Appendix A—Pineview Reservoir TMDL

Project Implementation Plan

Executive Summary

The purpose of this Project Implementation Plan (PIP) is to describe the activities necessary to achieve the 24 percent reduction in nutrient loads identified in the Pineview Reservoir TMDL. Another purpose is to estimate the costs associated with those activities, establish implementation priorities, and to begin to identify parties to be involved and a proposed schedule.

Table 1 summarizes the activities that are described in this PIP and provides cost estimates for each activity. Readers should understand that these activities and estimated costs are preliminary at this point in time and will continue to be refined as better information becomes available. However, the estimated costs provide some insight into how the activities should be prioritized. For example, the anticipated costs for converting from flood irrigation to sprinkler irrigation are

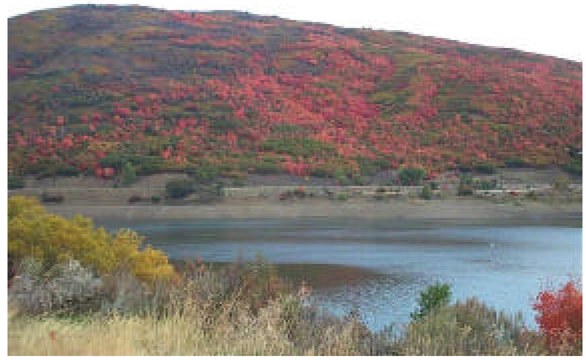

Figure 1. Pineview Reservoir.

Table 1. List of possible implementation activities, their expected impact, and estimated costs.

Activity	Impact	Capital Costs	Annual Operating Costs
Convert all flood irrigation to sprinkler irrigation	Expected to save more than 23,000 acre-feet of water per year and reduce nitrogen and phosphorus loadings from groundwater by more than 50 percent	$7.6 million	$170,800
Implement a septic system pollution prevention program	Make homeowners aware of the age, location, type, capacity, and condition of their septic system	$31,000	Minimal
Repair and replace failing septic systems	Decrease the percentage of failing septic systems from 15 to 6 percent to reduce phosphorus loading from this source by more than 60 percent.	$327,000	$52,200
Install sewer system in Ogden Valley	Eliminate nitrogen and phosphorus loads from wastewater	$3.9 million	N/A
Improve livestock and animal waste management practices at AFOs and CAFOs	Reduce nutrient loadings from animal wastes by a minimum of 25 percent by preventing animal waste from reaching surface waters	$302,000	N/A
Convert more than 20,000 acres of brush to grass to reduce erosion	Reduce total nitrogen and total phosphorus loads by reducing sheet and rill erosion	$316,410	Minimal
Install 600 acres of vegetated buffer strips along streams	Reduce total nitrogen and total phosphorus loads by decreasing sediment delivery to streams	$145,200	Minimal

N/A = Not Available AFO=Animal feeding operations CAFO=Centralized animal feeding operations considerably higher than other activities that provide comparable benefits and should perhaps be delayed pending the outcome of other implementation options. This issue is discussed further below.

The Pineview Reservoir TMDL will use a nonregulatory approach to TMDL implementation through control of nonpoint sources of pollutants. Watershed projects will be started incrementally as they are funded. The time frame for implementation is estimated to be five years. Therefore the timeframe estimated for Pineview Reservoir to meet standards is approximately 5 to 20 years, depending on implementation activities, funding availability, effectiveness, and reservoir response. The USEPA recognizes that TMDLs with primarily nonpoint sources of pollution can be difficult to manage, and may require a long time to correct.

A review of the total costs and cost per kilogram for reducing nitrogen and phosphorus is presented in Table 2. The effectiveness for each candidate activity varies significantly. Further, what is effective for reducing nitrogen may not be effective for reducing phosphorus and visa versa. From an overall cost perspective, focusing on the septic system improvements, livestock and manure management, and range treatments (including buffer strip installation along streams) are the least expensive options with a combined estimated cost of $1.1 million. The other two candidate activities (irrigation changes and constructing a sewer system) are an order of magnitude more expensive, with a total estimated price tag of $11.5 million.

Table 2. Cost comparison for possible implementation activities.

Activity	**Capital Costs**	**Anticipated N Reduction (kg)**	**Cost/kg N reduction**	**Anticipated P Reduction (kg)**	**Cost/kg P Reduction**	**Priority**
Irrigation changes	$7.6 million	10,999	$691	293	$25,939	
Septic system education, maintenance & upgrades	$499,450	276	$1,810	755	$662	1
Construct sewer system	$3.9 million	39,306	$99	1,215	$3,210	
Livestock & manure mgmt.	$302,000	7,514	$40	600	$503	1
Range treatments & vegetated buffer strips	$461,610	10,710	$43	1,487	$310	1

One common approach in addressing a nutrient enrichment water quality problem is to address the limiting nutrient (nitrogen or phosphorus) to effect the needed changes to the biological system. Although the limiting nutrient in Pineview Reservoir is unclear, phosphorus has been found to be the limiting nutrient in the majority of lakes and reservoirs nationwide. Given the cost factors discussed above, focusing on phosphorus for this TMDL may be the preferred initial course of action. If the three least expensive implementation items are undertaken the total annual phosphorus reduction is expected to be 2,842 kilograms, which is 153 percent of the goal for the TMDL. This should drive the biological system to be phosphorus limited if it is not already. Additionally, if these three items are implemented, nitrogen will be reduced by 18,500 kilograms, which is 67 percent of the TMDL target.

It appears reasonable to proceed initially with the three least expensive options while continuing to monitor and assess reservoir water quality. Further monitoring should be undertaken to refine the understanding of the inputs to Pineview while at the same time measuring the changes in water quality as implementation activities progress. If, after a reasonable period of time such as 5 to 10 years, measurable improvements are not being observed in the reservoir water quality, it may be appropriate to consider the more costly alternatives to nutrient reduction (i.e., sewering the valley or converting flood irrigation to sprinkler) or to reevaluate the TMDL.

To effectively implement the needed changes to Pineview Reservoir water quality, a concerted locally driven effort will be needed. Table 3 provides some details on timeframes and involved parties to achieve implementation goals.

Table 3. Implementation timeframes and involved parties

Activity	Timeframes & Steps	Involved Parties
1. Converting flood irrigation to sprinkler	Detailed plans 2012 Secure funding 2014 Implementation 2016 **(to be undertaken only if needed after items 2,4, and 5)**	Private landowners NRCS, FSA Weber SCD
2. Septic system improvements program	Detailed plans 2003 Secure funding 2004 Implementation 2005-07	Weber County Health Dept. Huntsville City Local residents
3. Construct sewer system for ogden valley	Detailed plans 2012 Secure funding 2014 Implementation 2016 **(to be undertaken only if needed after items 2,4, and 5)**	Weber County Division of Water Quality Huntsville City Local residents
4. Implement livestock and manure management improvements	Detailed plans 2003 Secure funding 2004 Implementation 2005–07	Private landowners NRCS, FSA Weber SCD
5. Range treatments and vegetated buffer strips along streams	Detailed plans 2003 Secure funding 2004 Implementation 2005–07	Private landowners NRCS, FSA Weber SCD, U.S. Forest Service

The locally led Ogden Valley Watershed Committee will provide guidance and direction for implementation activities needed to achieve necessary load reductions for the Pineview Reservoir TMDL. <u>The approaches outlined in this appendix are subject to change based on local input.</u> There are several possible ways to achieve the nitrogen and phosphorus reductions identified in the TMDL. Some of these are outlined in this document; others are not outlined at this time. Based on input from the local watershed committee, the following potential implementation options will be investigated in addition to those items already outlined in this document: *reservoir outlet works modifications, recreational use impacts, wetlands enhancements, stream bank remediation, county ordinances to protect sensitive areas, augmentation of instream flows, stormwater management, and lot size zoning changes*.

Actual implementation will be undertaken to meet the necessary reductions and in a manner that corresponds with local planning and direction.

1.0 Introduction

The Pineview Reservoir TMDL report indicates the need to reduce phosphorus and nitrogen loadings by approximately 24 percent from their current levels. The purpose of this PIP is to identify the activities necessary to achieve this reduction. Another purpose of the PIP is to estimate the costs associated with those activities and to begin to identify involved parties and timelines. It is expected that this implementation plan will continue to evolve as more details are clarified and a process of adaptive management begins.

Listed below are the five major sources of nutrients in the Pineview Reservoir watershed. The PIP is organized according to these sources.

- Onsite wastewater treatment (septic) systems
- Animal wastes
- Tributary loads
- Residential runoff
- Irrigation return flow.

2.0 Septic Systems

2.1 Background

Septic systems provide an economically feasible way of disposing of household wastes where other means of waste treatment are unavailable (e.g., public or private treatment facilities). The basis for most septic systems involves the treatment and distribution of household wastes through a series of steps involving the following:

- A sewer line connecting the house to a septic tank.
- A septic tank that allows solids to settle out of the effluent.
- A distribution system that dispenses the effluent to a leach field.
- A leaching system that allows the effluent to enter the soil.

Septic system failure occurs when one or more components of the septic system do not work properly and untreated waste or wastewater leaves the system. The waste may pond in the leach field and ultimately run off into nearby streams or percolate into the groundwater system. Untreated septic system waste is a potential source of nutrients (nitrogen and phosphorus), organic matter, suspended solids, and bacteria. Failure can occur for several reasons. The most common reason is improper maintenance. Other reasons for failure include improper installation, location, and choice of system. Harmful household chemicals can also cause failure by killing the bacteria that digest the waste.

The analysis for the TMDL indicates that loads from septic systems are a potentially significant source of nutrients to Pineview Reservoir. They are especially important because of their impact on groundwater flows, which comprise the bulk of loads to the reservoir during the summer. Although the percentage of systems that are not functioning properly is unknown, it is likely that not all the systems are providing maximum treatment. Based on site suitability information for Ogden Valley, a national survey of wastewater management officials, and best professional judgment, it was assumed that 85 percent of the systems are functioning properly (normal), 10 percent have some surfacing of effluent (ponded), and 5 percent are located too close to streams to allow complete adsorption of phosphorus (short-circuited). Table 4 summarizes the predicted load reductions associated with addressing loads from these systems by improving their performance. The impacts of removing the septic systems by sewering the valley are also presented.

Table 4. Predicted loads from septic systems under various scenarios.

Pollutant	Current Estimate	Scenario A	Scenario B	Scenario C
Phosphorus	1,215	460	160	0
Nitrogen	39,306	39,030	39,020	0

Current: 85 percent normal, 10 percent ponded, and 5 percent short-circuited.
Scenario A: 94 percent normal, 5 percent ponded, and 1 percent short-circuited.
Scenario B: 98 percent normal, 1 percent ponded, and 1 percent short-circuited.
Scenario C: Sewering of valley with waste transported out of the watershed.

2.2 Recommendations

Many homeowners do not realize they have a failing septic system, whereas others may know, but choose not to remedy the problem because of cost. One recommendation is to initiate an outreach program to educate valley residents about septic systems, and in some cases provide funding to help fix or replace failing systems. The components of an example outreach program are illustrated below:

- Make homeowners aware of the age, location, type, capacity, and condition of their septic system
- Teach homeowners to recognize a failing septic system.
- Teach homeowners about proper septic system maintenance.
- Provide information about different types of septic systems, and their costs, advantages, and disadvantages.
- Provide consultation and inspection services to homeowners.
- Teach homeowners about water quality concerns in their watershed.

In addition to conducting a public outreach campaign, an effort should be made to identify and repair failing systems. In some cases extremely old systems might need to be replaced. Systems located in close proximity to the reservoir or reservoir tributaries should be targeted first. This effort should be coordinated by the Weber County Health Department.
Finally, an effort needs to be made to ensure that septic systems are properly maintained. Homeowners should be required to pump out or inspect their septic tanks on a regular schedule. Septic tanks should be pumped when the solids in the tank accumulate to a point where the effluent no longer has enough time to settle and clarify. The timing of the pump-out depends on the tank and household size (Table 5).

Table 5. Estimated septic tank pumping frequencies in years[1,2].

Tank Size (gallons)	Household Size (number of people)								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
500	5.8	2.6	1.5	1.0	0.7	0.4	0.3	0.2	0.1
750	9.1	4.2	2.6	1.8	1.3	1.0	0.7	0.6	0.4
1,000	12.4	5.9	3.7	2.6	2.0	1.5	1.2	1.0	0.8
1,250	15.6	7.5	4.8	3.4	2.6	2.0	1.7	1.4	1.2
1,500	18.9	9.1	5.9	4.2	3.3	2.6	2.1	1.8	1.5
1,750	22.1	10.7	6.9	5.0	3.9	3.1	2.6	2.2	1.9
2,000	25.4	12.4	8.0	5.9	4.5	3.7	3.1	2.6	2.2

[1] *If garbage disposals are used, frequencies may have to be reduced by as much as 40 percent.*
[2] (Mancl and Magette, 1991).

If these efforts fail a final but very expensive option would be to sewer the valley. Because a wastewater treatment plant would not be allowed to discharge within the watershed under current water quality rules, all wastewater would need to be transported out of the watershed and loads to Pineview Reservoir would be eliminated. A likely option would be to connect residents in the valley to the Central Weber Sewer Improvement District.

2.3 Costs

The costs of establishing a septic system public outreach campaign can vary greatly, depending on factors such as staff time, outreach components, and the extent of septic use within a region. Table 6 provides some examples of programs from various parts of the country and the expenditures for septic outreach. Once a program is well established, the cost of creating educational materials and training programs decreases and funding can be redistributed to those outreach techniques that have proven to be the most successful. Programs should be sure to secure some funding for media outreach.

Table 6. Examples of cost and staff time to establish septic system outreach programs[1].

Program	Expenditure	Staff Time (Full-time equivalent)	Components
City of Olympia, WA	$40,000	0.50	Flyers/brochures Training workshops System monitoring
Thurston County, WA	$35,000	0.50	Flyers/brochures Discount coupons for septic pumping
Minnesota Cooperative Extension	$18,000	0.25	Publications/videos Flyers/brochures Training workshops/community visits Septic system owner's guide distributed with new permits Satellite conferences for policymakers "Train the Trainers" program

[1] SMRC, 2001a.

Research has shown that most of the causes of septic system failure are relatively easy and inexpensive to repair, with an average cost of only $285 per system (Glasoe and Tompkins, 1996). The average cost of replacing a system is much higher, perhaps around $4,500 for a conventional system (USEPA, 1993). The average cost to pump out a system is approximately $150 (URI, 2002). Using these costs and a number of assumptions about systems within the valley the following calculations can be made:

Table 7. Estimated septic system repair and replacement costs.

Item	Value	Source
Valley population (2000)	6,622	Festin, 2002.
Population served by septic systems	5,959	90 percent (from TMDL report); remaining population served by lagoons.
Number of septic systems	2,384	5,959 ÷ 2.5 persons/household.
Number of failing septic systems	357	15 percent (from TMDL report).
Repair costs	$76,950	270 systems * $285/system (Glasoe and Tompkins, 1996).
Replacement costs	$391,500	87 systems * $4500/system (USEPA, 1993).
Annual pump out costs	$71,550	477 systems * $150/system to achieve annual pump-out of all systems every five years (URI, 2002).

Of the 357 septic systems assumed to be failing, it was furthermore assumed that 270 require repairs and 87 require replacement. This was based on limited data from the literature (Glasoe and Tompkins, 1996). Until inspections occur, the number of failing systems, the number of systems requiring repairs, and the number of systems requiring replacement will remain unknown.

No current estimates of the cost of sewering the valley are available. However, the Pineview Reservoir Clean Lakes Study (WBWQMC, 1990) estimated that the costs would be approximately $2.6 million in 1988. This translates into approximately $3.9 million today (EHS, 2002).

3.0 Animal Wastes

3.1 Background

Animal feeding operations (AFOs) are agricultural enterprises where animals are kept and raised in confined situations. AFOs congregate animals, feed, manure and urine, and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures or fields or on rangeland. Concentrated animal feeding operations (CAFOs) are a relatively small number of AFOs that are regulated by the USEPA because of their size. An inventory of AFOs and CAFOs in the Ogden Valley was underway at the time of the Pineview TMDL. An estimate of CAFOs and 20 AFOs in Ogden Valley was used for this PIP, based on initial information from the inventory effort (Warnick, 2002). The Farm Services Agency estimates that there are 500 horses, 400 beef cattle, and 80 dairy cattle within the watershed (Fowers, 2001).

The way manure is stored and handled within AFOs affects its nutrient content dramatically. All of the nitrogen in manure that drops directly into streams goes into the aquatic system. When animals have a live stream in the corral, about 70 percent of the urine and feces is excreted directly into the water. On the other hand, if manure is in a corral and is scraped and gathered in the fall, almost all the nitrogen will have volatilized in dry warm summer conditions.

The TMDL report indicates the need to reduce nutrient loading to Pineview Reservoir from animal wastes. This can be accomplished by improving livestock and animal waste management practices at the AFOs and CAFOs within the Valley. The goal of Utah's AFO/CAFO strategy is to correct "unacceptable conditions" associated with AFOs and curtail the movement of animal waste into waterways.

3.2 Recommendations

An effort should be made to exclude livestock within the AFOs from riparian areas. This will reduce the quantity of nutrients that are directly deposited into surface waters. It will also allow the stream buffer to become more vegetated and stable, which can reduce the risk of streambank erosion, provide shade and habitat for aquatic species, and filter nutrients and sediments from runoff. The largest operations located in closest proximity to the reservoir and inflowing streams should be targeted first.

Livestock are usually excluded by fencing. Several alternatives are available for providing water to animals that can no longer obtain it directly from the stream. These include pipelines, ponds, wells, troughs, and tanks. Options are also available for providing livestock stream crossings and alternative shade areas.

3.3 Costs

Costs of excluding livestock are associated with the construction of fences and water pipelines and any planting programs aimed at reestablishing vegetation on streambanks. Rough estimates for the costs of excluding livestock from watercourses and for manure management facilities at the CAFOs in Ogden Valley will be $250,000 (five operations * $50,000/operation). Fencing the AFOs and installing stream buffers is expected to cost an additional $52,000 (20 operations * $2,400 for fencing + 20 operations * $200 for stream buffer). (Fencing costs assume 1,500 feet at $1.60/foot for 4-strand barbwire; stream buffer costs include grading, seeding, and irrigation).

4.0 Tributary Loads

4.1 Background

The TMDL report indicates the need to reduce nutrient loading to Pineview Reservoir from tributary loadings by 40 percent. A portion of these load reductions could come from reducing sheet and rill erosion by converting brushland to grasslands. Loads could also be reduced by installing vegetated filter strips along streams to catch pollutants before they enter the stream.

4.2 Recommendations

Conversion of brushland to grassland should be prioritized for areas of the watershed where erosion is expected to be the greatest, such as subwatersheds with steep slopes. Areas closer to the reservoir should also be given top priority.

Figure 2. Example of the benefits of revegetation from Bear River, Utah.

Vegetated filter strips are used to reduce the amount of nutrients and sediments that enter a waterbody, reduce erosion around a stream channel, and protect a waterbody from encroachment. If vegetated buffers are designed correctly, they can prevent suspended solids, nitrogen, and phosphorus from entering a stream. The ability for the buffer to uptake nutrients depends on the design and the residence time of the water. Suspended solids (which can transport nutrients) are more easily removed by vegetated buffers through settling. The Stormwater Manager's Resource Center (2001b) summarized several studies that indicate that buffers may reduce nitrogen and phosphorus concentrations in stormwater runoff (Table 8).

Table 8. Pollutant removal rates (%) in buffer zones[1]

Study	Buffer Vegetation	Buffer Width (meters)	Pollutant Removal Rate (%)		
			Total Suspended Solids	TP	Total Nitrogen
Dillaha et al., 1989	Grass	4.6	63	57	50
		9.1	78	74	67
Magette et al., 1987	Grass	4.6	72	41	17
		9.2	86	53	51
Schwer and Clausen, 1989	Grass	26.0	89	78	76
Lowrance et al., 1983	Native hardwood forest	20–40.0	-	23	-
Doyle et al., 1977	Grass	1.5	-	8	57
Barker and Young, 1984	Grass	79.0	-	-	99
Young et al., 1980	Grass	27.4	-	88	87

[1]SMRC, 2001b.

4.3 Costs

NRCS estimated the costs of converting brushland to grassland at $15 per acre, primarily to pay for spraying (Garn, 2002). Assuming that 20 percent of the land currently classified as brush is converted to grass results in a total cost of $316,430 (Table 9).

Table 9. Estimated costs associated with converting brush to grass in Pineview Reservoir watershed.

Tributary	Current Brush (Acres)	Proposed Acreage to Convert to Grass (20 percent)	Estimated Cost ($)
North Fork	19,407	3,881	58,220
Middle Fork	14,156	2,831	42,470
South Fork	65,704	13,141	197,110
Subbasin 4	3,385	677	10,160
Subbasin 5	1,512	302	4,540
Subbasin 6	410	82	1,230
Subbasin 7	766	153	2,300
Subbasin 8	89	18	270
Subbasin 9	42	8	130
Total	**105,472**	**21,094**	**316,430**

To estimate the number of acres of filter strips required in the Pineview Reservoir watershed the total length of stream miles was measured using a geographic information system (GIS). There are a total of 429 miles (100 miles in the North Fork subwatershed, 66 miles in the Middle Fork subwatershed, and 263 miles in the South Fork subwatershed). To achieve a 20 percent reduction in phosphorus loads it will be necessary to install filter strips along 35 percent of the stream miles in the watershed (57 percent pollutant removal rate [Dillaha et al., 1989] * 35 percent of streams = 20 percent load reduction). This means that filter strips will need to be installed along approximately 150 miles of streams. Assuming a width of 5 meters, the 150 miles of filter strips equals 600 acres.

The costs of installing vegetated filter strips were summarized by USEPA (1993) and are presented in Table 10. The average cost of the three case studies was $136 per acre, which converts to approximately $242 in current dollars (EHS, 2002). The capital costs of planting approximately 600 acres of filter strips is therefore $145,200.

Table 10. Cost of installing vegetated filter strips[1].

Location	Year	Unit	Capital Costs ($/unit)
National	1985	Acre	117.93
Michigan	1981	Acre	191.55
North Carolina	1980	Acre	98.61

[1] USEPA, 1993.

5.0 Residential Runoff

Nutrient loads from residential runoff are not considered a significant source when compared to other sources within Ogden Valley. However, an effort should still be made to reduce loadings from this source wherever feasible, especially since residential land in the valley has been rapidly increasing since 1960.

Urban land can be a source of a wide range of pollutants. Cars, lawns, factories, and construction sites are some of the many sources of urban pollutants. In addition to being a source of pollutants, urban areas also tend to increase the imperviousness in a watershed. Impervious areas reduce the amount of water infiltration and increase the amount of stormwater that flows into surface waterbodies. When water is allowed to run off of urban areas, it can transport various pollutants, including metals, greases and oils, nutrients, and sediment to surface waters. Stormwater flows and volumes are often higher in urban streams than in other streams. The Center for Watershed Protection (CWP, 1998) has estimated that watersheds with 11 to 25 percent impervious cover have impacted stream quality, and watersheds with more than 25 percent impervious cover have nonsupporting stream quality. The Pineview Reservoir watershed currently has less than 1 percent impervious cover.

Outreach programs are used to educate the public about watershed concerns, urban runoff issues, and alternative construction practices (such as open space planning). These programs can also teach the community about individual practices that can reduce nutrient loadings. For example, lawn fertilization and animal wastes may be a source of nutrient pollution in streams in urban areas. Instruction in proper fertilization practices could help reduce nutrient loadings from individual residential lots. Other individual homeowner practices include using nonphosphorus-containing detergents and reducing overall water use. Studies have found that newspapers and television are more effective in outreach programs than brochures and meetings (Tetra Tech, 2001).

The main goal of structural urban best management practices (BMPs) is to increase the amount of water infiltration and reduce the amount of runoff. By doing this, stormwater and pollutants carried by stormwater are prevented from directly entering a stream. Some common structural urban BMPs are listed below:

- Infiltration basin
- Infiltration trench
- Dry or wet ponds
- Porous pavement
- Constructed wetlands.

The premise of each of these BMPs is to route stormwater to a holding basin so that more water can infiltrate and suspended solids can settle out of the water. The Pineview Reservoir Clean Lakes Report (1988) suggests total containment of stormwater from all high-density development in the Pineview Reservoir watershed. The effectiveness of each of these BMPs depends on the retention time, the size (volume of the basin), flow, and type of soils. Pollutant removal effectiveness also depends on these factors. USEPA (1993) reports that the average nitrogen and phosphorus removal of an infiltration basin from several U.S. studies is 60 and 65 percent, respectively (Table 11). Basin costs depend on size and site conditions (Table 12).

Table 12. Average pollutant removal efficiency (%) of several urban BMPs[1].

BMP	Total Suspended Solids	Total Nitrogen	TP
Infiltration basin	75	60	65
Infiltration trench	75	55	60
Extended detention dry pond	45	30	25
Wet pond	60	35	45
Porous pavement	90	85	65
Constructed wetland	65	20	25

[1] USEPA, 1993.

Table 12. Costs of selected urban BMPs[1].

BMP	Average Construction Cost	Annual Average Maintenance Cost	Total Annual Cost
Infiltration basin	$\$0.5/ft^3$	7% of capital cost	$\$0.03–\$0.05/ft^3$
Infiltration trench	$\$4.0/ft^3$	9% of capital cost	$\$0.3–\$0.9/ft^3$
Extended detention dry pond	$\$0.5/ft^3$	4% of capital cost	$\$0.007–\$0.3/ft^3$
Wet pond	$\$0.5/ft^3$	3% of capital cost	$\$0.008–\$0.07/ft^3$
Porous pavement	$\$1.5/ft^2$	$\$0.01/ft^2$	$\$0.15/ft^2$
Constructed wetland	N/A	N/A	N/A

[1] USEPA, 1993.

6.0 Irrigation Return Flows

6.1 Background

Irrigation return flows are a substantial component of current nutrient loads in the Pineview Reservoir watershed. A large number of acres are flood-irrigated during the summer and their return flows cause increased nutrient loadings to the reservoir. The TMDL report indicates the need to reduce nutrient loading to Pineview Reservoir from these irrigation return flows by 50 percent. This can be accomplished by improving irrigation practices within the valley because there is a great deal of inefficiency associated with the current systems. The following description of the potential impact of improved irrigation practices was provided by the Natural Resources Conservation Service (NRCS) (Hansen, 2002a).

The valley bottom has annual precipitation of 20 inches. Many of the valley-bottom soils have a plant-available water capacity of 6 inches or more. Snowmelt fills the soil profile in the spring, and in an average year this stored water and spring rains provide adequate water for plant growth to the end of June. If the soil profile is filled again at that time it stores enough water to last another 30 days. Sandy or gravelly soils hold less water and need more frequent irrigation. Unnecessary spring irrigation leaches nitrogen and organic forms of phosphorus and contributes a major part of the groundwater. It also adds nutrients to surface water because of irrigation runoff. The technology exists to schedule irrigation water very precisely based on the needs of the crops, but this technology has thus far not been fully utilized in the valley.

NRCS uses the Farm Irrigation Rating Index (FIRI) to estimate the amount of change different irrigation systems and management styles cause in irrigation efficiency. Using this index with a typical flood-irrigated field in the valley-irrigation efficiencies are approximately 20 to 30 percent. Conveyance efficiencies are very low because most of the ditches are on gravelly soils with high percolation rates. The fields have relatively uneven, steep slopes and in many of the alluvial areas have quite shallow soils over gravel. Efficient surface irrigation systems are not an option because laser leveling would remove too much topsoil.

6.2 Recommendations

A number of options exist for improving irrigation practices within the valley. NRCS recommends that the following activities take place:

- Install sprinkler irrigation systems for the irrigated land south of the north branch of South Fork. This will include about 1,600 acres served by a mainline system with gravity pressure. Plans are available but project funding is required.
- Another 1,600 acres from the north side of South Fork to Middle Fork are planned for the future as a mainline system with gravity pressure. Some sprinkler irrigation systems already exist in this area.
- Eden Irrigation Company has approached NRCS for technical assistance in developing a pressurized irrigation system in Eden. If it is feasible it will bring in another 2,000 acres.
- Most of the land in the North Fork area is already under sprinkler irrigation. To finish that area, about 300 acres will need to be supplied with pressurized irrigation water.

Figure 3. Example of sprinkler irrigation.

Table 13 shows the expected water savings when the valley is converted to sprinkler irrigation systems, if the systems are managed based on consumptive use by the crops. The water savings will translate directly into reduced groundwater flows, which in turn will lead to reduced nutrient loadings. Since the annual water savings (23,120 acre-feet) are expected to be greater than 50 percent of current water use (43,200 acre-feet) it can reasonably be expected that nutrient loads will also be reduced by at least 50 percent.

Table 13. Summary of potential irrigation water management projects in the Pineview Reservoir watershed.

Location	Current			Planned		
	Surface (acres)	Sprinkler (acres)	Water Used (acre ft)	Surface (acres)	Sprinkler (acres)	Water Used (acre-ft)
South Fork	800	800	10800	0	1,600	5,540
Middle Fork	1200	400	12600	0	1,600	5,540
Eden	1500	100	13950	0	1,600	5,540
North Fork	300	700	5850	0	1,000	3,460
Total	3800	2000	43200	0	5,800	20,080

6.3 Costs

Implementing the irrigation practices described above is expected to be expensive. NRCS estimates that installation costs for on-farm sprinkler systems will cost approximately $1,000 per acre and delivery systems will cost an additional $1,000 per acre (Hansen, 2002b). These costs are higher than those reported in the literature (Table 14), perhaps because there are a lot of small fields with multiple landowners in the valley. The actual costs will vary with field size, crops, precipitation, and needs.

The estimated capital cost for converting to sprinkler irrigation is $7.6 million (3,800 acres * $2,000/acre) and the estimated operation costs are $170,800 (3,800 acres * $44.94/acre). The average per acre operation costs are based on values reported in the literature (Scherer, 1998).

Table 14. Comparative costs of sprinkler irrigation systems in North Dakota. Costs for these systems include equipment cost, well drilling and maintenance (if needed), electricity, and annual maintenance[2].

	Center Pivot	Center Pivot with Corner	Linear Move	Big Gun	Side Roll	Average
Acres Irrigated[1]	130	152	158	157	158	151
Total Capital Cost	$73,000	$98,000	$109,000	$97,000	$90,000	$93,400
Capital Cost per Acre	$561.54	$644.74	$689.87	$617.83	$569.62	$618.54
Total Annual Operating Cost per acre	$33.97	$35.22	$39.29	$63.32	$52.92	$44.94

[1]Acres irrigated is out of 160 total acres with one well on the center of the field.
[2] Scherer, 1998.

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