Off-stream Watering with Fencing and Off-stream Watering without Fencing Practices

Definitions and Nutrient and Sediment Reduction Efficiencies

For use in calibration and operation of the Chesapeake Bay Program's Phase 5.0 Watershed Model

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Summary

Offstream watering with fencing: This BMP incorporates both alternative watering and installation of fencing that excludes narrow strips of land along streams from pastures and livestock with management of the alternative watering area so it does not become a source of sediment or phosphorus.

- Effectiveness Estimates: 25% TN, 30% TP and 40% TSS

Offstream watering without fencing: This BMP requires the use of alternative drinking water sources away from streams to reflect partial removal of livestock from near stream areas and relocation of animal waste deposition areas and heavy traffic areas surrounding water sources to more upland locations with management of the alternative drinking watering area so it does not become a source of sediment or phosphorus.

- Effectiveness Estimates: 15% TN, 22% TP and 30% TSS

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University Of Maryland (UMD) led a project during 2006-2007 to review and refine definition and effectiveness estimates for BMPs implemented and reported by the Chesapeake Bay watershed jurisdictions prior to 2003. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers and county stormwater officials, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

One important outcome of the project is the wealth of documentation compiled on the BMPs. Previously, BMP documentation was limited and the CBP has been criticized for this in the press and in governmental reviews. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

To review efficiencies MAWQ contracted with an expert, Theo Dillaha, and asked him to review applicable literature and propose an efficiency for model calibration based on the literature and their experience. See Appendix A for his report. MAWP in consultation with the Nutrient Subcommittee (NSC) workgroups adapted Dillaha's recommendations to reflect average expected performance of stream protection measures. Attached to these definitions and efficiencies is a full accounting of the Chesapeake Bay Program's discussions on this BMP, who was involved, and how recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed. All meeting minutes are included in Appendix F.

Off-stream Watering with Fencing Practices

Definition

This BMP incorporates both alternative watering and installation of fencing that excludes narrow strips of land along streams from pastures and livestock. The implementation of stream fencing should substantially limit livestock access to streams but can allow for the use of limited hardened crossing areas where necessary to accommodate access to additional pastures or for livestock watering.

The fenced areas may be planted with trees or grass, but are typically not wide enough to provide the full benefits of buffers. When a fencing system is installed, the excluded land is not considered a buffer unless specific buffer installation criteria are met, as outlined by the National Resource Conservation Service (see Riparian Forest Buffer and/or Grass Buffer BMP reports for details). In situations where installation criteria are met jurisdictions are eligible to receive credit for off-stream watering with fencing and a riparian buffer on pasture land. Buffers are reported as a separate practice from off-stream watering with fencing, and are currently implemented between cropland and receiving waterways. While stream protection may provide some buffer like function when vegetated at a specified width, it is buffering a very low loading land use and the major benefit is from keeping cows out of creeks and streambanks. Fencing or stream protection is a pasture management practice. UMD/MAWP recommends developing effectiveness estimates for buffers implemented on pastureland.

Practice components meet criteria standards under the USDA-NRCS National Handbook of Conservation Practices (NHCP) (http://www.nrcs.usda.gov/technical/standards/nhcp.html) and associated Field Office Technical Guides (http://www.nrcs.usda.gov/technical/efotg/) for each state. Components included in the Off-stream Watering with Fencing Practices include, but may not be limited to the following USDA-NRCS conservation practices:

- Fence (382)
- Heavy Use Area Protection (561)
- Pipeline (516)
- Pond (378)
- Pumping Plant (533)
- Spring Development (574)
- Streambank and Shoreline Protection (580)
- Stream Crossing (578)
- Use Exclusion (472)
- Water Harvesting Catchment (636)
- Water Well (642)
- Watering Facility (614)

Note that credit cannot be taken for each practice; one or a suite of practices may be required to meet the definition of Off-stream Watering without Fencing Practices for the credited land acreage.

Future Research Need

For the future, when jurisdictions report the cumulative effects of stream protection with fencing and functional buffers, UMD/MAWP recommends defining and evaluating the effectiveness of pasture buffers as an individual BMP. Pasture buffers should be assigned their own efficiency and not rely on cropland buffer efficiency estimates to represent pasture buffer effectiveness.

Follow-up study

National Fish and Wildlife Foundation study in Virginia for Shenandoah County

Off-Stream Watering without Fencing Practices

Definition

This BMP requires the use of alternative drinking water sources away from streams. The BMP may also include options to provide off-stream shade for livestock, and implementing a shade component is encouraged where applicable. The hypothesis on which this practice is based is that, given a choice between a clean and convenient off-stream water source and a stream, cattle will preferentially drink from off-stream water source and reduce the time they spend near and in streams and streambanks. The net effectiveness of the practice must reflect partial removal of livestock from near stream areas and relocation of animal waste deposition areas and heavy traffic areas surrounding water sources to more upland locations. (Source: Chesapeake Bay Program Nutrient Subcommittee Agricultural Nutrient Reduction Workgroup. Agricultural BMP Descriptions as Defined for the Chesapeake Bay Program Watershed Model. March 31, 2004, http://www.chesapeakebay.net/pubs/waterqualitycriteria/doc-Ag_BMP_Defns.pdf (Accessed August 28, 2006)).

Practice components meet criteria standards under the USDA-NRCS National Handbook of Conservation Practices (NHCP) (http://www.nrcs.usda.gov/technical/standards/nhcp.html) and associated Field Office Technical Guides (http://www.nrcs.usda.gov/technical/efotg/) for each state. Components included in the Off-stream Watering Without Fencing Practices include, but may not be limited to the following USDA-NRCS conservation practices:

- Heavy Use Area Protection (561)
- Pipeline (516)
- Pond (378)
- Pumping Plant (533)
- Spring Development (574)
- Water Harvesting Catchment (636)

- Water Well (642)
- Watering Facility (614)

Note that credit cannot be taken for each practice; one or a suite of practices may be required to meet the definition of Off-stream Watering without Fencing Practices for the credited land acreage.

Future Research Need

UMD/MAWP recommends the Chesapeake Bay Program explore the extra benefit of adding shaded areas for livestock to pastures with off-stream watering without fencing. Some emerging literature shows how efficiencies change by adding structures that provide shade. The idea is that livestock will enter the stream less frequently on hot days if off-stream watering and shade are both provided.

Recommended Efficiency

Off-stream Watering with Fencing

The primary benefit of this BMP is exclusion of livestock from the stream and stream corridor delineated by the fencing. Livestock either drink from tanks, troughs, or similar systems away from the stream or from narrow hardened access points along the stream, which allows livestock to drink but not loiter in the stream.

Potential Environmental Benefits and Methods of Action:

- Livestock exclusion from stream. Direct deposition of livestock manure into streams is immediately eliminated (or greatly reduced if cattle have access to a few hardened access points for drinking). Pollutant loadings that are not deposited in the stream are redirected/deposited in adjacent pastures.
- Livestock exclusion from riparian zone. Livestock do not have access to the riparian zone protected by the fence, which decreases streambank disturbance and potential nutrient and sediment loadings from the fenced riparian area during stormflow events. Pollutant loadings that are not deposited in the stream are redirected/deposited in adjacent pastures.
- Protection of stream substrate. Livestock do not disturb the stream bottom when drinking, loitering in the stream, or crossing the stream, Depending on the type of stream substrate, this eliminates sediment and nutrient resuspension from bottom sediments and substrate.
- Regeneration of riparian zone vegetation. Exclusion of livestock from a portion of the riparian zone allows the fenced portion of the riparian zone to revegetate and act as a full or partial buffer.

Potential Negative Environmental Consequences and Methods of Action:

- Pollutant losses from watering sites. If not designed and maintained properly, off-stream watering sites can become a concentrated source of nutrients and sediments that can be carried to streams during surface runoff events and/or can contribute dissolved nutrient loadings to interflow and groundwater. The area around the watering points must be hardened and properly drained so that it is not continuously wet and muddy. In addition, accumulated manure must be regularly collected and spread in adjacent pastures. There should not be a well defined drainageway leading from the watering site as this would facilitate transport of sediment and nutrients to down slope streams during runoff events. Down slope, adjacent pasture should be maintained in good condition so that it acts as a buffer zone, with shallow uniform flow, to traps sediments and nutrients that may be washed from the watering site.

Off-stream Watering without Fencing

With off-stream watering without fencing, the benefits are similar to off-stream watering with fencing except that exclusion of livestock from the stream and stream corridor is only partial. The hypothesis on which this practice is based is that, given a choice between a clean and convenient off-stream water source and a stream, cattle will preferentially drink from off-stream water source and reduce the time they spend near and in streams. Off-stream watering without fencing may include off-stream shade, and is recommended, if the only other shade is in the riparian zone.

Potential Environmental Benefits and Methods of Action:

- Partial livestock exclusion from stream. Direct deposition of livestock manure into streams is reduced. Pollutant loadings that are not deposited in the stream are redirected/deposited in adjacent pastures.
- Partial livestock exclusion from riparian zone. Livestock spend less time moving through the riparian zone when going to drink, reducing streambank disturbance and potential nutrient and sediment loadings from the riparian area during stormflow events. Pollutant loadings that are not deposited in the stream are redirected/deposited in adjacent pastures.
- Partial protection of stream substrate. Stream bottom disturbance is reduced because cattle do not drink, loiter in, or cross the stream as much. Depending on the type of stream substrate, this reduces sediment and nutrient resuspension from bottom sediments and substrate.
- Partial regeneration of riparian zone vegetation. Reduced livestock activity in the riparian zone allows partial restoration of the riparian zone and its buffer functions.

Potential Negative Environmental Consequences and Methods of Action:

- The potential for pollutant losses from watering sites, as discussed for off-stream watering with fencing, is also true for off-stream watering without fencing.

UMD/MAWP contracted with Dr. Theo Dillaha, Virginia Tech, to conduct a literature review of off-stream watering practices and provide a report on the practice definitions and efficiencies. He used two journal articles and a research report to develop his proposed BMP efficiencies:

- Galeone, Daniel G., Robin A. Brightbill, Dennis J. Low, and David L. O'Brien. 2006. Effects of Streambank Fencing of Pasture Land on Benthic Macroinvertebrates and the Quality of Surface Water and Shallow Ground Water in the Big Spring Run Basin of Mill Creek Watershed, Lancaster County, Pennsylvania, 1993-2001. Scientific Investigations Report 2006–5141. U.S. Geological Survey, Reston, Virginia.
- Line, D.E., W.A. Harman, G.D. Jennings, E.J. Thompson, and D.L. Osmond. 2000. Nonpoint-Source Pollutant Load Reductions Associated with Livestock Exclusion. *Journal of Environmental Quality*. 29(6):1882-1890.
- Sheffield, R.E., S. Mostaghimi, D.H. Vaughan, E.R. Collins Jr., and V.G. Allen. 1997. Off-Stream Water Sources for Grazing Cattle as a Stream Bank Stabilization and Water Quality BMP. *TRANSACTIONS of the ASAE*, 40(3):595-604.

Dillaha recommended reducing the reported literature efficiency values by 50%. He stated his justifications for reducing the efficiencies as:

- ***Off-stream watering with fencing:*** To be conservative, since the results are from a single study, Theo Dillaha recommended reducing the reported reduction values by 50%.
- ***Off-stream watering without fencing:*** Data from two studies are used and are compared with data with fencing. To be conservative Theo Dillaha recommended reducing the reported reduction values by 50%. He also required the reductions to be less than those for off-stream watering with fencing because the literature review indicated that off-stream watering reduced but did not eliminate livestock activities in streams (80-90% reduction) and riparian areas (50% reduction).

After conducting a ranking exercise it became apparent the 50% reduction in effectiveness for off-stream watering was too severe after comparing the efficiencies to other agricultural BMPs. Using the 50% reduction for off-stream watering with fencing would equate it to Total Phosphorous (TP) reductions associated with conservation plans field and pasture erosion control practices. Conservation plans reduce nutrients and sediment by increased vegetative assimilation, increased trapping and retention of transported nutrient enriched sediment and particulates, improved water infiltration and nutrient adsorption to the soil matrix, and reduced erosion and transport of nutrient enriched sediment and particulates. Fencing practices will also reduce TP by the same mechanisms described above, and will also regenerate riparian zone vegetation allowing buffers to grow, providing some filtering benefits of buffers. In addition, fencing has the potential to further reduce nutrients and sediment compared to conservation plans primarily by eliminating or hindering direct deposition of livestock manure into streams, nutrient and sediment loadings from riparian area during stormflow are reduced, and sediment and nutrient resuspension from bottom sediments and substrate is eliminated. These benefits are considered mechanisms that greatly reduce nutrient and sediment loadings and will have a greater ability to reduce pollutant loadings than field and pasture erosion control plans.

In this case, the literature did not support the current reduction efficiencies, so some adjustment to current estimates was warranted. However, the developer used a conservative view of the literature values and then reduced them by 50% based on his experience to account for variability and uncertainty. While the literature made it evident that some reductions were needed, UMD/MAWP and Chesapeake Bay Program (CBP) partners felt the developer had reduced the efficiencies further than warranted, and effectiveness estimates selected should close to the conservative literature base that the developer cited (Appendix A).

As a general rule during the BMP efficiency development process, for all TP efficiencies where specific data is not available on phosphorous the TP load reductions were calculated to be 75% of the sediment reductions to account for soluble phosphorous losses. In the Chesapeake Bay watershed dissolved reactive phosphorous is assumed to be 25% and sediment bound phosphorous is 75% of the total phosphorous load (Sharpley et al 1993). Thus 75% of the TSS load reduction is an estimate of the sediment bound phosphorous reductions. Dissolved reactive phosphorous will not be reduced with a sediment reduction.

BMP	TN Reduction	TP Reduction	TSS Reduction
Off-stream watering w/ fencing	25%	30%	40%
Off-stream watering w/out fencing	15%	22%	30%

Off-stream Watering with Fencing and Rotational Grazing Practices

The review of the definition of this practice has been delayed until the Year 2 portion of the BMP Project due to the following reasons:

- Rotational grazing is a stand alone BMP that should be considered for its overall impact on forage and livestock management. It should not be solely compared to pasture losses, as was done when linked with stream protection measures and rotational grazing should be encouraged broadly, not just when pastures are in stream.
- The development of additional grazing management practices in Year 2 of the project will be reflective of the review of this practice. Both sets of practices should be developed in unison to enable compatible definitions and efficiencies.

- CBP partners, including New York State, Pennsylvania, and USDA-NRCS have requested that a final definition and efficiency be developed with additional research sources.

From this review it became apparent that rotational grazing should be separated into a stand alone BMP. It may be necessary to have different management levels or intensities for rotational grazing. MAWQ recommends:

- That the CBP separate Rotational Grazing from the other Year 1 pasture BMPs for further refinement in Year 2 of the BMP project.
- That additional research data be obtained to develop definitions and efficiencies for pasture management systems including Rotational Grazing and Precision Rotational Grazing BMPs that are separate from stream corridor management.

How Modeled

The effectiveness estimate assigned to off-stream watering with fencing and off-stream watering without fencing assumes the practice will be applied to a stream corridor land use category that represents average, natural stream segments with low nutrient loading rates. Degraded land uses proposed for use in Phase 5 of WSM have increased nutrient loads compared to average pasture lands. If the effectiveness estimates are applied to a degraded stream corridor land use than estimates need to be revised to account for the higher nutrient loading rates from the degraded land use category. There may be a limit to the nutrient and hydrologic treatment capacity of the BMP that will exceed its ability to achieve the proposed effectiveness estimates on a degraded land use.

Reference:

Sharpley, A.N., Daniel, T.C., and D.R. Edwards. 1993. Phosphorus movement in the landscape. J. Prod. Agr. 6(4):492-500.

Appendix A: Report by Theo Dillaha

Off-stream Watering with Fencing,
Off-stream Watering without Fencing,
Off-stream Watering with Fencing and Rotational Grazing

Strategies for Estimating Nutrient
and Sediment Reduction Efficiencies

For use in calibration and operation of the
Chesapeake Bay Program's Phase 5.0 Watershed Model

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Introduction

This document summarizes the recommended definitions, nutrient and sediment reduction efficiencies, and strategies for simulating the effects of BMPs involving off-stream watering. The BMPs considered include:

- Off-stream watering with fencing.
- Off-stream watering without fencing.
- Off-stream watering with fencing and rotational grazing.

The recommendations contained within are proposed for review and approval by the Tributary Strategy and Source Area Workgroups. Attached to this report are the BMP definitions and efficiencies found in literature that were provided by the University of Maryland as the basis for this review. This report describes (1) a proposed procedure for using HSPF to directly simulate the effects of reduced cattle access to streams and (2) recommended changes in the provided reduction efficiencies and the scientific basis for the proposed changes. It should be noted that the proposed efficiencies have an unusually high degree of uncertainty because they are based on only three field studies, and, as described in this report, each of these field studies had significant experimental limitations and/or problems. It is highly recommended that the Bay Program sponsor field research to provide better estimates of the effectiveness of these BMPs.

Basis for Review

The following material was provided by the University of Maryland as the basis for this review:

1. Review instructions/contract (Appendix A).
2. BMP definitions.
3. BMP efficiencies found in two journal articles and one research report. (Appendices B to D).
4. The two journal articles and research report used in developing the proposed BMP efficiencies:
    - Galeone, Daniel G., Robin A. Brightbill, Dennis J. Low, and David L. O'Brien. 2006. Effects of Streambank Fencing of Pasture Land on Benthic Macroinvertebrates and the Quality of Surface Water and Shallow Ground Water in the Big Spring Run Basin of Mill Creek Watershed, Lancaster County, Pennsylvania, 1993-2001. Scientific Investigations Report 2006–5141. U.S. Geological Survey, Reston, Virginia.
    - Line, D.E., W.A. Harman, G.D. Jennings, E.J. Thompson, and D.L. Osmond. 2000. Nonpoint-Source Pollutant Load Reductions Associated with Livestock Exclusion. *Journal of Environmental Quality*. 29(6):1882-1890.
    - Sheffield, R.E., S. Mostaghimi, D.H. Vaughan, E.R. Collins Jr., and V.G. Allen. 1997. Off-Stream Water Sources for Grazing Cattle as a Stream Bank Stabilization and Water Quality BMP. *TRANSACTIONS of the ASAE*, 40(3):595-604.
5. A report on the long-term effectiveness of BMPs:
    - Rosenthal, Alon, and Don Urban. 1989. *BMP Longevity: A Pilot Study*. Submitted to U.S. EPA, Chesapeake Bay Liaison Office, Office of Program Policy and Evaluation, Office of Water.

BMPs Considered and Definitions

The BMPs considered in this report include:

- Off-stream watering with fencing.
- Off-stream watering with fencing and rotational grazing.
- Off-stream watering without fencing.

Definitions of the BMPs provided by the University of Maryland with recommended changes are:

Off-stream Watering with Fencing

Definition: ~~From Agricultural BMP Descriptions As Defined For The Chesapeake Bay Program Watershed Model – Direct contact of pastured animals with surface water results in direct deposition of animal waste, streambank erosion, and re-suspension of sediments and associated nutrients held in streambeds. There are three unique systems that are variations to this BMP. The variations include off stream watering: (1) without stream fencing, (2) with stream fencing, and (3) with stream fencing and rotational grazing. The systems are mutually exclusive, so reduction efficiencies are not additive. With fencing –~~ This BMP incorporates both alternative watering and installation of fencing that ~~involves~~ *excludes* narrow strips of land along streams ~~to exclude~~ *from pastures and* livestock. The fenced areas may be planted with trees or grass, but are typically not wide enough to provide *the full* benefits of buffers. The implementation of stream fencing should substantially limit livestock access to streams but can allow for the use of limited hardened crossing areas where necessary to accommodate access to additional pastures or for livestock watering. (Source: Agricultural BMP Descriptions As Defined For The Chesapeake Bay Program Watershed Model ?)

Off-stream Watering with Fencing and Rotational Grazing

Description: Off-stream watering with stream fencing and rotational grazing (pasture) combines stream fencing and alternative watering with cross fencing systems, creating paddocks to enable rapid grazing of small areas in sequence. Once *the vegetation in a paddock is grazed to a height of approximately 5 cm* ~~an area is intensively grazed of most vegetative matter~~, the animals are moved to another paddock to enable *rapid* recovery of the *paddock vegetation* ~~pasture grasses~~. This BMP is beneficial in removing animals from stream areas *and in improving vegetative cover, which can increase vegetative uptake of nutrients, decrease surface runoff by promoting increased infiltration, and reduce erosion. However, these benefits may be offset in part or whole by increased stocking densities.* ~~but may be offset by an increased animal stocking rate per acre. This increases the concentration of~~ *Increased stocking densities can increase unit area loadings of livestock manure to adjacent pastures* ~~animal manure *loadings* per acre~~ and may adversely affect the quality of surface water runoff. (Source: Chesapeake Bay Program Agriculture Nutrient Reduction Workgroup, Agricultural BMP Descriptions, 11/3/03.)

Examples: Managing forage height through ~~mechanical means,~~ stocking rates, *limiting grazing time,* supplemental feeding and other methods.

Off-Stream Watering without Fencing

Definition: This BMP requires the use of alternative drinking water *sources* ~~troughs or tanks~~ away from streams. The BMP may also include options to provide *off-stream* shade for livestock. ~~away from streams. Limited research has been conducted for this practice that documents changes in livestock behavior resulting in significantly less time spent~~ *The hypothesis on which this practice is based is that, given a choice between a clean and convenient off-stream water source and a stream, cattle will preferentially drink from off-stream water source and reduce the time they spend* near ~~streambanks~~ and in streams. The net effectiveness of the practice must reflect partial removal of livestock from near stream areas and relocation of animal waste deposition areas and heavy traffic areas surrounding water sources to more upland locations. (Source: Chesapeake Bay Program Nutrient Subcommittee Agricultural Nutrient Reduction Workgroup. Agricultural BMP Descriptions as Defined for the Chesapeake Bay Program Watershed Model. March 31, 2004, http://www.chesapeakebay.net/pubs/waterqualitycriteria/doc-Ag_BMP_Defns.pdf (Accessed August 28, 2006)).

Processes and Factors Affecting BMP Performance

Off-stream Watering with Fencing

The primary benefit of this BMP is exclusion of livestock from the stream and stream corridor delineated by the fencing. Livestock either drink from tanks, troughs, or similar systems away from the stream or from narrow hardened access points along the stream, which allows livestock to drink but not loiter in the stream.

Potential Environmental Benefits and Methods of Action:

- Livestock exclusion from stream. Direct deposition of livestock manure into streams is immediately eliminated (or greatly reduced if cattle have access to a few hardened access points for drinking). Pollutant loadings that are not deposited in the stream are redirected/deposited in adjacent pastures.
- Livestock exclusion from riparian zone. Livestock do not have access to the riparian zone protected by the fence, which decreases streambank disturbance and potential nutrient and sediment loadings from the fenced riparian area during stormflow events. Pollutant loadings that are not deposited in the stream are redirected/deposited in adjacent pastures.
- Protection of stream substrate. Livestock do not disturb the stream bottom when drinking, loitering in the stream, or crossing the stream, Depending on the type of

stream substrate, this eliminates sediment and nutrient resuspension from bottom sediments and substrate.
- Regeneration of riparian zone vegetation. Exclusion of livestock from a portion of the riparian zone allows the fenced portion of the riparian zone to revegetate and act as a full or partial buffer.

Potential Negative Environmental Consequences and Methods of Action:

- Pollutant losses from watering sites. If not designed and maintained properly, off-stream watering sites can become a concentrated source of nutrients and sediments that can be carried to streams during surface runoff events and/or can contribute dissolved nutrient loadings to interflow and groundwater. The area around the watering points must be hardened and properly drained so that it is not continuously wet and muddy. In addition, accumulated manure must be regularly collected and spread in adjacent pastures. There should not be a well defined drainageway leading from the watering site as this would facilitate transport of sediment and nutrients to down slope streams during runoff events. Down slope, adjacent pasture should be maintained in good condition so that it acts as a buffer zone, with shallow uniform flow, to traps sediments and nutrients that may be washed from the watering site.

Off-stream Watering with Fencing and Rotational Grazing

With off-stream watering and fencing and rotational grazing, the benefits of this BMP are the same as with off-stream watering and fencing described above (exclusion of livestock from the stream and stream corridor delineated by the fencing). There should be additional benefits due to increased vegetative cover and activity in the adjacent paddocks. These additional benefits may be offset in part or whole by increased stocking densities, which can increase unit area loadings of livestock manure to adjacent pastures and may adversely affect the quality of surface water runoff. With good rotational grazing management, stocking densities may be increased by a factor of two or more. Whether stocking densities increase or not is a site-specific landowner decision.

Environmental Benefits and Methods of Action:

- Livestock exclusion from stream.
- Livestock exclusion from riparian zone.
- Protection of stream substrate.
- Regeneration of riparian zone vegetation.
- Reduced sediment and nutrient transport from adjacent pastures: Increased vegetative cover in adjacent pastures will promote increased vegetative uptake of nutrients, decreased surface runoff by promoting increased infiltration, and decreased erosion.

Potential Negative Environmental Consequences and Methods of Action:

- Pollutant losses from watering sites.
- The benefits of increased vegetative cover and growth may be offset in part or whole by increased stocking densities, which increase unit area loadings of livestock manure to adjacent pastures.

Off-stream Watering without Fencing

With off-stream watering without fencing, the benefits are similar to off-stream watering with fencing except that exclusion of livestock from the stream and stream corridor is only partial. The hypothesis on which this practice is based is that, given a choice between a clean and convenient off-stream water source and a stream, cattle will preferentially drink from off-stream water source and reduce the time they spend near and in streams. To further enhance the effectiveness of off-stream watering without fencing, off-stream shade must be provided if the only available shade is in the riparian zone.

Potential Environmental Benefits and Methods of Action:

- Partial livestock exclusion from stream. Direct deposition of livestock manure into streams is reduced. Pollutant loadings that are not deposited in the stream are redirected/deposited in adjacent pastures.
- Partial livestock exclusion from riparian zone. Livestock spend less time moving through the riparian zone when going to drink, reducing streambank disturbance and potential nutrient and sediment loadings from the riparian area during stormflow events. Pollutant loadings that are not deposited in the stream are redirected/deposited in adjacent pastures.
- Partial protection of stream substrate. Stream bottom disturbance is reduced because cattle do not drink from the stream as much. Sediment and nutrient resuspension from bottom sediments and substrate is reduced.
- Partial regeneration of riparian zone vegetation. Reduced livestock activity in the riparian zone allows partial restoration of the riparian zone and its buffer functions.

Potential Negative Environmental Consequences and Methods of Action:

- Pollutant losses from watering sites.

Literature Review BMP Efficiencies

Galeone et al. (2006) Study

Galeone et al. (2006) conducted a seven- to eight-year study in Lancaster, Pennsylvania, on the effects of streambank fencing on stream water quality. Effects of fencing on benthic macroinvertebrates and the quality of surface and shallow ground water were investigated. The study consisted of a nested experimental design including paired watersheds, and upstream/downstream and pre- and post-BMP implementation comparisons. The pre-BMP monitoring lasted three to four years, and the post-BMP monitoring period lasted four years. Approximately 2 miles of stream were fenced in the 1.42 mi^2 treatment watershed. Fencing created buffer strips 5 feet to 12 feet wide on each side of the stream. Off-stream watering sources were not provided. Each pasture was supplied with a cattle crossing at which livestock could drink or cross to pastures on the other side of the stream. The type of stream cattle crossing was not described, but because cattle could drink from the stream at the crossing, it would not have been elevated. Monitoring was conducted at the locations indicated in Table 1. In addition, a system of shallow groundwater wells was sampled.

Table 1. Galeone et al. monitoring sites with base-flow and stormflow sampling

Site	Description	Area, mi^2	Data use
C-1	Outlet of control basin	1.77	Compare to T-1 and T-2 for paired basin analysis
T-1	Outlet of treatment basin	1.42	Compare to C-1 for paired basin analysis and T-3 for upstream-downstream analysis
T-2	Upstream tributary in treatment basin	0.36	Compare to C-1 for paired basin analysis and T-4 for upstream-downstream analysis
T-4	Upstream tributary above all pasture in treatment basin	0.32	Compare to T-2 for upstream-downstream analysis

Baseflows were sampled 25 to 30 times per year and 35 to 60% of storm events were sampled. Water quality samples were analyzed for: nitrate, nitrite, dissolved ammonia, dissolved Kjeldahl nitrogen, TKN, dissolved P, Total P, and suspended sediment. The research encountered several significant problems, which introduce significant uncertainty into the reported results:

1. Precipitation was 5-in/year higher during the pre-treatment period than the post-treatment period. This resulted in a decrease in streamflow during the post-treatment period of 56 to 63%. This decrease in runoff would have greatly reduced NPS loadings from pervious land segments during the post-treatment phase and falsely contributed to reported BMP efficiencies.
2. Nitrogen and P fertilizer applications decreased 27 to 33%, respectively, in the treatment basin from the pre- to post-BMP treatment periods. In contrast, in the control basin, N and P applications decreased by 3% and increased by 7%, respectively. These differences would tend to contribute to an overestimation of treatment effectiveness.
3. The number of cattle in the control and treatment basins decreased by approximately 50% between the pre- and post-BMP periods. In the control watersheds, the cattle populations decreased over the last two years. In the treatment watershed, the decrease occurred during the last year of the study. These differences would tend to contribute to an overestimation of treatment effectiveness.

Because of the research problems encountered above, comparison of pre- and post-BMP implementation is of little value. Results based on differences in constituent yields between the control (C-1) and treatment watersheds (T-1 and T-2) during the post-BMP period are reported in Table 2 but should be used with caution because of the problems cited above. As shown in Table 2, there are substantial differences in results for the T-1 and T-2 watersheds. For the larger T-1 treatment watershed, which is comparable in size to the C-1 control watershed, streamside fencing without cattle access to the stream at cattle crossings for drinking decreased all nutrient loadings by 18 to 36% except for dissolved P, which increased by 19%. In contrast, for the smaller treatment watershed, nutrient losses were higher than those from the treatment watershed. The only consistent reduction was in suspended sediment, where sediment yields were reduced by 37 to 44% for the T-1 and T-2 watersheds, respectively.

Table 2. Constituent yields for the treated sites (T-1 and T-2) for the post-treatment period compared with the control basin (C-1) based on analysis of covariance (ANCOVA).

Constituent	T-1 to C-1 Comparison	T-2 to C-1 Comparison
Dissolved nitrate	-18%	+15%
Dissolved nitrite	-28%	+15%
Dissolved ammonia	-36%	+10%
Dissolved TKN	-20%	+30%
TKN	-26%	+43%
Dissolved phosphorus	+19%	+94%
Total phosphorus	-14%	+51%
Suspended sediment	-37%	-44%

In summary, while this study is the most comprehensive in terms of the effects of stream-side fencing available, its results have a high degree of uncertainty because of the extreme changes that occurred between the pre-and post-BMP implementation periods. In addition, results based on comparison of the treatment and control watersheds during the post-BMP implementation period are contradictory. The study does suggest that stream-side fencing and limiting cattle access to streams decrease sediment yields.

Line et al. (2000) Study

Line et al. (2000) conducted a four-year study in the Piedmont Region of North Carolina on the effects of off-stream watering, with and without stream-bank fencing, on surface water quality. The study consisted of a nested experimental design with upstream/downstream and pre- and post-BMP implementation comparisons. The pre-BMP monitoring period lasted 81 weeks, and the post-BMP monitoring period lasted 137 weeks. There were two monitoring sites on Kiser Branch. Site E was at the watershed outlet and drained approximately 56.7 ha. Site D was located approximately 355 m upstream of site E on Kaiser Branch and drained 41.8 ha (designated as Subwatershed D).

BMP Installation: The 355 m of stream between sites D and E (subwatershed D-D) was fenced along both sides of the stream, and a buffer zone 10 m to 16 m wide was created along each side of the stream. A 94-m long intermittent stream in subwatershed D-E was also fenced, and a 3-m buffer was created on each side of the intermittent drainageway. Fencing separated subwatershed D-E from subwatershed E. A severely eroding section of the stream bank between sites D and E was graded and seeded after fencing was installed. In addition, the riparian buffer between D and E was planted with soft and hardwood trees 3-m on center. A low-water cattle crossing was installed across the stream, but it was unclear if cattle could drink at the crossing.

Off-stream watering sources were provided in the pastures of both subwatersheds D-E and E, so the treatment difference between the two watersheds was fencing. Subwatershed E was lightly grazed and was not a good control for subwatershed D-E, which was intensively grazed and contained a farmstead with a dairy, numerous structures, manure storage facilities, etc. Approximately one-half the area of subwatershed D-E was estimated to be denuded or covered with impervious areas.

Discharge was measured continuously at sites D and E by USGS. Grab samples were collected weekly for water quality analysis, and three samples were collected with automated samplers during stormflow events to characterize stormwater flow. Total precipitation on an annual basis was similar during the pre- and post-BMP periods. Water quality samples were analyzed for: nitrate-nitrite, TKN, Total P, TSS, and total solids. The research had several significant problems, which introduce significant uncertainty into the reported results:

1. Although precipitation on an annual basis was similar during the pre- and post-BMP periods, there were four major storms (>100 mm) during the pre-BMP implementation phase and no similar storms during the post-BMP period. The larger storms during the pre-BMP period would be expected to produce more runoff, which they did (≈28% more on an annual basis), and greater NPS loadings to the streams than during the post-BMP implementation period. This would probably result in reported efficiencies that are too low.
2. The stormwater sampling methodology was rather coarse, three samples per storm event, and probably inaccurately represented stormwater flow concentration and yields.
3. There was no control treatment since the land uses in the two subwatersheds were so different.
4. The riparian buffers created in subwatershed D-E, are 10 to 16-m wide and thus constitute functional buffers, which would be expected to reduce pollutant loading to the stream. Channel regarding and stabilization, another structural BMP implement, also would have reduced sediment and contaminant losses. In addition, during the pre-BMP period, additional BMPs were installed, including improved stock trails, heavy use area protection, a large waste-holding pond, and a waste irrigation system. This experiment evaluated the combined effects of all of these BMPs in subwatershed D-E.

The results of this experiment, with its associated uncertainties, are presented in Table 3. Comparison of the pre- and post-BMP results for Site D, which represented the effects of off-stream watering without fencing in a pasture with low stocking density, shows that off-stream watering reduced nitrate-nitrate, TSS, and total solids loadings by 41, 38, and 44% respectively, and increased TKN and Total-P loadings by 27 and 13%, respectively. These results are somewhat surprising because one would have expected the TKN and Total-P loadings to decrease with the lower sediment yields if they were sediment bound, or to infiltrate and decrease like nitrate-nitrite if they were predominantly dissolved like nitrate-nitrite.

Subtracting the loadings at site D from those of site E theoretically gives the changes in loadings from subwatershed D-E. The system of BMPs in this subwatershed significantly reduced all pollutant loadings except nitrate-nitrite. Nitrate-nitrite, TKN, Total-P, TSS, and TS were reduced by 33, 79, 76, 82, and 83%, respectively. As indicated previously, fencing was just one of the BMPs that contributed to these reductions.

Table 3. Mean weekly discharge and pollutant loads for monitoring sites D and E

Site/Period	Discharge	Nitrate-nitrite	TKN	Total-P	TSS	Total solids
	m^3/wk	kg/wk				
Site D, Upstream subwatershed (effects of off-stream watering without fencing on water quality in low stocking density pastures)						
Pre-BMP	3,594a#	8.2a	11.8a	3.9a	1,657a	2,736a
Post-BMP	2,612a	4.8a	15.0a	4.4a	1,031a	1,531a
Reduction	27%	41%	-27%	-13%	38%	44%
Site E, Entire watershed (effects of a system of many BMPs)						
Pre-BMP	6,997a	18.7a	127.8a	54.2a	12,733a	17,846a
Post-BMP	4,135b	11.8b	39.9b	16.6b	2,988b	4,302b
Reduction	41%	37%	69%	69%	77%	76%
Between Site D and E, Downstream subwatershed (effects of a system of many BMPs)						
Pre-BMP	3,403a	10.5a	116.0a	50.3a	11,076a	15,110a
Post-BMP	1,523b	7.0a	24.9b	12.2b	1,957b	2,771b
Reduction	55%	33%	79%	76%	82%	82%

Within factors and sites, means followed by the same letter are not statistically different at the 0.05 level.

Sheffield et al. (1997) Study

Sheffield et al. (1997) conducted a 15-month study on the effects of off-stream watering on cattle behavior and water quality in the Ridge and Valley region of southwest Virginia. Cattle behavior was observed at three locations. Water quality data was collected only at one location: River Ridge Farm in Independence, Virginia. During the first seven months of the study (pre-BMP), cattle drank from a stream at each site. Water troughs were then installed in the pastures, and the cattle had access to either the troughs or the streams for drinking. The experimental design was for pre- and post-BMP implementation comparison. No mention was made of collection of stormwater samples. The site with water-quality monitoring had a recording rain gauge, and stream flow measurements were made with a bucket and stopwatch at a pond outlet pipe. Grab water quality samples were collected at two-week intervals. Samples were tested for: total suspended solids (TSS), nitrate-nitrogen (NO_3-N), ammonium (NH_4-N), total nitrogen (TN), orthophosphorus (PO_4-P), total phosphorus (TP), fecal coliform (FC), fecal streptococci (FS), and total coliform (TC).

Cattle Behavior: Cattle were observed at each of the three field sites for a day during both the pre- and post-BMP periods. The time that the cattle spent drinking from the stream and trough and the time that the cattle spent in the stream or trough areas (defined as time spent within 4.6 m of the center of the stream or from the edge of the trough) were recorded at five-minute intervals through the day (presumably just daylight hours). The pre-BMP observations occurred in the winter and the post-BMP observations in the summer.

The research had several significant problems, which introduce significant uncertainty into the reported results:

1. Precipitation during the pre-BMP period (Aug. 17, 1994, to March 17, 1995) was fairly normal, 70 cm, which is about 3 cm above the long-term average. In contrast, the post-BMP period (March 18, 1995 to October 15, 1996) was 107 cm (Sheffield, 1996) and about 42 cm above normal. There was thus a 54% increase in precipitation between the pre- and post-BMP periods, which would greatly increase runoff, channel erosion, and non-point loadings during the post-BMP implementation phase. Precipitation and runoff differences between the pre- and post-BMP periods were not reported or discussed in the journal article. Loadings were adjusted for precipitation by converting and reporting all loadings with units of kg/cm rain. This is not the best way of accounting for differences between the pre- and post-BMP periods.
2. Sampling was conducted bi-weekly, and no sampling of stormwater flows was reported. It is likely that the samples collected are more representative of yields and concentration during baseflow conditions rather than combined baseflow and storm water yields. It is probably best to assume that the reported flow-weighted concentrations and loadings are only representative of baseflow conditions and not storm water flows. If this is the case, the extremely high reduction efficiencies make more sense scientifically.
3. Pre-BMP cattle observations were made in the winter. Post-BMP cattle observations were made in the summer. One would suspect that changes in temperature would also influence cattle behavior. The times cattle spent drinking from streams or were in stream areas were reported, but times cattle spent drinking from troughs or near troughs were not reported. It is difficult to evaluate the significance of seasonal patterns because the trough data is not reported.

As indicated in Table 4, installation of off-stream watering troughs decreased the average time cattle spent drinking from streams and being in the stream area by 89 and 51%, respectively. The table also reports the time that cattle spent in the stream area, which probably best represents the time that cattle would be disturbing the stream bottom and adjacent riparian area. The time spent in the riparian area is likely a good approximation of the time that cattle would likely be depositing manure in the riparian area. If this is the case and if one supposes that the fraction of time spent in the stream area can be used to estimate the fraction of daily manure production deposited in the stream area and consequently has a high probability of affecting the stream, then the fraction of daily manure production reaching the stream, $L_{m,}$ is:

$$L_m = \frac{12.69\,\text{min}/\,day}{1440\,\text{min}/\,day} = 0.009$$

and the fraction of manure reaching the stream with off-stream watering would be 0.51*0.009 = 0.004. In bacterial TMDLs developed in the Chesapeake Bay region, cattle in fields with streams and no fencing are typically assumed to spend much more time in the stream area.

Table 4. Observed cattle behavior with and without off-stream watering

	Pre-BMP Time, min/day	Post-BMP Time, min/day	Post BMP reduction, %
Time spent in stream drinking	6.62	0.72	89
Time spent in stream area	12.69	6.19	51

The reported efficiencies of the off-stream watering BMP without fencing in reducing flow-weighted pollutant concentrations are reported in Table 5. I am suspicious of the reported loading values because I was unable to derive them from the reported flow-weighted mean concentrations. Assuming that the flow-weighted concentrations are correct, they suggest that for baseflow conditions, off-stream watering reduced total suspended solids, ammonium, Total-P, and sediment bound P by 89.2, 72.1, 64.6, and 42.9%, respectively. The contaminants that are typically predominately adsorbed to sediments appeared to be reduced. More soluble contaminants such as nitrate and orthophosphorus increased. There is an error in the reported Total N values as the reduction in ammonium, which is a sub-component of Total N, is greater than the reported reduction in Total N. This suggests that either the pre- or post-BMP, or both concentrations for total N or ammonium are in error. Because of these errors and suspected errors in the reported loadings discussed previously, I hesitate to use any of the reported reductions to estimate the efficiencies of off-stream watering in reducing pollutant loadings.

Table 5. Reductions in pollutants due to off-stream watering without fencing (Sheffield et al., 1997)

Parameter	**Flow-weighted Concentration (mg/L)**		**% Change**
	Pre-BMP	**Post-BMP**	
Total Suspended Solids	132.35	14.28	-89.2
Total Nitrogen	1.34	1.24	-7.7
Ammonium (NH_4-N)	0.32	0.09	-72.1
Nitrate (NO_3-N)	0.17	0.23	37.1
Sediment Bound N	0.47	0.47	-0.7
Total Phosphorus (TP)	0.20	0.07	-64.6
Orthophosphates (PO_4-P)	0.00	0.01	98.5
Sediment Bound P	0.12	0.07	-42.9
	Loadings (kg/cm rain)		**% Change**
	Pre-BMP	**Post-BMP**	
Total Suspended Solids	~~292.84~~[#]	~~11.06~~	~~-96.2~~
Total Nitrogen	~~3.02~~	~~1.34~~	~~-55.6~~
Ammonium (NH_4-N)	~~0.52~~	~~0.12~~	~~-76.9~~
Nitrate (NO_3-N)	~~0.31~~	~~0.35~~	~~12.9~~
Sediment Bound N	~~1.05~~	~~0.55~~	~~-47.6~~
Total Phosphorus (TP)	~~3.25~~	~~0.08~~	~~-97.5~~
Orthophosphates (PO_4-P)	~~0.04~~	~~0.01~~	~~-75.0~~
Sediment Bound P	~~0.93~~	~~0.07~~	~~-92.5~~

[#] These values could not be derived from the reported flow-weighted concentrations. Suspected error in reported values of either the flow-weighted concentrations or the loadings.

Rosenthal and Urban (1989) Study

Rosenthal and Urban (1989) conducted a study titled "BMP Longevity: A Pilot Study to Assess the Long-term Effectiveness of Various BMPs (terraces/diversions, animal waste storage, vegetative strips, grassed waterways, and conservation tillage)." The study had three components: a survey of SCS and conservation district personnel in 11 states concerning their judgment of the short- and long-term effectiveness of the BMPs; on-site evaluations of 120 BMPs in three states; and anecdotal and empirical information from discussions, observations, and literature. The results of this study did not provide any information on the longevity or maintenance of fencing and off-stream watering systems and consequently was not used in this review.

Literature Review Summary

All of the studies provided had significant experimental limitations but did provide some relevant information that can be used in estimating the effectiveness of off-stream watering systems with and without fencing. None of the studies provided any information on controlled grazing. The results of the studies are summarized in Table 6.

Table 6. Summary of reported BMP efficiencies

BMP and Study	Percentage Reduction												
	NO_3	NO_2	NO_3+NO_2	NH_4	Dissolved TKN	TKN	Total N	Sediment Bound N	Dissolved P	Total P	Sediment Bound P	TSS	Flow
Off-stream watering with fencing													
Galeone et al. (2006)													
Watershed T-1	18	28		36	20	26			-19	14		37	
Watershed T-2	-15	-15		-10	-30	-43			-94	-51		44	
Off-stream watering without fencing													
Line et al. (2000)			41			-27				-13		38	27
Sheffield et al. (1987)	-37			72			8		-99	65		89	

Galeone et al. (2006) investigated the effects of stream-side fencing, which restricted cattle access to the stream except at a few controlled points for drinking. The results of the study probably best represent the ***off-stream watering with fencing*** BMP. The study had some experimental problems that were discussed previously that make comparisons of the pre- and post-BMP periods problematic. The more reliable results came from the paired watershed comparisons. As shown in Table 2 for the main watershed (T-1 and C-1 comparison), sediment loss was reduced by 37%, dissolved P loss increased by 19%, and other nutrient losses decreased by 14 to 36%. These results seem reasonable except for the increase in dissolved P loss. For the small watershed (T-2 and C-1 comparison), all nutrient losses increased, but there was a 44% reduction in sediment loss. These results do not seem to be reasonable and are attributed to the large differences between the control and T-2 treatment watershed. The combined results suggest that the likely effectiveness of fencing with limited access to streams is highly variable.

Line et al. (2000) evaluated BMPs in two subwatersheds. The study had a good baseflow water quality sampling protocol, but stormflow water quality sampling protocol was less than optimal. Runoff decreased significantly between the subwatershed with fencing and off-stream watering and other BMPs installed during the pre-BMP period, so it is difficult to attribute the reported pollutant reductions solely to fencing and off-stream watering. Thus the results were judged to be inappropriate for use in this study. The second sub-watershed (Table 3, Site D) had ***off-stream watering with no fencing*** in a low stocking-density pasture. Reported reductions between the pre- and post-BMP periods in discharge, nitrate-nitrite, TKN, Total-P, and TSS were 27, 41, -27, -13, and 38%, respectively. TKN and Total-P losses increased.

The Sheffield et al. (1997) study investigated the effects of ***off-stream watering without fencing*** on water quality and cattle behavior. Some limitations were noted with the results due to the 42% increase in precipitation in the post-BMP period compared to the pre-BMP period and due to suspected errors some of the reported data values. Reported BMP efficiencies were generally higher than in the two longer-term studies; however, nitrate and dissolved P (orthophosphorus) losses were higher (Table 6).

Time Lags, Longevity, Maintenance, and Other Issues

These issues were not addressed in the research articles provided, so I am simply sharing my best professional judgments. These deserve critical discussion and collective modification. My judgments are based on my mental model of what happens when livestock are removed from streams. In my model, water quality improves because of:

1. Direct Deposition. Manure is no longer directly deposited in the stream,.
2. Stream Substrate Disturbance. Cattle do not stir up stream sediments and/or degrade the stream substrate.
3. Indirect Deposition in Riparian Areas. Manure is no longer deposited in riparian zones where it has a greater chance of being transported to streams during runoff events.
4. Streambank Degradation. Livestock no longer degrade streambanks and riparian vegetation, which makes the streambanks more susceptible to channel erosion and loss of nutrients with the resulting soil loss.
5. Riparian Zone Regeneration. Previously degraded riparian areas may revegetate and start to function as buffers.

Time Lags

The effect of fencing and off-stream watering on manure constituent loads to streams is immediate for:

1. Direct Deposition
2. Stream Substrate Disturbance
3. Indirect Deposition in Riparian Areas
4. Streambank Degradation

The effect of fencing and off-stream watering on manure constituent loads to streams is takes time for:

5. Riparian Zone Regeneration

I would presume that full buffer-function recovery takes 10 years; and that the recovery is 0% the first year and increases by 10% per year until it is fully functioning.

Longevity

Fencing and off-stream watering should be effective indefinitely if maintained. The only concern is flood events that may destroy the fencing. At issue is whether it will be replaced/repaired. Fences should be designed with potential flooding in mind. For example, high tensile fencing might be more appropriate than woven wire in flood-prone areas. I have some concern that off-stream watering over time may lead to pollutant build-up in the watering area and that at some point this build-up may become a potential point source. This could be avoided/reduced with proper design (mobile watering troughs, proper drainage and hardening, etc.) and maintenance.

Practice Maintenance

With fences, one supposes that they will be maintained to contain the livestock. If stream-side fencing is not maintained but off-stream watering is still available, the majority of the benefits occur in terms of reduced livestock in streams/riparian areas. Watering systems must be maintained, or they will fail and force livestock back to the stream if unfenced. They also can become a pollutant source if there are excessive water leakage/overflow, poor drainage, and excessive accumulation of manure. They must be checked and maintained regularly to ensure adequate water flow for livestock, prevent overflows, redistribute accumulated manure to pastures, etc.

Variability and Uncertainty in BMP Effectiveness

This is difficult to evaluate because there has been so little research on these practices, but I would presume that the effectiveness of these BMPs is highly site-specific. Variability and uncertainty in the effectiveness of fencing and off-stream watering systems is very high, as demonstrated in the research studies reviewed. Variability and uncertainty in effectiveness factors could be reduced with modeling studies.

Effects of Extreme Events

This is significant only where off-stream watering is in the flood zone. It is a problem if located in the flood plain. It is a major concern for fencing systems in flood plains, where many are located. Fencing BMPs in flood plains requires some sort of insurance program that will assist landowners in replacing and repairing damaged fences after floods. Without such provisions, landowners who installed fences through a cost-share program are liable if a flood destroys the fences. They must either replace it at their own expense or return all or a portion of the cost-share expenses. This liability makes some landowners reluctant to install stream-side fencing.

Scale Issues

Reviewed research was conducted at the small watershed scale (<600 ha in the largest study). With fairly intensive implementation, reductions were variable across studies. I am not sure how results from these studies can be scaled up. The recommended approach is to scale up with modeling studies as proposed below.

Proposed Procedure for Estimating Nutrient Reduction Factors

As indicated in the review of the articles and reports provided on the effectiveness of fencing, off-stream watering and related practices, inadequate research has been conducted on these BMPs to estimate their effectiveness with any degree of scientific confidence. However, there are two alternative ways in which their effectiveness could be estimated with a higher degree of confidence. These are described below.

The fencing and off-stream watering BMPs improve water quality by reducing or eliminating livestock access to streams and riparian areas. When livestock are removed from streams, water quality improves because:

1. Manure is no longer directly deposited in the stream.
2. Cattle do not stir up stream sediments and/or degrade the stream substrate.
3. Manure is no longer deposited in riparian zones where it has a greater chance of being transported to streams during run-off events.
4. Livestock no longer degrade streambanks and riparian vegetation, which makes the streambanks more susceptible to channel erosion and loss of nutrients with the resulting soil loss.
5. Previously degraded riparian areas may revegetate and start to function as buffers.

My understanding is that the Bay Watershed Model/HSPF has been modified to simulate buffers, so the developing buffers (5) could be simulated with the new buffer simulation routines.

I am not sure how HSPF can simulate the effects of livestock on items (2) and (4), above, but HSPF can simulate the effects of removing livestock from streams and riparian zones. This is routinely done in bacterial TMDLs in Virginia and elsewhere using HSPF. The approach makes the following which can then be implemented in HSPF:

1. Livestock contributions of manure (bacteria and nutrients) to streams can be simulated in HSPF as point source contributions to the applicable stream reach.
2. The manure production rate and composition (bacteria, nutrients, COD, etc.) of manure is known.
3. The magnitude of the point source contribution of manure constituents is a function of daily manure production for different types of livestock and the fraction of the day (which varies seasonally) that livestock spend in the stream/riparian area. Seasonal data on the estimated time that livestock spend in streams/riparian zones are available from the Center for TMDL and Watershed Studies.
4. Available county livestock census and land use data can be used to estimate livestock populations in pastures adjacent to streams with and without fencing.
5. Software can then be used to apportion the manure loadings between the stream/riparian area and adjacent pastures, animal waste storage systems, etc. An example of such software is the Bacteria Source Load Calculator (http://www.tmdl.bse.vt.edu/outreach/C85/) developed by the Center f or TMDL Studies. This program currently only simulates bacteria in manure, but it could easily be modified to simulate manure nutrients, COD, TSS, etc. The software outputs WDM files that can be used to input point-source bacterial loadings into HSPF and bacterial loadings to pervious land segments (PLSs). Modified software could do the same for nutrients and other manure constituents. All consulting firms and organizations developing bacterial TMDLs use similar software to develop the HSPF data files.
6. In bacteria TMDLs, the effects of fencing and off-stream watering are simulated by varying the amount of time that cattle spend in the stream/riparian zone. Seasonal estimates of the time that various livestock species spend in the stream/riparian zone without fencing and off-stream watering have been estimated.
    a. To simulate fencing with total livestock exclusion, the time that livestock spend in the stream/riparian area is reduced to zero, and all manure and its constituents are apportioned between PLSs adjacent to the stream reach, animal waste storage structures and other areas where livestock spend their time.
    b. To simulate fencing with partial exclusion (livestock drinking at controlled locations where their access is limited) or off-stream watering, the time that the livestock spend in the stream/riparian area is reduced, which shifts a portion of the manure constituents, previously deposited in the stream/riparian area, to other pools.
    c. This is currently implemented in HSPF for bacteria and could be done for nutrients.
7. In the above manner, HSPF can then be used to simulate bacteria/nutrient losses without fencing and off-stream watering, then rerun with cattle spending less time in stream/riparian areas to simulate the effects of off-stream watering with or without fencing.

Method 1: Direct Application in Bay Watershed Model

I do not know exactly how the Bay Watershed Model nutrient loadings to PLS are currently generated. Ideally nutrient loadings from commercial fertilizer, atmospheric deposition and livestock manure are handled separately. If this is the case, then the procedure described above could be used to reapportion manure loadings between PLSs and direct point source loadings to simulate the effects of stream side fencing and off-stream watering. If nutrient loadings to PLSs are lumped by land use or in some other method, it would be a major undertaking to separate out the manure loadings. This might not be practical but it is definitely technically feasible.

Method 2: Reference Watershed Approach

An alternative to incorporating the above approach into the Bay Watershed Model would be to apply it to a representative range of reference watersheds across the Bay watershed and to then use the results of these simulations to estimate reduction efficiencies for nutrients and other manure constituents for different combinations of livestock riparian zone exclusion, watershed conditions, seasons, types of livestock, buffer widths, etc. This could be done fairly quickly, and I recommend this approach. It would be an order of magnitude quicker and less expensive than conducting the field research required to obtain equivalent information. This would provide information on the uncertainties associated with specific reduction efficiencies.

Recommended BMP Efficiencies Based on Reviewed Articles

I personally do not have a high degree of confidence in the efficiencies reported in the reviewed articles, but using them, I would recommend the following BMP reduction efficiencies. I am not considering the results of the Galeone et al. (2006) T-2 watershed study, for they do not appear to be scientifically logical (removing cattle from streams increases pollutant loadings).

- ***Off-stream watering with fencing:*** Only the efficiencies for the Galeone T-1 watershed are applicable. To be conservative, since the results are from a single study, I recommend reducing the reported reduction values by 50%. The resulting recommended efficiencies, based on a single study, are given in Table 7.
- ***Off-stream watering without fencing:*** Data from two studies are used and are compared with data with fencing. To be conservative I intended to reduce the reported reduction values by 50%. I also required the reductions to be less than those for off-stream watering with fencing because the literature review indicated that off-stream watering reduced but did not eliminate livestock activities in streams (80-90% reduction) and riparian areas (50% reduction). Since the study with fencing had lower efficiencies than the studies without fencing, the recommended reduction efficiencies for off-stream watering with and without fencing are essentially the same.

- ***Off-stream watering with fencing and rotational grazing:*** These are presumed to be the same as off-stream watering with fencing because no information was available on the effects of rotational grazing. Also, there was concern that stocking density increases due to higher forage production with rotational grazing would offset the water quality benefits of increased vegetative cover in pastures.

Table 7. Reported and recommended BMP efficiencies

BMP and Study	Percentage Reduction												
	NO_3	NO_2	NO_3+ NO_2	NH_4	Dissolved TKN	TKN	Total N	Sediment Bound N	Dissolved P	Total P	Sediment Bound P	TSS	Flow
Off-stream watering with fencing													
Galeone et al. (2006)													
Watershed T-1	18	28		36	20	26			-19	14		37	
Watershed T-2	-15	-15		-10	-30	-43			-94	-51		44	
Recommended Efficiency	*9*	*14*		*18*	*10*	*13*			*0*[1]	*7*		*19*	
Off-stream watering without fencing													
Line et al. (2000)			41			-27				-13		38	27
Sheffield et al. (1987)	-37			72			8		-99	65		89	
Recommended Efficiency	*5*[2]		*5*[2]	*18*[2]		*7*[2]	*4*		*0*[1]	*7*[2]		*19*[2]	

[1] 50% safety factor for reductions ignored and best professional judgment used to estimate a reduction of 0%.

[2] Assumed that it was impossible for off-stream watering without fencing to be more effective than with fencing so off-stream without fencing was assumed to be the same as with fencing if the reported efficiency was higher.

Studies to follow-up on upon completion:

"Streamside Livestock Exclusion: A tool for increasing farm income and improving water quality" *Authors: R. Zeckoski, B. Benham, C. Lunsford.* Contact: Brian Benham, Virginia Tech

References

Galeone, Daniel G., Robin A. Brightbill, Dennis J. Low, and David L. O'Brien. 2006. Effects of Streambank Fencing of Pasture Land on Benthic Macroinvertebrates and the Quality of Surface Water and Shallow Ground Water in the Big Spring Run Basin of Mill Creek Watershed, Lancaster County, Pennsylvania, 1993-2001. Scientific Investigations Report 2006–5141. U.S. Geological Survey, Reston, Virginia.

Line, D.E., W.A. Harman, G.D. Jennings, E.J. Thompson, and D.L. Osmond. 2000. Nonpoint-Source Pollutant Load Reductions Associated with Livestock Exclusion. *Journal of Environmental Quality*. 29(6):1882-1890.

Rosenthal, Alon, and Don Urban. 1989. *BMP Longevity: A Pilot Study.* Submitted to U.S. EPA, Chesapeake Bay Liaison Office, Office of Program Policy and Evaluation, Office of Water.

Sheffield, R. E., S. Mostaghimi, D. H. Vaughan, E. R. Collins Jr., and V. G. Allen. 1997. Off-Stream Water Sources for Grazing Cattle as a Stream Bank Stabilization and Water Quality BMP. *TRANSACTIONS of the ASAE*, 40(3):595-604.

Sheffield, R.E. 1996. Off-stream water sources for grazing cattle as a stream bank stabilization and water quality BMP. M.S. Thesis. Virginia Polytechnic Institute and State University, Blacksburg.

Appendix B: BMP Efficiency Review Statement of Work

The University of Maryland will provide the BMP definition and efficiency found in literature for contractor to provide feedback. Specifically, the contractor will discuss the accuracy of the efficiency and comment on any adjustments that should be made to the efficiency. For example, mention that the BMP takes high operation and maintenance to achieve and maintain the proposed efficiency but you cannot provide the resulting adjusted reduction efficiency percent. If an adjustment value is not available contractor is not required to suggest the efficiency change. However, contractor will comment on whether or not the literature value should be adjusted based on the following considerations:

- Identify the loss pathways and estimate the hydrologic lag time associated with the practice.
- The expected spatial variability for a practice should be estimated based on available science and knowledge of the expected geographic extent of implementation of the practice. Different reduction efficiencies should be established for practice implementation across different physiographic, geomorphic or hydrologic settings. Where possible, discuss how surface water and groundwater interactions (permeability), along with geology and soil types (slope, seeps, floodplain, etc.) alter efficiencies.
- Implementation lag times - BMP efficiencies should match the practice implementation schedule. Many practices are reported as implemented once the plan or design has been completed. In reality, the plan may call for phased implementation over as much as five to ten years. In addition, the farmer may not implement the practice as scheduled due to climatic, management or economic constraints. The time it takes for an implemented practice to reach its full potential may also delay pollution reduction percentages. Identify possible lag times in reaching BMP pollution reductions due to phased-in implementation or time to maturity of BMP.
- Define the impact of extreme climatic events on the BMP and discuss the BMPs efficiency function in events above its designed maximum. Where data is available, please discuss how the practice efficiency should be adjusted for events approaching, but within, the design maximum.
- Where applicable explain how different lengths or widths of the BMP will alter efficiencies.
- Discuss how the efficiency of the BMP will change with various watershed management conditions, including operation and maintenance of BMP, construction supervision, and/or upland land use change, among others.
- Discuss how the efficiency will change from the research/demonstration scale to the watershed/basin scale application. This does not have to be a quantified answer, but please identify issue with adjusting the efficiency at various scales. For example if the BMP requires high operation and maintenance to work properly please explain that here.

Finally please provide the efficiency you recommend the Chesapeake Bay Program uses for its Watershed Model and Tributary Strategies.

Appendix C: Univ. of Maryland Literature Review of Galeone et al., 2006

BMP Name: Offstream watering

Definition of BMP provided in article:

Efficiencies provided in article:
Overall water-quality changes in constituent yields for the treated sites (T-1 and T-2) of the Big Spring Run Basin, Lancaster County, Pa., for the post-treatment period based on analysis of covariance (ANCOVA) results and the separation of constituent yields into base-flow and stormflow components. [DKN, dissolved ammonia plus organic nitrogen; TKN, total ammonia plus organic nitrogen]

Constituent	T-1 change	T-2 change
Dissolved nitrate	-18%	+15%
Dissolved nitrite	-28%	+15%
Dissolved ammonia	-36%	+10%
DKN	-20%	+30%
TKN	-26%	+43%
Dissolved phosphorus	+19%	+94%
Total phosphorus	-14%	+51%
Suspended sediment	-37%	-44%

Improvements relative to control or untreated sites in surface-water quality (nutrients and suspended sediment) during the post-treatment period were evident at the outlet (T-1) of the treatment basin; however, a tributary site (T-2) (0.36 mi2 drainage) showed reductions only in suspended sediment.

The average reduction in suspended-sediment yield for the treated sites was about 40 percent.

The results indicated that effects on suspended sediment were fairly consistent in the treatment basin, but this was not true for nutrients.

Two factors were evident at T-2 that helped to overshadow any positive effects of fencing on nutrient yields. One was the increased concentration of dissolved P in shallow ground water. This influx of P through the ground-water system partially helped to increase P yield during the post-treatment period at T-2. This indicates that nutrient management in a basin is critical to reducing P yields, and that streambank fencing with small buffer widths cannot compensate for increased dissolved P moving to the stream system through shallow subsurface zones. Another factor that appeared to affect water quality at T-2 was that the cattle crossings were embedded in the stream, which was necessary for a drinking-water supply for the cattle and was less costly than installation of culverts and raising the crossing above the stream. Cattle excretions at the crossings appeared to increase concentrations of dissolved ammonia plus organic N and dissolved P. This factor would be one reason to install crossings using culverts if at all possible, but an alternative water supply would need to be provided for the animals.

Location of study:
Study area was predominantly agricultural land, about 90%. Agricultural use consisted of primarily row crop (corn and alfalfa), with most remaining agricultural land for pasture and hay fields, with dairy-cattle husbandry as the predominant form of animal agriculture.

The Mill Creek Basin lies within the Susquehanna River Basin. The broad valleys in northern Lancaster County are drained by an elaborate, branched network of meandering streams. A ridge formation occurs within the study area with Big Spring Run and an unnamed tributary to Big Spring Run in the treatment basin bisecting the ridge with little or no deviation in their flow direction.

Geology consists of carbonate and siliciclastic Cambrian rocks covered by thin layer of soil and a mantle of regolith derived from weathered bedrock. The ground-water/surface-water system that has developed is complex. This system is controlled by the bedrock geology but is driven by the timing, duration, and intensity of precipitation events

Soils in the two study basins are generally similar composed of six soil types. Soils along the ridges and adjacent side slopes are predominantly of the Conestoga series (fine-loamy, mesic Typic Hapludalf), followed by Penlaw (fine-silty, mixed, mesic, Aquic Fragiudalf) and Pequea (coarse-loamy, mixed, mesic Typic Eutrochrept) series. Soils of the Hollinger series (fine-loamy, mixed, mesic Typic Hapludalf) were identified only on the side slopes. The most common series identified in the basins was the Lehigh series (fine-loamy, mixed, mesic Aquic Hapludalf), which was along the lower and middle slopes.

Gentle sloping terrain is the most common topography in the basin. The soils adjacent to the stream channel were identified as the Clarksburg series (fine-loamy, mixed, mesic Typic Fragiudalf). Most soils are deep and moderately to well drained. The reported soil depths range from 50 to 75 in. (Custer, 1985). Slopes are low to moderate, primarily between 3 and 8 percent.

BMP Characteristics:
Fence was installed in the treatment basin from May 1997 through July 1997. All pasture areas in the treatment basin along the stream network were fenced. One- or two-strand high-tensile wire was used with an electrical current supplied by solar power. On either side of the stream, the distance between the streambank and the fence was anywhere from 5 to 12 ft. For each pasture fenced, approximately two cattle crossings were installed to allow the animals to access pasture and also to supply the cows with an area for water consumption. After fence installation, a variety of brushy, herbaceous vegetation was naturally established.

Watershed Management details:

Fencing installed included electrical current which was supplied through solar power. This particular type of fencing would probably require expert installation. Maintenance of fencing and cow crossing would require periodic monitoring to ensure fencing and crossing were functioning properly. Establishment of vegetation between fencing and stream was important as it provided stream buffer capacity.

How were the proposed efficiencies monitored?

The paired-basin monitoring design requires the use of two relatively similar basins with one basin used as a control and a second basin in which treatment is applied. Basins selected were similar physical characteristics. Eight surface-water locations were sampled; four were continuous-recording stations (C-1, T-1, T-2, and T-4) and four were intermittent stations (C1-2, T1-3, T2-3, and T-3)

A nested experimental design including paired-basin and upstream/downstream components was used to study the effects of fencing on surface-water quality and benthic-macroinvertebrate communities. Five surface-water sites, one at the outlet of a 1.77-mi2 control basin (C-1), two sites in the treatment basin (T-3 and T-4) that were above any fence installation, and two sites (one at an upstream tributary site (T-2) and one at the outlet (T-1)) that were treated, were sampled intensively.

The ground-water system in the study area was characterized on the basis of water levels, flow directions, age dating, and chemical quality. Wells and piezometers were used to measure water level and ground water flow direction.

Pre-treatment data were collected primarily from October 1993 until July 15, 1997. Post-treatment data collection was mostly discontinued by the end of June 2001.

Farm operators provided data on the dairy-cow activity in the pastures and the loading of inorganic and organic fertilizers within the study area. Prior to and during early parts of the study, each farmer had developed nutrient-management plans with the Lancaster County Conservation District (LCCD) and Natural Resource Conservation Service (NRCS). One aspect of the plan was to calibrate manure spreaders. The information from these calibrations was used to determine the weight of each “load” of manure applied by each farmer which was converted to pounds of N and P based on published values for concentrations of nutrients in different sources and forms of animal manure. The time that cows were in pasture was used to estimate the amount of waste excreted by the animals. These estimates were then added to manure-application data supplied by the farmers so that a total amount of N and P applied to the landscape could be estimated. The nutrient-application data were used to estimate the loading of N and P to both basins over time.

Water samples for analyses of nutrients and suspended sediment were collected at a fixed-time interval and during storm events. Samples were analyzed for dissolved forms of ammonia, nitrite, ammonia plus organic N (DKN), nitrite plus nitrate, P, and orthophosphate. Analyses also included total forms of ammonia plus organic N (TKN) and P, and suspended sediment. Fixed-time interval (grab) samples were collected every 10 days (regardless of flow conditions) from April through November and on a monthly basis during a low-flow period from December through March. These fixed-time samples were collected at four sites in the treatment basin (T-1, T-2, T-3, and T-4) and one site in the control basin.

Chilled samples were shipped to the USGS National Water Quality Laboratory (NWQL) in Arvada, Colo., for nutrient analysis. Analyses were performed according to techniques described in Fishman and Friedman (1989). Suspended-sediment concentration analyses were conducted by the USGS Sediment Laboratory in Pennsylvania through water year 1995 and thereafter at the USGS Sediment Laboratory in Kentucky. Both sediment laboratories used procedures described by Guy (1969) to determine suspended-sediment concentrations.

Nutrient and suspended-sediment yields for low-flow and stormflow samples were determined for each sample collected so that pre- and post-treatment comparisons could be conducted.

Source of article:
Government agency – USGS

Effects of Streambank Fencing of Pasture Land on Benthic Macroinvertebrates and the Quality of Surface Water and Shallow Ground Water in the Big Spring Run Basin of Mill Creek Watershed, Lancaster County, Pennsylvania, 1993-2001
Daniel G. Galeone, Robin A. Brightbill, Dennis J. Low, and David L. O'Brien
In cooperation with the Pennsylvania Department of Environmental Protection
Scientific Investigations Report 2006–5141
U.S. Department of the Interior
U.S. Geological Survey

Appendix D: Univ. of Maryland Literature Review of Line et al., 2000

BMP Name:
Off stream watering w/ fencing (and riparian vegetation planting)
Off stream watering w/out fencing

Definition of BMP provided in article
Livestock Exclusion Fencing – The fencing keeps livestock away from streambanks, thereby preventing the mechanical breakdown of banks by livestock hooves and facilitating the establishment of a vegetative filter along the streams. For this BMP site riparian vegetation was planted.

Alternate Watering System w/ out fencing – Providing an off-stream watering supply w/out fencing.

Efficiencies provided in article:
Difference between sites D and E (captures alt watering system with fencing):
32.6% nitrate-nitrite
78.5% TKN
75.6% TP
81.7% TSS
Mean weekly loads post-fencing were significant ($P < 0.05$) for all pollutants except nitrate-nitrite.
The nitrite and nitrate load will probably decrease in the future as the trees become established and denitrification and nutrient uptake in the riparian corridor increase. Thus, the BMPs were effective at reducing loads of TKN, TP, and TSS, but were much less effective at reducing the nitrate and nitrite load.

At site D (captures only the alternative watering system):
No reductions in loads are statistically significant at the 0.05 level; results of this study indicate that the effect of this BMP by itself is not significant.

Location of study: soil, climate, hydrology
Piedmont region of North Carolina

56.7 ha watershed, predominantly pasture for dairy cows and replacement heifers. The upper pasture (41.8 ha upstream of Site D) is lightly grazed by 75 to 100 heifers and calves and a lower pasture (14.9 ha between sites D and E) that was heavily grazed by adult cows. The dairy farm has been at this location for at least 100 years. In both pastures animals had unlimited stream access.

Stream is Kiser Branch, originates in the upper pasture and flows about 180 meters before entering the lower pasture. There is degradation along the streambanks and channel bed.

Typical nonstorm daily mean Q at both upstream and downstream monitoring sites was 8 L/s w/ peak instantaneous Q as high as 3100 L/s during some storm events. Average annual rainfall for the general area around the study watershed is 1090 mm. The watershed geology is typical of the western Piedmont region of NC w/ a saprolite layer of varying thickness overlaying fractured igneous and metamorphic rock. The predominant soils were Tatum silt loam and Vance sandy loam, which are generally well drained and moderately to slowly permeable. Both soils have a loamy A horizon and a predominantly clayey Bt horizon that extend to a depth of between 36 to 100 cm. The depth to bedrock for these soils was typically 1.1 to 1.8 m. The watershed area was hilly w/ land slopes of 5 to 15% w/ a few flatter areas on the tops of ridges and along the stream. Average slope of the channel was 1.3%.

Vegetation in the 41.8 ha upper pasture was primarily common bermudagrass. Grass lightly grazed. The 14.9 ha lower pasture was grazed regularly

BMP Characteristics: BMP age, date of construction, size, and species composition.

Design: Following the collection of 81 wk of monitoring data (August 1994 to February 1996) an alternate watering system was installed in both pasture areas. Watering tanks were installed at upland locations at least 50 m away from the stream and were surrounded by a geotextile fabric overlain w/ gravel. Additionally, livestock exclusion fencing was installed in the lower pasture in February 1996. The fence excluded cows from a 10 to 16 meter wide and 335 meter long section of pasture along either side of Kiser Branch between Sites D and E.

Shortly after fence construction, various hard and softwood trees were planted in the riparian corridor and a severely eroding section of streambank was reshaped and seeded.

Fencing to exclude cows from a 6 meter wide riparian corridor containing a major tributary to Kiser Branch also was installed in February 1996. The volunteer vegetation inside the fenceline provided about a 3 meter grassed filter strip alog either side of the 94 meter long intermittent channel.

Species composition: In a zone w/in 3 m of the Branch, button bush, hazel alder, red maple, and bald cypress trees were planted while on the drier upland areas green ash, red and white oak and loblolly pine trees were planted. All trees were planted in rows on a 3 m centers in holes drilled w/ a post hole digger, except for loblolly pine, which were planted by a dibble. Volunteer vegetation has grown in the riparian corridor. Along and in the stream, willows and cattails have proliferated while on the banks a variety of weeds and grasses have become established.

Watershed Management details: Does the BMP require high operation and maintenance, as well as monitoring? How technical is construction, does it require an engineer to install or can a farmer do it?

Maintenance:

One application of herbicide around the trees, to release them from the competition of volunteer vegetation, was the only follow up work performed after planting the trees.

No info on fencing or watering system maintenance or construction was mentioned.

How were the proposed efficiencies monitored? Type of equipment used, how often monitored, what tests were done (ex – if used EPA methods for testing for TN or some other orgs methods)

Continuous Q measurements were made at upstream (Site D) and downstream (Site E) monitoring stations from August 1994 through September 1998 by the USGS. Two recording raingages measured rainfall continuously. Grab samples from the overall of a V-notch weir at Site D and a large culvert at Site E were collected weekly, iced w/in 15 min and transported to a nearby USEPA-certified laboratory. Samples were analyzed for nitrate + nitrite nitrogen, TKN, TP, TSS and TS concentrations using Methods 353.1, 351.2 and 35.4 from the USEPA for nitrate and nitrite, TKN, and TP and 2540D and 2540B from Anonymous for TSS and TS. Split, blank, and spiked samples were prepared and analyzed to verify the quality and representativeness of the samples.

Samples were collected during storm events at Sites D and E using automated samplers activated by the stage recording equipment. Samplers were programmed to collect two samples on the rising limb, one near the peak, and one at a stage approximately halfway between the first grab sample collected on the rising limb and the peak of they hydrograph. Each sample was placed in two bottles, one that was pre-acidified for preservation of nitrogen and phosphorus forms and one that was non-acidified for storage of the solids or sediment. Samples were transported to the lab as soon after the events as possible and analyzed using the same methods as those used for grab samples.

However due to irregular hydrographs from extended-duration storms or storms w/ multiple peak Q's and equipment malfunction, significant portions of storm flows were not sampled.

Source of article (w/ full citation): Please note if it is a NGO or gov't agency.

Line, D.E.; Harman, W.A.; Jennings, G.D.; Thomposn, E.J., and D.L. Osmond. 2000. Nonpoint-Source Pollutant Load Reductions Associated with Livestock Exclusion. *Journal of Environmental Quality*. 29(6):1882-1890.

Appendix E: Univ. of Maryland Literature Review of Sheffield et al., 1997

BMP Name:
OFF-STREAM WATER SOURCES FOR GRAZING CATTLE AS A STREAM BANK STABILIZATION AND WATER QUALITY BMP

Definition of BMP provided in article:
The overall goal of this study was to evaluate the feasibility of using water troughs as a Best Management
Practice (BMP) to reduce the losses of soil, nutrients, and bacteria from pasture lands.

Efficiencies provided in article:

	Flow-weighted Concentration (mg/L)		
	Pre-BMP	**Post-BMP**	**% Change**
TSS	132.35	14.28	-89.21
Total Nitrogen (TN)	1.340	1.237	-7.72
Ammonium (NH4)	0.321	0.090	-72.06
Nitrate (NO3)	0.167	0.229	37.05
Sediment Bound Nitrogen	0.472	0.468	-0.66
Total Phosphorus (TP)	0.203	0.072	-64.56
Orthophosphates (PO4)	0.004	0.007	98.47
Sediment Bound Phosphorus	0.120	0.068	-42.87

	Loading (kg/cm rain)		
	Pre-BMP	**Post-BMP**	**% Change**
TSS	292.84	11.06	-96.22*
Total Nitrogen (TN)	3.02	1.34	-55.63*
Ammonium (NH4)	0.52	0.12	-76.92*
Nitrate (NO3)	0.31	0.35	12.90
Sediment Bound Nitrogen	1.05	0.55	-47.62
Total Phosphorus (TP)	3.25	0.08	-97.54*
Orthophosphates (PO4)	0.04	0.01	-75.00
Sediment Bound Phosphorus	0.93	0.07	-92.47*

* Significant difference between means at a = 0.05 level

Location of study:
This study was conducted on two commercial cow-calf operations in the Ridge and Valley region of southwest Virginia which used rotational stocking. One study pasture (14.2 ha) was located on the River Ridge Farm in Independence, Virginia (fig. 1), and two additional study pastures (16.6 and 22.3 ha) were located on the Bender
Farm in Floyd, Virginia (fig. 2). The River Ridge Farm produces Brahma-Angus calves using high stocking density and stocking rates of 200 cows and 170 calves on eight pastures totaling 136 ha. The Bender Farm produces Angus-Hereford calves at a stocking rate of 150 cows and 60 calves on eight pastures totaling 187 ha. The Bender Farm used first-last grazing during the spring and fall, rotating yearlings onto paddocks for three

days before grazing lactating cows and calves.

The three study pastures were chosen for several reasons. First, a spring-fed first-order stream originates in each pasture. Second, spring-developments provide water to a three-trough system on the River Ridge Farm, and a single trough system provides water for cattle on each of the pastures on the Bender Farm. Lastly, tall fescue (*Festuca arundinacea* L.) was the dominant grass on both farms among a mix of orchardgrass (*Dactylis glomerata*), Kentucky bluegrass (*Poa pratensis*), red clover (*Trifolium pratense*) and white clover (*Trifolium repens*). A more detailed description of the study sites is given by Sheffield (1996).

The tall fescue present in the River Ridge and two Bender pastures was found to be highly infected (77%, 72%, and 78%, respectively) by the fungal endophyte (*Acremonium coenophialum* Morgan, James and Gams). The endophyte has long been identified with three syndromes among cattle (Ball et al., 1991). Cattle grazing toxic tall fescue and suffering from the effects of fescue toxicosis or “summer slump” have been observed to have a tendency to wallow in mud (Bowman et al., 1973) or stand in ponds or creeks during hot portions of the day. Fescue toxicosis causes the body temperature of cattle to elevate and subsequently the cattle spend more time within the stream areas. Therefore, it can be expected that the level of impact (erosion, degraded water quality) upon these areas would increase in pastures where high levels of the endophyte are present.

BMP Characteristics:

Off-stream water sources, as suggested by Smith et al. (1992) and Marlow and Pogacnik (1986), is a water quality management practice which has been noted by farmers and conservationists to be quite effective in reducing cattle impact upon stream environments.

pre-BMP period: Aug. 1994 through Apr. 1995: cattle had access to only one stream in the observed pasture as their source of water.

post-BMP period: Apr. 1995 through Oct. 1995: water troughs were installed in the pastures and cattle had continued access to streams. To provide water for the troughs, springs were developed according to design specifications of the Natural Resources Conservation Service (1992). At no time during the study were cattle excluded from the stream by fencing.

Watershed Management details:

The BMP required troughs to be built. The sample farms had springs that were used.

How were the proposed efficiencies monitored?

Prior to the study, various monitoring equipment were installed on the River Ridge Farm, and surveys were conducted in preparation of this project. A weighing raingauge and a standard raingauge were installed. The standard and weighing raingauges were read by the farm operator. Surveys for stream length and slope were conducted prior to the start of the project. Stream flow data were obtained by measuring the time to collect a known volume of water (3.785 L or 18.925 L) at the pond outlet.

The following water quality parameters were measured from semi-monthly water quality samples: total suspended solids (**TSS**), nitrate-nitrogen (**NO3-N**), ammonium (**NH4-N**), total nitrogen (**TN**), sediment-bound nitrogen (**SBN**), ortho-phosphorus (**PO4**), total phosphorus (**TP**), sedimentbound phosphorus (**SBP**), fecal coliform (**FC**), fecal streptococci (**FS**), and total coliform (**TC**).

Due to the skewness of the data, the nonparametric Wilcoxon sign-rank sum test was used to evaluate each parameter.

Source of article (w/ full citation): Please note if it is a NGO or gov't agency.
Authors: R. E. Sheffield, S. Mostaghimi, D. H. Vaughan, E. R. Collins Jr., V. G. Allen
Title: OFF-STREAM WATER SOURCES FOR GRAZING CATTLE AS A STREAM BANK STABILIZATION AND WATER QUALITY BMP
Journal: TRANSACTIONS OF THE ASAE, VOL. 40(3):595-604

Appendix F. Meeting Minutes

Agricultural Nutrient and Sediment Reduction Workgroup

Maryland Department of Agriculture
Annapolis, Maryland
May 10, 2007

Off-Stream Watering BMPs

- Off-stream watering BMPs include: 1) off-stream watering with fencing, 2) off-stream watering without fencing, and 3) off-stream watering with fencing and rotational grazing.
- The proposed efficiencies for the off-stream watering BMPs are much lower than the current efficiencies.
- For the off-stream watering with fencing BMP, the efficiencies recommended in the handouts are: 12% TN reduction, 10% TP reduction, and 20% TSS reduction. Concern was voiced by workgroup members that these efficiencies are too low. Tom Simpson indicated that they made an error in how they treated the data and agreed that they were too low. He proposed changing these efficiencies to 24% TN, 40% TP, and 40% TSS. Tom says he believes that the data can support this change, but increasing the efficiencies even more would require additional data for support. If workgroup members know of data that would support higher efficiencies for this practice, they can send it to Tom and Sarah.
- Workgroup recommendations:
    - One criticism was that the definitions for these practices do not reflect what farmers are actually doing.

    - It was suggested that rotational grazing be taken out of this practice since we do not have the data. Tom Simpson said that they will try to segregate this out and that they will suggest that it be a separate practice.
- It was recommended that workgroup members look at the STAC white paper entitled *Innovation in Agricultural Conservation for the Chesapeake Bay: Evaluating Progress and Addressing Future Challenges*. This paper can be accessed at: http://www.chesapeake.org/stac/Pubs/STACAgWhitepaper.pdf.

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Agricultural Nutrient and Sediment Reduction Workgroup
Conference Call
May 24, 2007
10:00 AM - 12:00 PM

Off-Stream Watering with Fencing:
Jeff Sweeney commended UMD for developing such thorough documentation for this BMP.

ACTION: Mark Dubin will work with NRCS to insert codes and continue to work with NRCS in refining this BMP.

DECISION: UMD decided that they would separate out rotation grazing and deal with this BMP in Year 2 of their project.

ACTION: The workgroup asked UMD to address the nutrient balance in defining rotation grazing with respect to manure storage, feed imports, etc. The workgroup agreed to provide guidance to UMD on how to address year 2 BMPs and what factors to consider at the July workgroup meeting. NY needs to be consulted about this.

ACTION: MDA requested more time to evaluate the science behind this recommendation.

DECISION: The workgroup recommended pulling out critical area planning from this BMP since it constitutes the buffer component of fencing and is covered under the buffer BMP.

DECISION: UMD will clarify how buffers relate to this BMP and how fence set backs are addressed.

Offstream watering without fencing:
The assumption with this BMP is that shade will be provided near the watering source so that cows don't seek shade in streams. Having an offstream watering site won't prevent cows from going into streams to get away from the heat or flies. Have we factored in that level of uncertainty into the efficiency? MDA says that their BMP focuses just on watering source, not on a shade requirement.

ACTION: Sarah Weammert, UMD, will determine whether or not the studies they used for developing the efficiency factored in shade.

Workgroup ideas for how to address this issue:

- Option 1: Propose name change to "offstream watering without fencing but with shade". However, this may be impossible to define and track.
- Option 2: Adjust the efficiency to be lower to account for situations where cows may seek refuge in streams to cool down, to get away from flies, etc.
- Option 3: Carry out option 2 AFTER we line up all ag BMPs to see if their efficiencies make sense compared to one another. At that time, it may be clear whether or not we need to reduce the efficiency.
- Other options?

Participants:
Herb Reed, UMD
Beth Horsey, MDA
Kelly Shenk, EPA CBPO
Jeff Sweeney, UMD/CBPO
Kari Cohen, NRCS
Sarah Weammert, UMD
Peter Tarby, PA DEP
Tom Juengst, PA DEP
Becky Thur, CRC

Mark Dubin, UMD MAWP/CBPO - could not get on call due to technical difficulties with conference line.

Minutes: Tributary Strategy Workgroup Meeting
June 4, 2007
10:00 AM to 3:00 PM
NRCS MD State Office, Annapolis

Off-Stream Watering Practices

Off-Stream Watering Practices

- The expert reviewer recommended a 50% reduction from the literature numbers because of the limitation of literature and the fact that it wasn't spatially representative.
- The MARWP did not agree with the suggested 50% reduction and suggested efficiencies between the current efficiencies and the expert-suggested efficiencies. The AgNSRWG agreed that the expert-recommended efficiencies were too low but wanted more time to review the MARWP's recommendations.
- The TSWG suggested that shade play a part in the efficiency of off-stream watering without fencing because if there is shade, this practice could be 75 to 90% more effective because the animal won't have as a great an urge to go down to the water to cool off.
- For off-stream watering with fencing, the workgroup discussed how riparian buffers should fit into this practice. The reviewer suggested a new BMP called 'off-stream watering with fencing with a minimum width,' but the MARWP did not support that proposal. The AgNSRWG called for fencing and buffers to be reported separately.
    - If NEIEN is successful, off-stream watering with fencing and buffers should be able to be reported separately.
- ACTION: The reviewer's comments were not yet incorporated into the recommendation document, so Sarah Weammert will incorporate the reviewer, Mary Leigh Wolfe's, comments into the off-stream watering practices document.
- Consistency across states' BMP definitions is greatly needed.
- DECISION: The AgNSRWG is further reviewing the MARWP's proposed efficiencies for off-stream watering with and without fencing. The TSWG will wait for the AgNSRWG's comments before making a decision.
- DECISION: The MARWP and the TSWG agreed to separate rotational grazing from off-stream watering practices because it operates a separate practice and may have a separate efficiency. Rotational grazing and off-stream watering practices will be reported separately. Rotational grazing will be reviewed in the 2nd year of the BMP Project within a suite of pasture management BMPs.
- ACTION: Sarah Weammert will incorporate Mary Leigh Wolfe's comments into the off-stream watering practices recommendation document.
- Consistency across states' BMP definitions of off-stream watering practices is greatly needed.
- ACTION: States will tell Jeff Sweeney how to treat all pasture BMPs in the model within the next month. If buffers are implemented along with off-stream watering practices, they need to reported. If states can determine how much of their pasture land use is degraded, that should also be reported.

- DECISION: The AgNSRWG is further reviewing the MARWP's proposed efficiencies for off-stream watering with and without fencing. The TSWG will wait for the AgNSRWG's comments before making a decision.
- DECISION: The MARWP and the TSWG agreed to separate rotational grazing from off-stream watering practices. Rotational grazing and off-stream watering practices will be reported separately. Rotational grazing will be reviewed in the 2nd year of the BMP Project within a suite of pasture management BMPs.

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Minutes: Nutrient Subcommittee Meeting
June 6, 2007
10:00 AM to 3:00 PM
Fish Shack—Chesapeake Bay Program Office

Off-Stream Watering Practices

- The current numbers for the off-stream watering with fencing BMP are not supported by much data according to Tom, who helped to develop them.
- The existing literature is limited, and the developer believed to be overly optimistic, so the developer's suggested numbers are half of what the literature suggested. Roughly, MAWP doubled and adjusted the developer's recommendations.
- The issue of whether or not buffers were included in Off-stream Watering with Fencing was discussed. It was believed that if requiring a sufficient setback in state cost-share programs, then it would constitute a buffer and we need to work on a buffer against pastureland. Buffers and Off-stream Watering remain 2

separate practices. Jeff Sweeney needs to know if buffers are implemented in addition to the Off-stream Watering with Fencing.

- The Off-stream Watering suite of BMPs may include a new land use called "degraded stream corridor" which would have a nutrient load equal to 9.5 times the load from the average pastureland. This figure is based on calculations done by Russ Mader.
    - The AgNSRWG and TSWG are still reviewing this issue.
- The issue of shade in the Off-stream Watering without Fencing BMP was raised. It was suggested that providing shade is required to make this BMP work.
- The numbers for TP and TSS percent reduction of 30 for Off-stream Watering without Fencing and 40 for Off-stream Watering with Fencing appeared to be too close to Russ Perkinson.
    - ACTION: Tom will review the TP and TSS numbers for Off-stream Watering with and without fencing and will discuss the issue further with Russ. The issue will go back to the AgNSRWG if necessary.
- NRCS grazing specialists wish to weigh in to this discussion as well.
- For Off-stream Watering with Rotational Grazing, MAWP recommends that further review be delayed until Year Two. This practice is under consideration to be separated into its own BMP.

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Minutes: Tributary Strategy Workgroup Meeting
July 9, 2007
10:00 AM – 1:30 PM
NRCS MD State Office

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- Pasture Management has been discussed in terms of whether or not Off-Stream Watering Without Fencing should include shade. NRCS does not recognize this as a separate practice, and some believe that it could be detrimental because of a lack of management.
- Rotational Grazing has been moved to year 2 of the BMP Project. In year 2, the MARWP will look into how to deal with differences between rotational and intensive grazing and the conjunction of rotational grazing with streams which is likely to be separated.

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Meeting Minutes
Agricultural Nutrient and Sediment Reduction Workgroup
Adams County Agricultural and Natural Resource Center
Gettysburg, Pennsylvania
July 12th, 2007

- Russ Perkinson raised concerns that dissolved reactive phosphorus (DRP) was not factored into efficiencies. Tom replied that that no known literature on DRP and its impact on BMPs existed, and could not find expert opinion to quantify differences between DRP and soluble P. Tom did feel that DRP was a bigger issue on cropland than stream protection.
- Russ Perkinson indicated that he struggled with the pasture exclusion figures (with and w/o fencing) and could not endorse the numbers as presented for the state of VA. The biggest point of contention for him was the limited efficiency increase between the practice with fencing versus without. A greater benefit should be expressed with the addition of stream bank fencing.
- Mark Dubin explained that the efficiencies associated with fence and w/o are only looking at reductions from exclusion, and do not factor in buffers. The exclusion of livestock from the stream would only account for a portion of the nutrient/sediment reductions gained. Additional reductions would be associated with the land use change of the area in the exclusion, as well as the reductions from functional riparian buffers of 35 feet or greater under the riparian buffer practice.
- Russ pointed out that in order to qualify for a cost share in VA, a fence BMP is always done in conjunction with a buffer, which would account for greater than a 10% difference compared to the w/o fencing BMP. He sees a 50%:25% split as being a much more accurate portrayal of these efficiencies.
- Workgroup members felt that the livestock shading provision in the Off-Stream Watering w/o Fencing practice should not be required since it was not consistent with NRCS standards and has not been a cost shared practice under state conservation implementation programs.

Participants

Greg Albretcht	NYS SWCC CNMP
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Renato Cuizon	MDA
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Becky Thur	CRC

Calling In

Tom Simpson	UMD

Agricultural Nutrient and Sediment Reduction Workgroup
Conference Call
August 2, 2007

- Issue 1: For the off-stream watering with/without fencing BMP, the workgroup recommended that the livestock shading requirement be removed from the stream protection without fencing definition.
    - DECISION: UMD accepted the workgroup's recommendation. Shade should not be a requirement for this practice, although they suggested saying in the definition that shading should be encouraged where applicable.

- Issue 2: For the off-stream watering with/without fencing BMP, the workgroup recommended that the efficiencies for the without-fencing category be reduced to increase the difference between this category and the with-fencing category. A higher efficiency is primarily proposed for this category because some states require at least a 35-foot setback for the fencing.
    - VA requires a 35-foot setback.
    - A 35-foot setback is not in MD's requirements. It is site specific.
    - A 35-foot setback is standard now in PA, but in the past it was 12 or 15 feet.
    - UMD stated that off-stream fencing has been used to refer to the act of simply fencing cattle out of the stream and it isn't tied to width.
    - DECISION: UMD will not change their recommended efficiencies for the off-stream watering practices. However, in order to address the workgroup's concerns, they agreed to recognize that when a wide area is fenced off (such as with a 35-foot setback), it should qualify as two practices: stream protection and a buffer for pasture. The workgroup accepts this suggestion, unless Russ Perkinson (who brought up this issue at the last meeting and is not in attendance today) has any objections. If he does, then this issue will be brought back to the workgroup at a later date.

- Issue 3: The workgroup recommended that phosphorus efficiencies be set 5% lower than sediment efficiencies as a general rule to account for dissolved phosphorus losses not associated with soil losses, unless the scientific research indicates differently.
    - UMD supports the recommendation that TP efficiencies be set lower than TSS efficiencies; however they suggest that the TP efficiencies be lowered by 10% rather than by 5%. They favor 10% because it implies that there is a significant difference and because it does not indicate a greater level of

precision than we have. However, they will defer to the workgroup regarding what percentage is used.
    - Some members voiced concern that subtracting 10% from TP will affect some BMPs more than others. For example, if the original efficiency is 40% and it is lowered to 30% than it is only reduced by 25%, whereas if the original efficiency is 20% and it is lowered to 10% than it will be reduced by 50%.
    - DECISION: In order to make the reductions more proportional, UMD and the workgroup agreed to reduce TP by 25%, rather than simply subtracting 10%. This was based on research findings which suggest that 25% of TP are attributable to Dissolved Reactive Phosphorus (DRP) according to the UMD.

The workgroup decided to accept the UMD recommendations with the agreed upon adjustments for the agricultural practices. The only exception was for the cover crop practices which will require additional revisions prior to final review by the workgroup.

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Minutes: Tributary Strategy Workgroup
August 6, 2007
Chesapeake Bay Program Office—Fish Shack

Off-Stream Watering With Fencing Practices:

- The AgNSRWG is comfortable with MARWP's proposed recommendations, with a couple of caveats.
    - The AgNSRWG recommended TP reductions reflect a 75% value of the TSS reductions due to dissolved reactive phosphorus losses.
    - There would be an accumulative effect of N, P, and S reductions for riparian buffers of 35 feet or greater.
- DECISION: The TSWG agreed with the Off-Stream Watering with Fencing Practices recommendations.

Off-Stream Watering without Fencing Practices:

The AgNSRWG recommended TP reductions reflect a 75% value of the TSS reductions due to dissolved reactive phosphorus losses.

- NRCS does not have a national standard for livestock shading which causes concern with AgNSRWG members. The workgroup decided to address shading by leaving the language in the definition and noting that it is an optional aspect that is encouraged and may be more formally addressed in the future.

- The AgNSRWG believed the practice would be more effective with shading.
  - Peter Freehafer asked if additional credit could be given if shading is addressed.
  - The AgNSRWG believed the language worked with current circumstances and would support a more formal crediting process in the future.
  - Kelly Shenk mentioned that more research would be needed to more formally address the impacts of shading.
- The AgNSRWG wishes to delay Rotational Grazing to Year 2 of the BMP project.
  - There are many opportunities and management methods available that could call for changes in efficiencies.
- DECISION: The TSWG agreed with the Off-Stream Watering Without Fencing recommendations.

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AgNSRWG, TSWG, and NSC Conference Call
August 24, 2007

- Jeff Sweeney, UMD-CBPO, gave a presentation on the effectiveness of pasture fencing in the Phase 5 watershed model. His presentation can be accessed at: http://www.chesapeakebay.net/pubs/calendar/ANRWG_08-24-07_Presentation_1_9035.pdf.

- At the last NSC meeting, the states requested that Jeff explain how we credit this BMP in the watershed model.
- For the Phase 5 watershed model, Jeff is proposing that the method used for crediting pasture fencing be changed. Currently in the Bay model, they credit the pasture protected area with an efficiency. For Phase 5, however, they are proposing a land use conversion that would convert land in the high-loading corridor to the “hay without nutrients” land use. In Phase 5, pasture would be divided into pasture corridor and non-corridor pasture.
- The amount of pasture protected area (phase 4.3) and the amount of total pasture land designated as a pasture corridor (phase 5.0) are based on state Tributary Strategies. Pasture corridor designated land assumes a 35-foot width between the stream and the fence.
- The PowerPoint presentation includes graphs that compare the projected nitrogen, phosphorus, and sediment loads in the Phase 5 model for four different options: (1) current efficiency/ current method, (2) current efficiency/ proposed method, (3) proposed efficiency/ current method, and (4) proposed efficiency/ proposed method. The proposed efficiency refers to the efficiency recommended by MAWP and the proposed method refers to the land use conversion discussed above.
- An issue that needs to be discussed further by the workgroups in the future is what will happen to this corridor land over time. Will it become grass? Will it grow into forest?
- DECISION: The AgNSRWG agreed that we should move forward with the proposed method (making a land use change) and that we should accept MAWP’s proposed efficiencies. The TSWG and the NSC approved of this decision.

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Chesapeake Bay Program
Water Quality Steering Committee
Conference Call
August 27, 2007

SUMMARY OF DECISIONS, ACTIONS AND ISSUES

Water Quality Steering Committee Approval of Year 1 MAWP BMP Efficiencies

Issue: At the Water Quality Steering Committee's June 20-21, 2007 meeting, the Steering Committee agreed that they would conduct the final review all of the Nutrient Subcommittee's recommended BMP definitions and efficiencies and take action on any BMPs that the Nutrient Subcommittee (NSC) could not agree on an efficiency for. Definitions and efficiencies for twelve of the thirteen Year 1 BMPs were approved by the Nutrient Subcommittee and determined to be consistent with the available data by the MAWP. The Cover Crop BMP was not resolved. The Steering Committee was asked by the Nutrient Subcommittee to approve the package of the 12 consensus-supported BMP efficiencies and make the final decision on the cover crop BMP efficiencies based on three options.

- Bill Brannon (WV DEP) questioned the Off-Stream Watering BMP efficiencies, noting the significant decrease in efficiency between the current and recommended numbers. He noted that his WV representation on the Nutrient Subcommittee raised this as an issue and he just wanted to make sure that the NSC addressed this issue in its final recommendation.
  - Mark Dubin (UMD/CBPO) informed the group that this issue was discussed on Friday's (August 24) Nutrient Subcommittee conference call with the Agricultural Nutrient and Sediment Reduction Workgroup (AgNSRWG) and the Tributary Strategy Workgroup. Jeff Sweeney (UMD/CBPO) had been looking into the work done previously by Russ Mader on pasture loads through riparian forest buffers. Jeff and Mark made some assumptions based on this work and discussed them with the AgNSRWG. The workgroup believed their work was a good first step in the process and that the assumptions will continue to be studied to ensure they are correct. The workgroup recommended moving forward with the recommended efficiencies for use in Phase 5 of the Watershed Model based on the agreement on August 24 conference call that what we have so far is a good first step. The workgroup recommended the partners continue to work on looking at how to model the loads the recommended efficiencies will be applied to.

ACTION: Water Quality Steering Committee members with further questions about the off-stream watering BMP efficiencies should contact Mark Dubin.

DECISION: The Water Quality Steering Committee approved the 12 BMP definitions and efficiencies, described in the advance briefing papers, as recommended by the

Nutrient Subcommittee and its workgroups for use in Phase 5 Chesapeake Bay Watershed Model.

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