections 404 and 401 of the Clean Water Act if installed adjacent to a stream or wetland.

Contact county regional control district.

Rock Rip Rap

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

Level 400: MODERATE ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED COST:

○ LOW ○ MEDIUM ◉ HIGH

Design Considerations include:

1. Size of rock,
2. Length and height of bank to be protected
3. Depth of toe protection (scour depth)
4. Cost

Impacts to be considered:

1. Potential effect to downstream landowners,
2. Potential effects on stream processes,
3. Potential loss of habitats,
4. Alternative practices

Riparian Planting Zone: Toe, Bank, Overbank and Upland Zones.

PLANNING AND IMPLEMENTATION:

1. Rock riprap is expensive and can adversely impact downstream landowners. As a result it should be designed specifically to meet project objectives. In general, technical assistance is recommended when designing and installing this practice.

2. The rock should extend down to a depth below scour from high flows.

3. Upstream and downsteam ends of the rock must be tied into the streambank to minimize risk of failure.

4. In general, the height of rock protection should be limited to floodplain or other appropriate flood stage elevation.

Photo courtesy of ADEQ Streambank Stabilization Plan

Rock Vane/Barb

POLLUTANTS ADDRESSED: Sediments

DESCRIPTION:
Rock vanes or barbs are used to redirect stream flows away from banks. The structure is located on the outside of the stream bends, is directed upstream and slopes from the bank down to the stream bed.

LOAD REDUCTION MECHANISM:
Sediment Reduction – By stabilizing the banks, the rock vane reduces sediment erosion.

LAND USE CLASSIFICATION:
Construction Sites
Grazing Lands
Mining Lands

POTENTIAL TREATMENT AREAS:
Streamside

ADDITIONAL BENEFITS:
Provides habitat for aquatic and terrestrial species

ALTERNATIVE MANAGEMENT MEASURES:
Brush Revetment
Brush Mattress
Fiberschenes/Biologs
Pole Planting
Toe Rock

PERMITTING REQUIREMENTS:
Permits are required under Sections 404 and 401 of the Clean Water Act if installed adjacent to a stream or wetland.

Contact county regional flood control district

Rock Vane/Barb

POLLUTANTS ADDRESSED: Sediments

Level 400: MODERATE ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

○ LOW ○ MEDIUM ◉ HIGH

Photo courtesy of ADEQ Streambank Stabilization Plan

PLANNING AND IMPLEMENTATION:

1. Rock vanes or barbs must be very carefully designed and installed. They are generally installed in series along an eroding bank at the outside of a meander. The structure is keyed into the bank to reduce the chance of the stream eroding around it. At the bank the structure elevation should be higher than the floodplain to allow high flows to spread. The vane is angled sharply upstream at a 20° - 30° from the bank as it dips down to the channel bed elevation.

2. Vanes/barbs are spaced such that flow striking the bank below one vane is intercepted by the next and redirected.

3. Vanes/barbs can be constructed of large rock, generally 2 feet in diameter, angular rock riprap, logs, or upright posts. It is critical that the structure extend below the level of stream scour in the channel bed to protect from undermining and failure.

4. These structures are less expensive than rock riprap and provide better habitat benefits. However, they inhibit the stream channels natural need to adjust. Bioengineering practices such as vertical bundles, brush mattresses, brush revetment, and pole planting should be considered and installed if applicable.

Riparian Planting Zone: Base flow and Toe Zone.

Rock Weir

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments

DESCRIPTION:
This is a grade control structure constructed from large rocks.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- Reduces sediment which has the ability to transport Nutrients and Organics

Sediment Reduction – Reduce bank erosion and protect against channel incision or downcutting

LAND USE CLASSIFICATION:
Stream Bank Protection

ADDITIONAL BENEFITS:
The rock weir can also be used as a diversion for off channel watering facilities.

POTENTIAL TREATMENT AREAS:
Streamside

ALTERNATIVE MANAGEMENT MEASURES:
Irrigation Water Management
Water Facilities

PERMITTING REQUIREMENTS:
Permits are required under Sections 404 and 401 of of the Clean Water Act.

Contact county regional flood control district.

Rock Weir

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments

Level 500: INTENSE ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

Photo courtesy of ADEQ Streambank Stabilization Plan

PLANNING AND IMPLEMENTATION:

1. Rock weirs can be used to stabilize incising channels and to provide more stable diversion systems for irrigation and livestock water.
2. Rock weirs must be very carefully designed and installed. They should only be installed in the transition or riffle sections of stream between meanders. The structure is keyed into both banks to reduce the chance of the stream eroding around it. At the banks the structure elevation should be higher than the floodplain to allow high flows to spread. The weir arms are angled sharply upstream at a 20° - 30° from the bank as it dips down to the channel bed elevation.
3. Weirs can be constructed of large rock, generally 2 - feet in diameter, angular rock riprap, logs, or upright posts. It is critical that the structure extend below the level of stream scour in the channel bed to protect from undermining and failure.
4. These structures are more stable than traditional flat topped diversion dams because they maintain natural water and sediment transport. The central flow also allows fish passage.

Riparian Planting Zone: Base flow and Toe Zone.

Seeding

POLLUTANTS ADDRESSED: Sediments

DESCRIPTION:
Seeding is used to establish forage species and to apply an herbaceous seed mix to disturbed areas. Methods of seeding include broadcasting, mulching, hydro seeding and aerial seeding.

LOAD REDUCTION MECHANISM:
Sediment Reduction – Plant roots protect the soil from erosion, reducing sediment input to streams.

LAND USE CLASSIFICATION:
Construction sites
Agricultural lands
Grazing lands
Mining lands

ADDITIONAL BENEFITS:
Production of a forage crop
Seeding nitrogen-fixing species can add nutrients to soil

POTENTIAL TREATMENT AREAS:
Agricultural Lands
Developed Lands
Streamside

ALTERNATIVE MANAGEMENT MEASURES:
Exotic Removal
Erosion Control Fabric
Mulching
Tree Planting

PERMITTING REQUIREMENTS:
None

Seeding

POLLUTANTS ADDRESSED: Sediments

Level 200: ACTIVE MANAGEMENT

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

Plan

PLANNING AND IMPLEMENTATION:

Successful seeding requires the use of appropriate native plant seeds sowed during the appropriate time of year. In general the seed is covered with a mulch, compost, or hydro mulch to retain moisture, protect the seed, and provide cover.

Riparian Planting Zone: Toe, Bank, and overbank Zones; also Upland zone and Flood flows.

Photo courtesy of ADEQ Streambank Stabilization

Silt Fence

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments

DESCRIPTION:
A silt fence is a porous plastic barrier installed to temporarily contain surface sediments on disturbed lands or construction sites. Water is allowed to flow through the fabric while sediments are trapped.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- Fabric traps sediments that can contain nutrients and organics.

Sediment Reduction – The silt fence prevents sediments from flowing to adjacent surface water bodies

LAND USE CLASSIFICATION:
Construction sites
Mining lands
Urban lands

ADDITIONAL BENEFITS:
None

POTENTIAL TREATMENT AREAS:
Agricultural Lands
Developed Lands
Lakes Areas

ALTERNATIVE MANAGEMENT MEASURES:
Sediment Barrier
Straw Bale Barrier

PERMITTING REQUIREMENTS:
None

Silt Fence

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments

Level 300: MILD ENGINEERING

LOAD REDUCTION POTENTIAL:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. Silt fences are installed perpendicular to overland water flow. In large areas fences are installed in series to slow the flow of water across disturbed lands. These fences should be considered temporary, installed to buy time for seeding or other revegetation practices to mature.

2. While the practice does not generally require regulatory permits, it is often a requirement in stream alteration permits to minimize pollutants during construction projects.

Riparian Planting Zone: Upland Zone and Flood flows

Sloped Drain

POLLUTANTS ADDRESSED: Sediments

DESCRIPTION:
A sloped drain is a pipe to convey water from one elevation to a lower one without erosion.

LOAD REDUCTION MECHANISM:
Sediment Reduction – Because the water conveyed by the drain does not flow directly over the land, erosion is prevented and thus sedimentation does not occur.

POTENTIAL TREATMENT AREAS:
Agricultural Lands
Developed Lands

ALTERNATIVE MANAGEMENT MEASURES
Detention Basin
Erosion Control Fabric
Irrigation System, Tailwater Recovery

PERMITTING REQUIREMENTS:
Contact county representative

LAND USE CLASSIFICATION:
Construction sites
Agricultural lands
Mining areas

ADDITIONAL BENEFITS:
Water is directed to areas of need.

Sloped Drain

POLLUTANTS ADDRESSED: Sediments

Level 300: MILD ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

○ LOW ○ MEDIUM ◉ HIGH

PLANNING AND IMPLEMENTATION:

Sloping drains should be engineered with enough capacity to carry expected flows. If not, water will flow around them creating erosion and threatening the drain. Inlets should regularly be cleared of debris.

Riparian Planting Zone: Bank, Overbank and Transition Zones.

SOURCES OF ADDITIONAL INFORMATION:

TMDL Water Quality Study of the Virgin River Watershed, submitted to Utah Department of Environmental Quality, Division of Water Quality. http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

Straw Roll/Bale Barrier

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

DESCRIPTION:
Straw barriers are semi-permeable barriers that temporarily contain sediments generated by flows across bare or disturbed ground.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- The barriers traps nutrients that are carried by overland water flows.

Salinity Reduction- They also temporarily impedes the flow of saline waters.

Sediment Reduction – They temporarily trap sediment from overland water flows.

LAND USE CLASSIFICATION:
Construction sites
Agricultural lands
Mining lands

ADDITIONAL BENEFITS:
None

POTENTIAL TREATMENT AREAS:
Agricultural lands
Developed lands

ASSOCIATED BMP:
Silt Fence

PERMITTING REQUIREMENTS:
None

Straw Roll/Bale Barrier

POLLUTANTS ADDRESSED: Nutrients and Organics, Salinity, Sediments

Level 300: MILD ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

Straw bales are temporarily placed perpendicular to surface sheet flow. In small channels velocities are high enough to require anchoring of the bales with steel or wooden stakes. These barriers should be considered temporary and require maintenance.

Riparian Planting Zone: Overbank, Transition and Upland Zones

SOURCES OF ADDITIONAL INFORMATION:

TMDL Water Quality Study of the Virgin River Watershed, submitted to Utah Department of Environmental Quality, Division of Water Quality. http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

Stream Channel Stabilization

POLLUTANTS ADDRESSED: Sediments

DESCRIPTION:
Stream channel stabilization is the reconstruction or restoration of a reach of stream. It may involve channel realignment, grade control, and the use of bank stabilization structures.

LOAD REDUCTION MECHANISM:
Sediment Reduction – Bank stabilization, grade control, and or channel realignment reduce the amount of sediment that is transported into adjacent streams.

LAND USE CLASSIFICATION:
Agricultural lands
Grazing lands
Mining lands

ADDITIONAL BENEFITS:
Protects adjacent structures (roads, buildings, etc.) from flood damage and erosion.

POTENTIAL TREATMENT AREAS:
Stream Side

ALTERNATIVE MANAGEMENT MEASURES:
Pole/Post Planting
Rock Vanes
Rock Weirs
Seeding
Toe Rock
Various Bioengineering Practices

PERMITTING REQUIREMENTS:
Permits are always required under Sections 404 and 401 of the Clean Water Act.

Contact county regional flood control district

Stream Channel Stabilization

POLLUTANTS ADDRESSED: Sediments

Level 500: INTENSE ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

○ LOW ○ MEDIUM ◉ HIGH

PLANNING AND IMPLEMENTATION:

Stream channels and their processes are complex and dynamic. As a result, restoration of stable dimension, pattern, and profile to a stream channel is a highly technical undertaking. It should only be undertaken with qualified technical assistance.

This practice potentially includes realignment of stream channels as well as widening floodplains, and stabilizing grade. However, stream adjustment to inadequate designs can create greater impacts than the original condition.

Considerations:

1. What are project objectives?
2. What portions of the system are currently working?
3. What are the causes for impairment (including watershed causes) and how can they is addressed?
4. What are the naturally stable dimension, pattern, and profile of the stream channel?
5. What is the minimum practice necessary to achieve project objectives?
6. What monitoring procedures should be implemented to measure success?
7. Management changes to eliminate causes should be considered and implemented first, followed by revegetation and other bioengineering practices using native plants. Structural practices and changes to channel dimension or pattern should be implemented only if other measures are not deemed to be effective.

Riparian Planting Zone: Toe and Bank Zones.

SOURCES OF ADDITIONAL INFORMATION:

TMDL Water Quality Study of the Virgin River Watershed, submitted to Utah Department of Environmental Quality, Division of Water Quality http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

Terrace

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments, Salinity

DESCRIPTION:
A terrace is an earth embankment, channel, or a combination ridge and channel constructed across the slope to intercept runoff water. A terrace provides level surfaces within sloping fields thus increasing irrigation efficiencies and reducing surface sheet flows.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- Vegetated strips between terraces provide a filter for nutrients carried down-slope by runoff

Salinity Reduction- Vegetated strips between terraces provide a filter for salinity carried down slope by runoff

Sediment Reduction – Vegetated strips between terraces provide a filter for sediment carried down slope by runoff

ADDITIONAL BENEFITS:
Increases crop-growing area
Prevents loss of soil from erosion

LAND USE CLASSIFICATION:
Agricultural lands

POTENTIAL TREATMENT AREAS:
Agricultural Lands

ALTERNATIVE MANAGEMENT MEASURES:
Cover Crop
Filter Strip
Irrigation Land Leveling

PERMITTING REQUIREMENTS:
None

Terrace

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments, Salinity

Level 300: MILD ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

○ LOW ◉ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

This practice generally applies to cropland but may also be used on other areas where field crops are grown such as wildlife or recreation lands.

1. Terraces are installed for one or more of the following purposes:
    a. Reduce slope length for erosion control
    b. Reduce sediment content in runoff water
    c. Improve water quality
    d. Intercept and conduct runoff to a safe outlet
    e. Retain runoff for moisture conservation
    f. Prevent gully development
    g. Reform the land surface for better farm ability
    h. Reduce flooding

2. A variety of terrace configurations have developed as a result of research and field experience. Four common types of terraces include broad-based which are farmed on both sides and used on more uniform gently sloping fields; flat channel which are used to conserve moisture; steep back slope which result in a benching effect; and narrow based which have permanent cover planted on both sides of the ridge.
3. Terraces may be parallel on fairly uniform terrain or vary from parallel when the terrain is undulating. Since parallel terraces are more acceptable, designs often provide for cuts and fills to improve terrace alignment and farm ability.
4. Channel grades may be uniform or variable as long as the water velocity is non-erosive and meet other design criteria. The runoff from terraces may be handled by grassed waterways or underground pipe outlets depending on site conditions and economics. Soil infiltration may also be utilized for disposal of runoff when level terraces are installed and the soil is sufficiently permeable to remove the water stored in the channel before crop damage occurs.
5. Terraces require careful design, layout and construction. Additional information including standards and specifications are on file in the local NRCS Field office Technical Guide.

Riparian Planting Zone: Upland Zone and Flood flows.

SOURCES OF ADDITIONAL INFORMATION:

TMDL Water Quality Study of the Virgin River Watershed, submitted to Utah Department of Environmental Quality, Division of Water Quality. http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

Toe Rock

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments

DESCRIPTION:
Toe rock is a layer of rock placed at the base of an eroding stream bank, extending up to bankfull elevation. It is often used in conjunction with other bioengineering practices.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- Prevents erosion of organics-rich streambank soils.

Sediment Reduction – Prevents erosion of streambank and sediment production..

LAND USE CLASSIFICATION:
Agricultural lands
Grazing lands
Urban area

ADDITIONAL BENEFITS:
Streamside

-Providing an area for animals to live

POTENTIAL TREATMENT AREAS:

ALTERNATIVE MANAGEMENT MEASURES:
Brush Trench
Brush Revetment
Post/Pole Plantings
Seeding

PERMITTING REQUIREMENTS:
Permits are required under Sections 404 and 401 of the Clean Water Act.

Contact county regional flood district

Toe Rock

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments

Level 400: MODERATE ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

○ LOW ◉ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

Toe rock is an armoring technique to provide additional strength to stream banks. A variety of rock sizes can be used but must be designed to withstand stream forces. The rock is installed in a trench that extends below the stream scour level. Toe rock should not extend above the elevation of the adjacent floodplain. Often a filter fabric is installed behind the rock to keep stream flows from washing out soils behind the structure.

Riparian Planting Zone: Toe Zone.

SOURCES OF ADDITIONAL INFORMATION:

TMDL Water Quality Study of the Virgin River Watershed, submitted to Utah Department of Environmental Quality, Division of Water Quality. http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

Vertical Bundle

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments, Salinity

DESCRIPTION:
This technique uses bundles of willow cuttings placed in vertical trenches along an eroding streambank. The willow cuttings will sprout and take root, thus stabilizing the streambank with a dense matrix of roots.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- Through plant uptake
Salinity Reduction- Through plant uptake
Sediment Reduction – Vegetation roots will stabilize stream bank

LAND USE CLASSIFICATION:
Agricultural lands
Grazing lands

ADDITIONAL BENEFITS:
Rooted willows will provide basis for the development of riparian plant communities and habitats for riparian animal species.

POTENTIAL TREATMENT AREAS:
Streamside

ALTERNATIVE MANAGEMENT MEASURES:
Brush Revetment
Erosion Control Fabric
Fibeschines/Biologs
Post/Pole Plantings
Seeding

PERMITTING REQUIREMENTS:
Generally none if installed by hand. If vertical bundles are part of an extensive stream project or if mechanical means are used, a permit under Sections 404 & 401 of the Clean Water Act may be required.

Contact county regional flood control district.

Vertical Bundle

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments, Salinity

Level 300: MILD ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

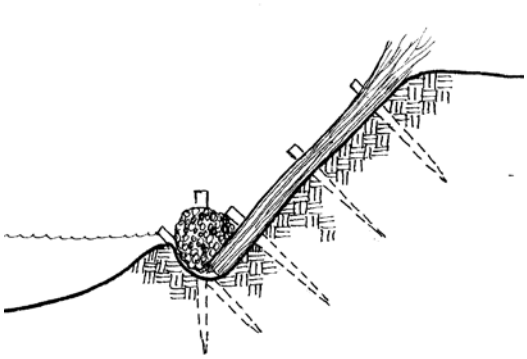
ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

SOURCES OF ADDITIONAL INFORMATION:

http://plant-materials.nrcs.usda.gov/pubs/idpmcpustguid.pdf

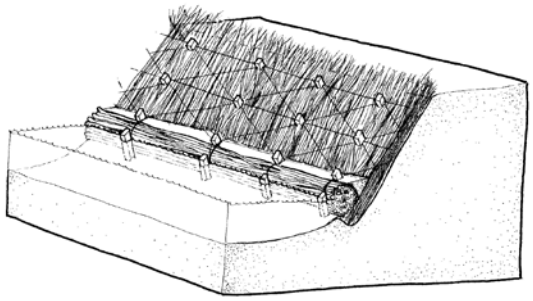
http://www.srnr.arizona.edu/nemo/BMPdocs/StreambankStabilizationManagementMeasures.pd



PLANNING AND IMPLEMENTATION:

1. Coyote willow (Salix exigua) is a particularly good species for this method because of its' dense root system. Seep willow (*Baccharis salicifolia*) is another useful species that is widely available.
2. If this method is used in a highly erodible area, some protection should be placed in front of the wattles to prevent scour. Analysis and calculations of forces will provide guidance for suitable toe protection. In some cases, brush revetment or fiberschines may be adequate, while other situations may require rock. If no other protection is used, the wattle should be 12 to 24 inches in diameter.
3. Another variation of this technique is to cover the wattles with erosion control fabric to prevent the soil from being washed away from the wattles. Secure the fabric under the first wattle. Poles can be planted into the permanent water table between the wattles. The following illustration also shows the use of a rock toe to prevent scour.
4. Rooting hormones and fertilizers do not significantly improve success for the cost of the materials.
5. Never disturb the site unnecessarily. Remember the goal is to stabilize a site. The less it is disturbed, the easier it will be to restore.

Riparian Planting Zone: Toe and Bank



Waste Utilization

POLLUTANTS ADDRESSED: Nutrients and Organics, Pathogens, Sediments

DESCRIPTION:
Waste utilization is the application of agriculture waste or other waste on the land in an environmentally acceptable manner while maintaining or improving the natural resources.

LOAD REDUCTION MECHANISM:

Organics/Nutrients Management- Organic materials in the waste are taken up by soil organisms and plants.
Pathogen Reduction- Pathogens in the waste are eliminated by soil organisms.
Sediment Reduction – Application of agriculture wastes improves soil quality, making it more cohesive.

LAND USE CLASSIFICATION:
Agricultural lands
Grazing lands

ADDITIONAL BENEFITS:
This practice improves soils and provides nutrients for crop growth.

POTENTIAL TREATMENT AREAS:
Agricultural lands

ALTERNATIVE MANAGEMENT MEASURES:
Cover Crops
Grazing Management
Irrigation Management
Nutrient Management

PERMITTING REQUIREMENTS:
Land application of waste requires an ADEQ permit.

Contact county regional flood control district.

Waste Utilization

POLLUTANTS ADDRESSED: Nutrients and Organics, Pathogens, Sediments

Level 200: ACTIVE MANAGEMENT

LOAD REDUCTION POTENTIAL:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. The effect of Waste Utilization on the water budget should be considered, particularly where a shallow ground water table is present or in areas prone to runoff. Limit waste application to the volume of liquid that can be stored in the root zone.

2. Minimize the impact of odors of land-applied wastes by making application at times when temperatures are cool and when wind direction is away from neighbors. Agricultural wastes contain pathogens and other disease-causing organisms. Wastes should be utilized in a manner that minimizes their disease potential.

3. The effect of Waste Utilization on the water budget should be considered, particularly where a shallow ground water table is present or in areas prone to runoff. Limit waste application to the volume of liquid that can be stored in the root zone.

4. Minimize the impact of odors of land-applied wastes by making application at times when temperatures are cool and when wind direction is away from neighbors. Agricultural wastes contain pathogens and other disease-causing organisms. Wastes should be utilized in a manner that minimizes their disease potential.

5. Priority areas for land application of wastes should be on gentle slopes located as far as possible from waterways. When wastes are applied on more sloping land or land adjacent to waterways, other conservation practices should be installed to reduce the potential for offsite transport of waste.

6. It is preferable to apply wastes on pastures and hay land soon after cutting or grazing before re-growth has occurred.

7. Reduce nitrogen volatilization losses associated with the land application of some waste by incorporation within 24 hours.

8. Minimize environmental impact of land-applied waste by limiting the quantity of waste applied to the rates determined using the practice standard Nutrient Management (590) for all waste utilization.

Riparian Planting Zone: Upland Zone and Flood flows.

SOURCES OF ADDITIONAL INFORMATION:

TMDL Water Quality Study of the Virgin River Watershed, submitted to Utah Department of Environmental Quality, Division of Water Quality. http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

Watering Facility

POLLUTANTS ADDRESSED: Nutrients and Organics, Pathogens, Sediments

Photo by Richard Conway
http://ag.arizona.edu/azwater/arroyo/Arroyo_2010.pdf

DESCRIPTION:
This is a watering facility that is a solar powered well pump; it supplies water to livestock in remote location where electrical power is not available. This facility is cost effective and self supporting.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- Reduces animal wastes in streams by providing alternate source of drinking water.
Pathogens- Reduces animal wastes in streams by providing alternate source of drinking water.
Sediment Reduction – Reduces livestock trampling along stream banks.

LAND USE CLASSIFICATION:
Grazing lands

ADDITIONAL BENEFITS:
Better control over livestock movement
Better control over livestock drinking water quality

POTENTIAL TREATMENT AREAS:
Grazing lands

ALTERNATIVE MANAGEMENT MEASURES:
Cross-Vane Weir Diversion
Fencing
Grazing Management

PERMITTING REQUIREMENTS:
Well will require a permit from ADWR.

Watering Facility

POLLUTANTS ADDRESSED: Nutrients and Organics, Pathogens, Salinity, Sediments

Level 300: MILD ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ◉ MEDIUM ○ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

◉ IMMEDIATE ○ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ◉ HIGH

ESTIMATED COST:

○ LOW ◉ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. The purpose of a watering facility is to provide adequate water for livestock and/or wildlife while minimizing impacts to streambanks and other areas that produce sediments.
2. Water facilities should be located to minimize trail erosion and maximize forage.
3. Topography should be evaluated to minimize trail erosion and flooding erosion from tank overflow.
4. Watering facilities should be accessible to small animals. Escape ramps for birds and small animals should be installed.
5. Adequate protection for livestock from wind and snow/ rain during the winter and sun/heat during the summer should be considered.
6. The facility should allow for ice expansion without damage.
7. The facility should require the minimum maintenance possible.

Riparian Planting Zone: Upland and Transition Zones

Willow Fascines

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments, Salinity

DESCRIPTION:
Willow wattles or live fascines are cigar or sausage-like bundles of live cuttings tied together and inserted into a shallow trench dug into the streambank. Plants will sprout and create a dense matrix of roots stabilizing the slope of the bank.

LOAD REDUCTION MECHANISM:

Nutrients/Organics Management- Willow and associated plants will take up nutrient materials.
Salinity Reduction- Willow and associated plants will take up salts.
Sediment Reduction – Plant roots will stabilize stream bank, reducing sediment production.

LAND USE CLASSIFICATION:
Agricultural lands
Grazing lands
Urban areas

ADDITIONAL BENEFITS:
Promotes development of riparian plant communities along the streambank which will also provide habitat for other riparian species.

POTENTIAL TREATMENT AREAS:
Streamside

ALTERNATIVE MANAGEMENT MEASURES:
Brush Mattress
Erosion Control Fabric
Pole Plantings
Seeding
Tree Planting
Vertical Bundles

PERMITTING REQUIREMENTS:
Generally none if installed by hand. If part of an extensive stream project or if mechanical means are used, a permit under Sections 404 & 401 of the Clean Water Act may be required.

Willow Fascines

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments, Salinity

Level 300: MILD ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

◉ LOW ○ MEDIUM ○ HIGH

ESTIMATED COST:

◉ LOW ○ MEDIUM ○ HIGH

PLANNING AND IMPLEMENTATION:

1. Coyote willow (Salix exigua) is a particularly good species for this method because of its' dense root system. Seep willow (*Baccharis salicifolia*) is another useful species that is widely available..

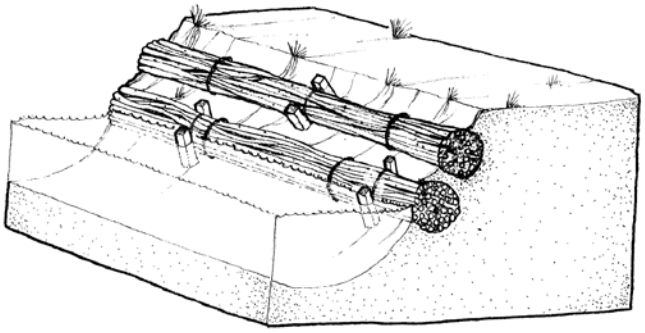
2. If this method is used in a highly erodible area, some protection should be placed in front of the wattles to prevent scour. Analysis and calculations of forces will provide guidance for suitable toe protection. In some cases, brush revetment or fiberschines may be adequate, while other situations may require rock. If no other protection is used, the wattle should be 12 to 24 inches in diameter.

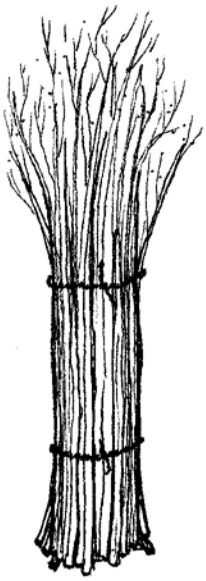
3. Another variation of this technique is to cover the wattles with erosion control fabric to prevent the soil from being washed away from the wattles. Secure the fabric under the first wattle. Poles can be planted into the permanent water table between the wattles. The following illustration also shows the use of a rock toe to prevent scour.

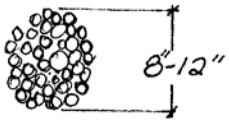
4. Rooting hormones and fertilizers do not significantly improve success for the cost of the materials.

5. Never disturb the site unnecessarily. Remember the goal is to stabilize a site. The less it is disturbed, the easier it will be to restore.

Riparian Planting Zone: Toe and Bank Zones.







Willow Fascines

POLLUTANTS ADDRESSED: Nutrients and Organics, Sediments, Salinity

Level 300: MILD ENGINEERING

LOAD REDUCTION POTENTIAL:

○ LOW ○ MEDIUM ◉ HIGH

ESTIMATED TIME FOR LOAD REDUCTION:

○ IMMEDIATE ◉ MONTHS-2 YEARS ○ > 2 YEARS

EXPECTED MAINTENANCE:

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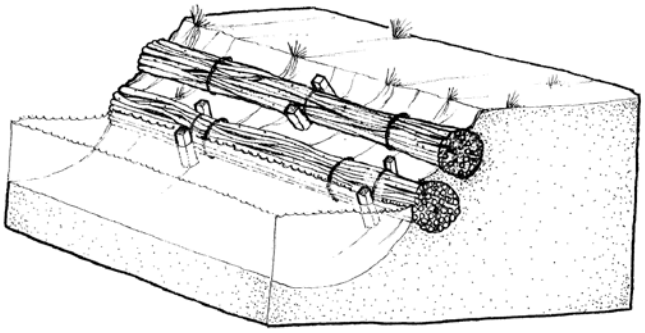
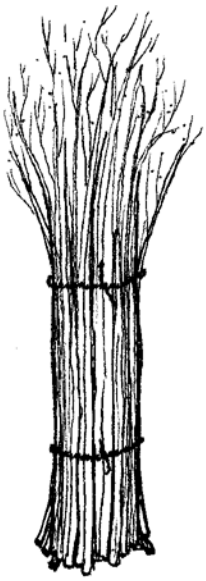
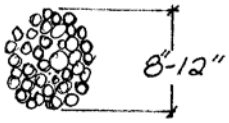






Chapter: 3 Reducing Nonpoint Sources

3.1 A Community Plan

The strategic plan of any community groups, for the protection and /or restoration of its water resources (or watershed), must contain specific development standards, education/public outreach, and partnership goals and objectives that will strengthen its nonpoint source program. The goals of a plan should:

Community volunteers at Wet/Dry mapping session
Photo courtesy of NEMO

1. Protect surface or groundwater resources by preventing and reducing nonpoint pollution sources.

2. Coordinate efforts of various programs within the community with other agencies, such as ADEQ, The University of Arizona Cooperative Extension, and Arizona NEMO, to reduce nonpoint source pollution impacts to surface and groundwater.

3. Identify surface waters or aquifers that are impaired or not attaining water quality standards in the community's watershed then take actions to reduce pollutant loadings, to meet water quality standards, and to delist impairments; watershed assessment data is available at http://www.azdeq.gov/environ/water/assessment/assess.html.

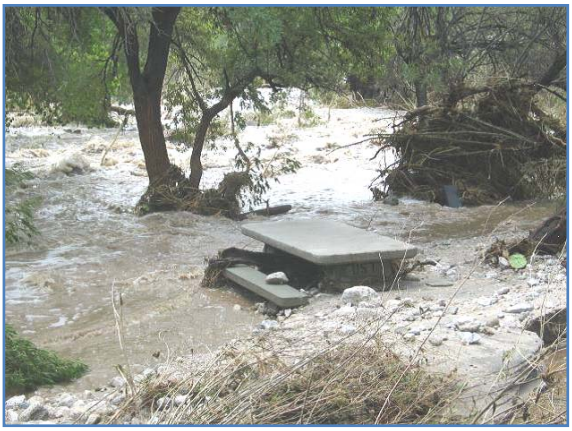
4. Evaluate and improve the effectiveness of nonpoint source pollution projects and communicate the success to the general public.

The strategic plan should further describe how resources (volunteers, funding and policy focus) will be allocated to achieve the goals and objectives of a nonpoint source program. This chapter will highlight some development standards and public education/public outreach programs that will assist in this objective.

3.2 Development Standards and Ordinances as a Best Management Practice

Storm water is responsible for flushing of nonpoint source pollutants to drainage ways and contributes significantly to water quality contamination in Arizona. Local ordinances are used to manage NPS from storm water. Most municipal areas, because of flood events, have created "Flood Control Districts", to establish flood control regulations that reduce the impacts of flood waters in urban area. Storm water management is

regulated under the federal Clean Water Act provisions administered by ADEQ through the Arizona Pollutant Discharge Elimination System (AZPDES). These regulations apply to storm water runoff once the water enters the streets in heavily populated urban areas (at least 50,000 people and density of 1000 people per square mile). To reduce water quality impacts from storm water, Arizona's Nonpoint Source Program works with numerous agencies such as county flood control agencies, municipalities, the AZPDES Storm Water Permit Program, and other watershed partners. (For more information on local requirements, check with the flood control department in your county)



Flood water in Sabino Canyon in 2005 after fire on Mount Lemmon
Photo courtesy of ADEQ NPS Plan

The Environmental Protection Agency (EPA) in 2009 launched its "Green Infrastructure in Arid and Semi-Arid Climate" program to promote innovative stormwater management techniques using rainwater harvesting on a community wide basis. These techniques promote 1) rain gardens and swales into the street designs (green streets) to retain and treat stormwater while beautifying streets and slowing traffic; 2) green roofs (vegetated roofs) on buildings which reduce and treat stormwater runoff; and 3) riparian buffers to restrict development in the land adjacent to washes, arroyos, creeks, or streams which would reduce erosion, capture pollutants and preserve channel form and function. The EPA promotes these techniques as a low-cost efficient way of managing stormwater runoff. For more information on green infrastructure visit: www.epa.gov/greeninfrastructure and www.epa.gov/smartgrowth.

The City of Tucson's "Ordinance No. 10-03.0 Commercial Rainwater Harvesting" is an example of how communities are managing NPS originating from storm water. The Tucson ordinance establishes development standards that require the utilization of rainwater for landscape irrigation in commercial development to reduce dependency on potable and reclaimed water sources, and reduce transport of nonpoint source pollutants to surface water. New commercial development must fill 50% of its landscape water demand by using harvested rainwater. For more information the ordinance visit the City of Tucson's website at: http://www.ci.tucson.az.us/water/docs/rainwaterord.pdf.

Water harvesting system in Tucson Arizona
Photo courtesy of Technicians for Sustainability

In 1999 and 2000 Arizona enacted its "Smart Growth" legislation. The legislation created a Scorecard as an incentive-

based tool to help cities, towns and counties evaluate their growth management efforts and encourage more comprehensive strategies that lead to smarter land use decisions. Entities applying for grants and loans from participating state funding programs must reference this Scorecard. This approach also encourages citizens, non-profit organizations, shareholders, and other entities to talk with their community leaders, to make sure that a Scorecard is filled out. For more information visit website: http://www.azcommerce.com/doclib/smartgrowth/scorecard/smartgrowthscorecard.pdf

3.3 Education/Public Outreach

The education and public outreach goals of a community plan are 1) education of targeted audiences that empowers them to be actively involved in project implementation, and 2) change long-term behavior. Public outreach and information dissemination has been identified as an important component of watershed project programs. The benefits to a community's riparian systems can be multiplied by effective dissemination of information about projects. This raises awareness of conservation issues in the community by demonstrating useful methods and the impacts of specific community projects.

Public outreach efforts can be divided into two categories. The first includes approaches that directly reach the public such as on-site workshops, interpretive signs/trails, and project tours. The second category includes knowledge-based approaches such as articles in newspapers, magazines, newsletters, and technical journals. Public workshops are common outreach method, followed by interpretive signs and published articles (Final Report: Arizona Water Protection Fund).

Workshops:

Volunteer involvement is critical throughout the planning and implementation of "best management practices" and local watershed improvement strategies. The assessment, planning, implementation and management of watershed protection strategies are iterative processes driven by continuous evaluation and adaptation. The Environmental Protection Agency (EPA) has outlined a series of steps to involve volunteers in local watershed improvement strategies:

1. Define the watershed and the nested hydrologic units (subwatersheds);
2. Conduct initial outreach; organize volunteers and technical teams;
3. Establish broad consensual goals and/or conduct a visioning exercise;
4. Collect relevant watershed and community assessment information;
5. Analyze and evaluate information; identify and address data gaps;
6. Assess, prioritize, and analyze key concerns and issues;

7. Develop management objectives and strategies for implementation; and,
8. Implement, evaluate, and adapt selected management actions.

Volunteers need to be involved at each stage of the process. Their knowledge of local, social, economic, political, and ecological conditions provide invaluable knowledge to the project. Also, the goals, problems and remediation strategies generated by the volunteers define what's desirable and achievable.

Target Audiences:

The targeted audiences for education and outreach may include developers, private land owners and managers, livestock growers, home owners, citizen groups, and other shareholders.

Education Programs**:**

Education materials and support can be provided by a variety of programs including but not limited to the University of Arizona's Water Resource Research Center (WRRC) that hosts, Arizona Nonpoint Education of Municipal Officials (NEMO) program, Arizona Master Watershed Steward Program, as well as Arizona Project WET. For example:

NEMO – This program helps communities protect their natural resources while still accommodating growth through education of land use decision makers. NEMO is designed to address issues related to water quality or quantity in the state of Arizona. This is accomplished through research-based education and outreach using geographic information systems (GIS) and other advanced technologies. NEMO's website provides interactive mapping capabilities, Best Management Practices by land use categories, watershed-based plans for the entire state, and links to other agencies and watershed partners (for more information about NEMO visit website: http://www.ArizonaNEMO.org).

Community volunteers attending a NEMO informal education session

Project WET – This project provides water education programs for teachers and students in all grade levels. Since 2000, Project Wet has trained hundreds of teachers, who in turn report reaching thousands of students annually. In addition, "Make a Splash with Project WET" water festivals have engaged 4th grade students and teachers in standards-base water education across Arizona (for more information about Project WET visit website: http://cals.arizona.edu/arizonawet.

Master Watershed Stewards – This program educates and trains citizens to serve as volunteers in the protection, restoration, monitoring, and conservation of their watersheds. More than 300 stewards have graduated from certification classes since the program was initiated in 2004. Other classes and workshops have been developed to fulfill specific watershed needs (e.g., pollutant(s) of concern, monitoring, pollutant mitigation techniques, grant writing). For more information about the Master Watershed Steward program visit website: http://wwwcals.arizona.edu/watershedsteward/

These programs work through the University of Arizona Cooperative Extension Service, in partnership with entities like the Arizona Department of Water Resources and the Arizona Department of Environmental Quality (ADEQ) Water Quality Division. The goal of these programs is to engage average citizen in understanding water management practices and to motivate them into taking action to protect their watersheds. For more information on these programs and their services visit their individual websites or Water Resources Research Center (WRRC): http://www.ag.arizona.edu/azwater.

3.4 Partnerships

One area where a community plan must focus a great deal of its energy is bringing state, federal, local agencies, and citizens together to form partnerships. These partnerships are essential for low or no cost materials, technical support and grant funding to implement various aspects of its watershed protection program. ADEQ has more than 20 watershed partnerships working on water quality and quantity issues.

Forming Watershed Partnership Photo courtesy of

One example is the Friends of the Santa Cruz River (FOSCR), which was formed in 1991 to protect and enhance the Santa Cruz River. Discarded pollutants, residential sewage, and trash all gather in Nogales Wash with other urban tributaries coming out of Nogales Mexico and run into the Santa Cruz River. This pollution directly threatens the health of the river and border residents. Groundwater pumping also threatens the river's flow. Members of the Friends of the Santa Cruz River became involved in watershed education, monitoring of water quality, on-the-ground conservation projects, community outreach, and vegetation mapping. Their persistent advocacy for the river and their public involvement in water quality protection has been instrumental in achieving the international agreements needed to obtain improvements in wastewater facilities in both Mexico and the United States. Such efforts and partnerships throughout Arizona must be created and sustained in the future, in order to protect and/or restore Arizona's

watersheds. For more information on the Friends of the Santa Cruz River visit their website at: http://www.friendsofsantacruzriver.org/.

Grant Funding Source:

The Arizona Department of Environmental Quality Water Quality Improvement Grant (WQIG) Program allocates money from the United States Environmental Protection Agency (EPA) to interested parties for implementation of nonpoint source management and watershed protection. The distribution of grant funds from EPA is provided pursuant to Section 319(h) of the Clean Water Act and administered by the ADEQ Water Quality Division. ADEQ uses these federal funds to implement on-the-ground water quality improvement projects to control nonpoint source pollution. For more information about WQIG visit website: http://www.azdeq.gov/environ/water/watershed/fin.html . For information on successful implementation of BMPs visit the EPA Grants Reporting Tracking System (GRTS) at: http://www.epa.gov/nps/success/.

Appendix A: Glossary of Terms and Acronyms

ADEQ – Arizona Department of Environmental Quality

BMPs – Best Management Practices

Bioaccumulate - Accumulation of substances, such as pesticides (DDT is an example), methylmercury, or other organic chemicals in an organism or part of an organism. The accumulation process involves the biological sequestering of substances that enter the organism through respiration, food intake, epidermal (skin) contact with the substance, and/or other means.

Calcic - Composed of, containing, derived from, or relating to calcium or lime.

EPA – The U.S. Environmental Protection Agency, a government agency whose mission is "…to protect human health and the environment."

Eutrophication - Process whereby water bodies, such as lakes, estuaries, or slow-moving streams receive excess nutrients that stimulate excessive plant growth (algae, and nuisance plants weeds).

GIS – Geographic Information Systems. A software program that combines different layers of information (streams, land use, cities, counties, elevation, etc.) for analysis.

GPS- Global Positioning System. Hand-held or larger devices that triangulate your position on earth from satellites in orbit. One can take reading(s) at a sample site, and later download this data onto a map.

Imperviousness – Impenetrable surfaces such as driveways, roads, etc.

Lentic - Still waters as in lakes or ponds.

Limnology - The scientific study of bodies of fresh water for their biological and physical and geological properties.

Lotic - Relating to or living in actively moving water.

NEMO - Nonpoint Education for Municipal Officials

Nonpoint source pollution – Also known as "runoff pollution." Nonpoint source pollution is a major contributor to water pollution in the United States and in other countries. Nonpoint source pollution comes from a broader area. Nonpoint source pollutants are picked up and transported during rain and snowmelt events. The rain and/or snowmelts pick up human-made and/or natural pollutants and transport them into lakes, rivers, wetlands, and groundwater.

Oxidation - The combination of a substance with oxygen. A reaction in which the atoms in an element lose electrons and the valence of the element is correspondingly increased.

Point source pollution – Pollution which enters the water from specific locations (such as a discharge pipe from a factory or wastewater facility, an oil or chemical spill).

Residual - Something left after other parts have been taken away.

TMDL – Total Maximum Daily Load. A TMDL is a regulation that specifies the sum of the pollutant contributions from point source discharges, *nonpoint* (diffuse) sources, and natural background levels that a water body can process and still meet water quality standards.

Turbidity - Thick or opaque with or as if with roiled sediment (a turbid stream).

Tributary – Smaller streams that feed into a larger portion of the main stream or river.

Watershed – The area of land that drains to a common water body.

Appendix B: References

Other Resources/Links:

ADEQ's Streambank Stabilization Management Measures document.
http://nemo.srnr.arizona.edu/nemo/BMPdocs/StreambankStabilizationManagementMeasures.pdf.
Arizona Riparian Council: http://azriparian.org/.
Agriculture and Irrigation practices: http://nemo.srnr.arizona.edu/nemo/index_old.php?page=bmpagriculture
AWPF Grant Projects Evaluation Phases I & II: Case Studies.
http://www.azwpf.gov/Grant_Project_Reports/documents/PhaseIFinalReport.pdf.
Green Infrastructure for Southwest Neighborhoods; Watershed Management Group.
http://www.watershedmg.org/sites/default/files/greenstreets/WMG_GISWNH_1.0.pdf.
Livestock grazing: http://nemo.srnr.arizona.edu/nemo/index_old.php?page=bmpgrazing.
Mining and Abandoned mine land: http://nemo.srnr.arizona.edu/nemo/index_old.php?page=bmpmining
Onsite septic systems: http://nemo.srnr.arizona.edu/nemo/index_old.php?page=bmpseptic
Riparian Areas: http://nemo.srnr.arizona.edu/nemo/index_old.php?page=bmpriparian.
Soil Erosion: http://nemo.srnr.arizona.edu/nemo/index_old.php?page=bmperosion.
Urban runoff / Stormwater / Rainwater Harvesting:
http://nemo.srnr.arizona.edu/nemo/index_old.php?page=bmpstormwater.

Chapter 1: Introduction – Nonpoint Pollution in Arizona

Arizona water quality standards
http://www.azsos.gov/public_services/Title_18/18-11.htm
Arizona impaired waterbodies report
http://www.azdeq.gov/environ/water/assessment/monitoring.html
Arizona groundwater assessment report
http://www.azdeq.gov/environ/water/assessment/assess.html
Aquifer Protection Permits
http://www.azdeq.gov/environ/water/permits/app/html
Inactive Arizona mines report
http://www.asmi.state.az.us/faq.asp.
Active Arizona mines report
http://www.admmr.state.az.us/info/mining_update2007.pdf
Arizona Department of Environmental Quality (ADEQ). 2009. Arizona's Nonpoint Source State Management Plan. Phoenix, Arizona. http://www.azdeq.gov/environ/water/watershed/download/final5.pdf.

Chapter 2: Best Management Practices for the control of NPS

Levick, L., D. Goodrich, M. Hernandez, D. J. Semmens, J. Stromberg, R. Leidy, M. Apodaca, P. Guertin, M. Tluczek, and W. G. Kepner, 2007.
Utah Department of Water Quality Division; Virgin River Watershed Appendix A: Implementation Practices; "Riparian Planting Zones in the Intermountain West", NRCS, Plant Material Center, Aberdeen, ID.
Figure 1. Hoag, et al., 2001. Riparian Planting Zone in the Intermountain West. Information Series # 16. NRCS – Plant Material Center, Aberdeen, ID.

Chapter 3: Reducing Nonpoint Sources

Final Report: Arizona Water Protection Fund (AWPF) Grant Projects Evaluation; Phase II case studies).
http://www.azdeq.gov/environ/water/assessment/assess.html
Green Infrastructure in Arid and Semi-Arid Climate
www.epa.gov/greeninfrastructure
EPA Smart Growth Guidelines
www.epa.gov/smartgrowth
Arizona's Smart Growth Scorecard
http://www.azcommerce.com/doclib/smartgrowth/scorecard/smartgrowthscorecard.pdf
City of Tucson's Ordinance No. 10-03.0 Commercial Rainwater Harvesting
http://www.ci.tucson.az.us/water/docs/rainwaterord.pdf
Arizona NEMO
http://www.ArizonaNEMO.org
Arizona W.E.T.
http://www.cals.arizona.edu/arizonawet.
Arizona Master Watershed Stewards
http://ag.arizona.edu/watershedsteward
University of Arizona Water Resources Research Center
http://www.ag.arizona.edu/azwater
ADEQ Water Quality Improvement Grant Program
http://www.azdeq.gov/environ/water/watershed/fin.html
EPA Nonpoint Source Funding Program
http://iaspub.epa.gov/grts/projects

Implementation Work Sheets

The Practical Streambank Bioengineering Guide prepared by Gary Bentrup and J. Craig Hoag, Interagency Riparian/Wetland Plant Development Project, USDA Natural Resources Conservation Service, Plant Materials Center, has been incorporated into this document.
http://www.waterquality.utah.gov/TMDL/Virgin_River_Watershed_Implementation_Appendix.pdf

BRUSH LAYER

SOURCES OF ADDITIONAL INFORMATION:

Gray, Donald H., and Robbin B. Sotir. 1996. Biotechnical and Soil Bioengineering Slope Stabilization*: A* Practical Guide for Erosion Control*.* John Wiley and Sons, Inc., New York.
Schiechtl, H.M., and R. Stern. 1994. Water Bioengineering Techniques for Watercourse, Bank and Shoreline Protection. Blackwell Science, Berlin.

BRUSH MATTRESS

Gray, Donald H., and Robbin B. Sotir. 1996. Biotechnical and Soil Bioengineering Slope Stabilization: A Practical Guide for Erosion Control*.* John Wiley and Sons, Inc., New York.
Schiechtl, H.M., and R. Stern. 1994. Water Bioengineering Techniques for Watercourse, Bank and Shoreline Protection. Blackwell Science, Berlin.

BRUSH REVETMENT

SOURCES OF ADDITIONAL INFORMATION:

Gray, Donald H., and Robbin B. Sotir. 1996. Biotechnical and Soil Bioengineering Slope Stabilization: A Practical Guide for Erosion Control*.* John Wiley and Sons, Inc., New York.
Schiechtl, H.M., and R. Stern. 1994. Water Bioengineering Techniques for Watercourse, Bank and

Shoreline Protection. Blackwell Science, Berlin.

BRUSH TRENCH

SOURCES OF ADDITIONAL INFORMATION:

Gray, Donald H., and Robbin B. Sotir. 1996. Biotechnical and Soil Bioengineering Slope Stabilization*: A* Practical Guide for Erosion Control*.* John Wiley and Sons, Inc., New York.

Schiechtl, H.M., and R. Stern. 1994. Water Bioengineering Techniques for Watercourse, Bank and Shoreline Protection*.* Blackwell Science, Berlin.

CONSTRUCTED WETLAND

SOURCES OF ADDITIONAL INFORMATION:

Design Manual: Constructed Wetlands and Aquatic Plant System for Municipal Wastewater Treatment, EPA 1988

http://epa.gov/wetlands/pdf/design.pdf

BrookHaven National Laboratory Technology Factsheet: Wetlands Restoration/Constructed Wetlands.

http://www.bnl.gov/erd/Peconic/Factsheet/Wetlands.pdf

CONSTRUCTION SITE MANAGEMENT

SOURCES OF ADDITIONAL INFORMATION:

Developing Your Stormwater Pollution Prevention Plan*:* A Guide for Construction Sites, prepared by the US Environmental Protection Agency, has been incorporated into this document.

http://www.epa.gov/npdes/pubs/sw_swppp_guide.pdf

COVER CROP

SOURCES OF ADDITIONAL INFORMATION:

ATTRA: Overview of Cover Crops and Green Manures, 2003

http://attra.ncat.org/attra-pub/PDF/covercrop.pdf

AWQA: Cost Studies Publication; Annually Planted Cover Crops

http://www.awqa.org/pubs/CostEstimates/PlantedCoverCrop.pdf

Developing Your Stormwater Pollution Prevention Plan: A Guide for Construction Sites, prepared by the US Environmental Protection Agency, and Estimated Costs and Potential Benefits for an Annually Planted Cover Crop, prepared for the U.C. Cooperative Extension Service by Laura Tourte and Merilee Buchanan*,* has been incorporated into this document

http://www.epa.gov/npdes/pubs/sw_swppp_guide.pdf

CROSS-VANE WEIR DIVERSION

SOURCES OF ADDITIONAL INFORMATION:

CONSERVATION PRACTIVE STANDARD, DAM, DIVERSION, PREPARED FOR THE NATURAL RESOURCES CONSERVATION SERVICE*,* HAS BEEN INCORPORATED INTO THIS DOCUMENT.

http://dnrc.mt.gov/permits/stream_permitting_book/chap6.d

DETENTION BASIN

SOURCES OF ADDITIONAL INFORMATION:

Conservation Practive Standard, Structure for Water Control, prepared for the Natural Resources Conservation Service*,* has been incorporated into this document.)

EROSION CONTROL FABRIC

SOURCES OF ADDITIONAL INFORMATION:

The Practical Streambank Bioengineering Guide prepared by Gary Bentrup and J. Craig Hoag, Interagency Riparian/Wetland Plant Development Project, USDA Natural Resources Conservation

Service, Plant Materials Center, has been incorporated into this document. http://www.srnr.arizona.edu/nemo/BMPdocs/StreambankStabilizationManagementMeasures.pdf.

EXOTIC REMOVAL

SOURCES OF ADDITIONAL INFORMATION:

Conservation Practice Brush Management, prepared for the Natural Resources Conservation Service, has
been incorporated into this document. http://www.nps.gov/redw/naturescience/exotic-vegetation.htm

FENCING

SOURCES OF ADDITIONAL INFORMATION:

Streambank Stabilization Management Measures, prepared for the Arizona Department of Water Quality, has been incorporated into this document.
http://www.extension.iastate.edu/agdm/livestock/html/b1-75.html

FIBERSCHINES/BIOLOGS

SOURCES OF ADDITIONAL INFORMATION:

The Practical Streambank Bioengineering Guide prepared by Gary Bentrup and J. Craig Hoag, Interagency Riparian/Wetland Plant Development Project, USDA Natural Resources Conservation Service, Plant Materials Center, has been incorporated into this document.
http://plant-materials.nrcs.usda.gov/pubs/idpmcpustguid.pdf

FILTER STRIP

SOURCES OF ADDITIONAL INFORMATION:

Vegetation Buffers prepared for the National Pollution Discharge Elimination System (NPDES) of the US Environmental Protection Agency has been incorporated into this document.
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=browse&Rbutton=detail&bmp=50&minmeasure=4

GRADE STABILIZATION STRUCTURE

SOURCES OF ADDITIONAL INFORMATION:

Streambank Stabilization Management Measures, prepared for the Arizona Department of Water Quality, has been incorporated into this document.
http://www.extension.iastate.edu/agdm/livestock/html/b1-75.html

GRAZING MANAGEMENT

SOURCES OF ADDITIONAL INFORMATION:

Pollution Runoff (Nonpoint Source Pollution): Grazing Management prepared for the US Environmental Protection Agency and Conservation Practice Standard, Prescribed Grazing prepared for the Natural Resources Conservation Service has been incorporated into this document.
http://www.epa.gov/nps/MMGI/Chapter2/ch2-2e.html

IRRIGATION LAND LEVELING

SOURCES OF ADDITIONAL INFORMATION:

Conservation Practice Standard, Irrigation Land Leveling prepared for the Natural Resources Conservation Service has been incorporated into this document.)
http://efotg.nrcs.usda.gov/references/public/NM/464.pdf

IRRIGATION PIPELINE

SOURCES OF ADDITIONAL INFORMATION:

Farm Water Quality Management Practice, Irrigation Systems, Sprinkler, #442, prepared by the University of California Cooperative Extension, Natural Resources Conservation Service.
http://extension.oregonstate.edu/catalog/html/pnw/pnw290/

IRRIGATION SYSTEM, DRIP

SOURCES OF ADDITIONAL INFORMATION:

TMDLs for Total Dissolved Solids in the Duchesne River Watershed, prepared for the US Environmental Protection Agency by the Utah Department of Environmental Quality, Division of Water Quality, and the NRCS New Jersey Irrigation Guide, prepared for the US Department of Agriculture, Natural Resources Conservation Service, has been incorporated into this document.
http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

IRRIGATION SYSTEM, SPRINKLER

SOURCES OF ADDITIONAL INFORMATION:

Conservation Practice Standard, Irrigation Land Leveling prepared for the Natural Resources Conservation Service.
http://www.ag.ndsu.edu/pubs/ageng/irrigate/ae91.pdf

IRRIGATION SYSTEM, SURFACE

SOURCES OF ADDITIONAL INFORMATION:

Conservation Practice Standard, Irrigation System, Surface and Subsurface, prepared by the Natural Resources Conservation Service, have been incorporated into this document.
http://www.ag.ndsu.edu/pubs/ageng/irrigate/ae91.pdf

IRRIGATION SYSTEM, TAIL WATER RECOVERY

SOURCES OF ADDITIONAL INFORMATION:

Conservation Practice Standard, Irrigation System, Surface and Subsurface, prepared by the Natural Resources Conservation Service, have been incorporated into this document.
http://www.ag.ndsu.edu/pubs/ageng/irrigate/ae91.pdf

IRRIGATION WATER MANAGEMENT

SOURCES OF ADDITIONAL INFORMATION:

Farm Water Quality Management Practice, Irrigation Systems, Sprinkler, #442, prepared by the University of California Cooperative Extension, Natural Resources Conservation Service.
http://extension.oregonstate.edu/catalog/html/pnw/pnw290/

MULCHING

SOURCES OF ADDITIONAL INFORMATION:

Conservation Practice Standard, Mulching, prepared by the Natural Resources Conservation Service, has been incorporated into this document.
ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/484.pdf

NUTRIENT MANAGEMENT

SOURCES OF ADDITIONAL INFORMATION:

Water Quality and Animal Feeding Operations in Arizona: A Producer's Notebook, prepared by the Concentrated Animal Feeding Operation Education Group for the University of Arizona Cooperative Extension, Natural Resources Conservation Service, and has been incorporated into this document.
http://www.nrcs.usda.gov/technical/NRI/pubs/cnmp1f.pdf

POLE/POST PLANTING

SOURCES OF ADDITIONAL INFORMATION:

The Practical Streambank Bioengineering Guide prepared by Gary Bentrup and J. Craig Hoag, Interagency Riparian/Wetland Plant Development Project, USDA Natural Resources Conservation Service, Plant Materials Center, has been incorporated into this document.)
http://plant-materials.nrcs.usda.gov/pubs/idpmcpustguid.pdf

RESIDUE MANAGEMENT

SOURCES OF ADDITIONAL INFORMATION:
Soil Conservation Program, Agriculture in Montcalm County, Michigan, has been incorporated into this document
http://www.montcalm.org/agriculture0030.asp

ROAD STABILIZATION

SOURCES OF ADDITIONAL INFORMATION:
Streambank Stabilization Management Measures, prepared by the Arizona Department of Environmental Quality, has been incorporated into this document
http://www.srnr.arizona.edu/nemo/BMPdocs/StreambankStabilizationManagementMeasures.pdf

ROCK RIP RAP

SOURCES OF ADDITIONAL INFORMATION:
Streambank Stabilization Management Measures, prepared by the Arizona Department of Environmental Quality, has been incorporated into this document
http://www.srnr.arizona.edu/nemo/BMPdocs/StreambankStabilizationManagementMeasures.pdf

ROCK VANE/BARB

SOURCES OF ADDITIONAL INFORMATION:
TMDL Water Quality Study of the Virgin River Watershed, submitted to Utah Department of Environmental Quality, Division of Water Quality, has been incorporated into this document.
http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

ROCK WEIR

SOURCES OF ADDITIONAL INFORMATION:
TMDL Water Quality Study of the Virgin River Watershed, submitted to Utah Department of Environmental Quality, Division of Water Quality, has been incorporated into this document.
http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

SEEDING

SOURCES OF ADDITIONAL INFORMATION:
TMDL Water Quality Study of the Virgin River Watershed, submitted to Utah Department of Environmental Quality, Division of Water Quality, has been incorporated into this document.
http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

SILT FENCE

SOURCES OF ADDITIONAL INFORMATION:
TMDL Water Quality Study of the Virgin River Watershed, submitted to Utah Department of Environmental Quality, Division of Water Quality, has been incorporated into this document.
http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

SLOPED DRAIN

SOURCES OF ADDITIONAL INFORMATION:
TMDL Water Quality Study of the Virgin River Watershed, submitted to Utah Department of Environmental Quality, Division of Water Quality, has been incorporated into this document.
http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

STRAW ROLL/BALE BARRIER

SOURCES OF ADDITIONAL INFORMATION:
TMDL Water Quality Study of the Virgin River Watershed, submitted to Utah Department of

Environmental Quality, Division of Water Quality, has been incorporated into this document.
http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

STREAM CHANNEL STABILIZATION

SOURCES OF ADDITIONAL INFORMATION:

TMDL Water Quality Study of the Virgin River Watershed, submitted to Utah Department of Environmental Quality, Division of Water Quality, has been incorporated into this document.
http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

TERRACE

SOURCES OF ADDITIONAL INFORMATION:

TMDL Water Quality Study of the Virgin River Watershed, submitted to Utah Department of Environmental Quality, Division of Water Quality, has been incorporated into this document.
http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

TOE ROCK

SOURCES OF ADDITIONAL INFORMATION:

TMDL Water Quality Study of the Virgin River Watershed, submitted to Utah Department of Environmental Quality, Division of Water Quality, has been incorporated into this document.
http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

VERTICAL BUNDLE

SOURCES OF ADDITIONAL INFORMATION:

The Practical Streambank Bioengineering Guide prepared by Gary Bentrup and J. Craig Hoag, Interagency Riparian/Wetland Plant Development Project, USDA Natural Resources Conservation Service, Plant Materials Center, and from *TMDL Water* Quality Study of the Virgin River Watershed, submitted to Utah Department of Environmental Quality, Division of Water Quality has been incorporated into this document. http://plantmaterials.nrcs.usda.gov/pubs/idpmcpustguid.pdf

WASTE UTILIZATION

SOURCES OF ADDITIONAL INFORMATION:

TMDL Water Quality Study of the Virgin River Watershed, submitted to Utah Department of Environmental Quality, Division of Water Quality, has been incorporated into this document.
http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

WATERING FACILITY

SOURCES OF ADDITIONAL INFORMATION:

TMDL Water Quality Study of the Virgin River Watershed, submitted to Utah Department of Environmental Quality, Division of Water Quality, has been incorporated into this document.
http://www.waterquality.utah.gov/TMDL/Duchesne_River_Watershed_TMDL.pdf

WILLOW FASCINES

SOURCES OF ADDITIONAL INFORMATION:

The Practical Streambank Bioengineering Guide prepared by Gary Bentrup and J. Craig Hoag, Interagency Riparian/Wetland Plant Development Project, USDA Natural Resources Conservation Service, Plant Materials Center, and from *TMDL Water* Quality Study of the Virgin River Watershed, submitted to Utah Department of Environmental Quality, Division of Water Quality has been incorporated into this document.
http://plantmaterials.nrcs.usda.gov/pubs/idpmcpustguid.pdf