6. Implementation Strategies

The following section describes specific strategies to address the objectives established by the WMA. The section is organized by the six main goals of the WMA defined above. Each section defines the strategies specific to that goal although there is significant overlap between goals. For instance many of the action items outlined in the Education/Outreach section are also found in the water quality, recreation and habitat goals. Also, the strategies for meeting the water quality goals overlap with the strategies for restoring the natural hydrology of the watershed.

6.1. Education/Outreach Strategies

Increasing awareness of watershed issues is the foremost goal of any watershed management plan. The following are the proposed strategies for meeting the WMA goal of increasing people's awareness and understanding of the individual connections and efforts within the watershed. This goal is built around education and awareness of all members within the watershed. In order to develop a strong educational effort, we must recognize that there are three types of members we will be speaking to over the next ten years. First, folks who know little or nothing about their watershed and whom we are starting at ground zero to inform and engage. Second, people who need more intensive education to continue to build their knowledge and who are looking to change their behaviors. And third, those persons who are very knowledgeable and may be able to craft information needed for educating the other two audiences.

We will continuously develop our educational process to: identify and analyze our target audience, create appropriate messages, package the message using the appropriate media, events and leveraging resources, and distribute our messages. This will ensure that the information we have assembled in our plan can be utilized well through education, that the water quality goals we have set will be understood and inspire all members in the watershed to assist in reaching our goals. And that after twenty years, we will have a healthier watershed to live, work and play in.

The first strategy is to educate landowners and residents in our watershed so that by 2035, 80% can identify their watershed. The following action steps will be used to achieve this strategy;

- Promote using website and social media
- Develop Maps for distribution and electronically
- Press Releases
- Water Quality Celebrations
- City/County marked boundaries - signage

We will use an outreach campaign through the media to support the strategies identified in the plan for meeting the other five goals of the watershed.

Each year the following action steps will be employed to increase awareness of the objectives and progress towards meeting those goals;.

- Press Releases
- Field days
- Water monitoring results
- Increasing habitat

Promoting stewardship in the watershed will be done by holding field days in the watershed. Up to 3 field days per year will be held on specific topical issues including cover crops, soil health, nutrient management BMPs, stream restoration, hydrology and other topics to be identified.

Conducting field days will consist of;

- Planning each Year and Identifying Field Days
- Securing hosts and partners
- Conduct a press campaign to inform the public about the Field Days
- Develop educational materials and utilize partner materials to educate and inform landowners of ways to improve their soil, move water through their soils and save money in their farming operations.

As watershed stewards begin to emerge in the watershed we will develop and launch a recognition program, i.e. conservation award to recognize efforts each year that honors 1 city, 1 county, 1 urban resident or business and 1 farm/producer for conservation efforts. The recognition should keep stewards motivated and encourage others to join in to the effort.

Specifically, developing the recognition program will consist of;

- Develop a process with peer review
- Identify an award plaque
- Promote winners at the Annual Meeting

A baseline for current recreational opportunities/uses of the stream will be developed through an audit/survey program. The information to be gathered will be important for future watershed management decision (see the recreational enhancement strategies) so the audit will be conducted by 2017.

The audit will consist of the following steps;

- Survey residents for what recreation they prefer and are currently participating in.
- Map current recreation locations and continue to add to the map each year.
- Develop a recreation plan to support community interests in 2018.
- Announce and promote the recreational plan in 2018-2025.

While restoring a viable fishery in Squaw Creek will likely require restoring the natural stream hydrology, establishing a stock and catch fishery is an excellent tool to build interest in the stream and to foster watershed stewardship. Establishing fishing as an activity in the stream will be accomplished by 2020

Specifically the following steps will be taken;

- Partner with Iowa Rivers Revival, DNR Fisheries and others to create a plan for building fishing opportunities along the stream.
- Hold fishing forums/kids competition by 2018
- Develop an educational campaign utilizing PSAs, videos, newspaper ads and newsletter articles to link fishing and water quality together. Begin campaign in 2018-25

Building upon the goal of enhancing the recreational value of the stream and its riparian corridor, a regional river trail plan will be developed in the watershed (see the recreational enhancement strategies). An outreach campaign will be built into the trail system to promote the mission of the watershed and to increase awareness of watershed issues.

The following steps will be taken following development of the trail plan, which is envisioned to occur by 2017;

- Incorporate our trail plan into the Story and Boone Counties master trail plans by 2018
- Develop river trail signage by 2019.
- Develop a river trail event to promote a clean water trail in Squaw Creek Watershed in 2019 and then every year after until 2035.

6.2. Strategies for Improving Water Quality

The following section describes the recommended approach for improving water quality in the watershed and meeting the specific nutrient reduction objectives adopted by the WMA. At the heart of this approach is the subwatershed-scale nutrient reduction strategy that was developed through the use of the Agricultural Conservation Planning Framework (ACPF) developed by the National Laboratory for Agriculture and the Environment, USDA Research Service in Iowa (Tomer et al., 2013, 2014). The tool consists of a set of GIS terrain analysis applications which are used within a conservation framework to optimize the placement of structural BMPs on the landscape.

6.2.1. Introduction and Approach

Best Management Practice (BMP) strategies were analyzed for all areas within the watershed, from farm fields to the urban areas. Since corn and soybean agriculture comprises the majority of the watershed these areas contribute far and away the greatest proportion of nitrogen in terms the total loading mass and also in terms of the nitrogen yield per unit area. This is a consequence of the amount of commercial fertilizer and manure applied to support crop production but also the inherent nutrient content of the watershed's soils which, due to their glacial and prairie land cover histories, are some of the most productive soils on Earth. Agricultural sources of phosphorus also dominate the total watershed loads but, unlike for nitrogen, urban and channel (stream bed and bank erosion) sources are also significant. As a result, the primary focus of the subwatershed nutrient reduction strategies is on agricultural BMPs, although approaches to control nutrient loading from urban areas is also addressed.

BMP strategies were analyzed by taking into account the following factors:

- **Watershed Hot Spots**: areas within the watershed where the SWAT modeling predicts higher than average nutrient production rates. See Figure 4-2 for nitrogen hot spots and Figure 4-3 for phosphorus hot spots
- **BMP Performance**: research-based nutrient removal rates for a suite of BMPs
- **BMP Cost**: the cost associated with BMPs from an installation AND lost income standpoint
- **Terrain Suitability**: the watershed was evaluated for areas where the terrain is most suited to implement specific structural BMPs

Watershed Hot Spots

Targeted land cover and management areas are general areas where nutrient yields are highest -- e.g., N or P pounds/acre/year entering stream channels from adjacent lands and where prioritization planning should begin. These areas present more practical BMP opportunities as costs for implementation would generally be a function of size of the area treated and independent of the amount of nutrient treated. Potential target areas were predicted using the SWAT modeling task outlined in Section 4. Results from the SWAT simulations are useful for developing context around current nutrient sources and proportions and better understanding the targeting and results of BMP scenarios. Key general conclusions from the SWAT modeling were:

- Corn and soybean agriculture are estimated to contribute 97% of the nitrogen and 92% of the phosphorus loading in the Squaw Creek watershed.
- Tile drained land (which is estimated to comprise 70% of the total agricultural area) is estimated to contribute 86% of the total nitrogen loading in the Squaw Creek watershed.
- Approximately 33% of the total agricultural nitrogen and phosphorus loads are estimated to originate from 20% of the agricultural land.
- SWAT modeling predicts roughly equivalent phosphorus yields between Squaw Creek watershed urban and agricultural areas (~0.7 lbs/ac/yr)
- Urban areas comprise about 5% of the total watershed area and contributing approximately 5% of the total watershed phosphorus load. Urban landuse is primarily concentrated in the City of Ames where low density residential comprises over 70% of the area (from 2006 National Land Cover Dataset).

These findings reinforce the importance of developing BMP strategies that address agricultural practices and tile drainage in particular.

BMP Performance

Nitrogen and phosphorus reductions associated with BMPs were compiled from existing research and prior experience. Most of the reduction estimates came from the 2014 Iowa Nutrient Reduction Strategy (INRS, 2014). Although much variability in BMP effectiveness exists across studies, average values were used to provide estimates of expected outcomes and were necessary to calculate and analyze cost-effectiveness.

BMP Costs

Costs per acre per year were estimated based on information in the INRS and EQIP (Environmental Quality Incentives Program) BMP database. Total nitrogen and phosphorus percent reductions were divided by unit costs to generate a cost-effectiveness index. This index is designed to the show relative difference between BMPs. Negative cost and cost-effectiveness indicate BMPs that have been demonstrated to

Iowa Nutrient Reduction Strategy

The Iowa Nutrient Reduction Strategy is a science and technology-based framework to assess and reduce nutrients to Iowa waters and the Gulf of Mexico. The strategy outlines a pragmatic approach for reducing nutrient loads discharged from the state's largest wastewater treatment plants, in combination with targeted practices designed to reduce loads from nonpoint sources such as farm fields. Working together, the Iowa Department of Agriculture and Land Stewardship, the Iowa Department of Natural Resources, and the Iowa State University College of Agriculture and Life Sciences developed this proposed strategy.

result in a net profit. Reductions, costs and cost-effectiveness are all discussed in detail in the following section.

Terrain Suitability

Terrain Suitability is based on the notion that certain Ag BMPs are much more practical to implement if the topography in the targeted area maximizes the effectiveness of the practice and minimizes the installation and operating costs. An example of this concept is a nutrient removal wetland for which research has shown that denitrification is maximized when the wetland pool is shallow enough to support emergent wetlands plants but is continually filled. These attributes have been shown to be tied to existing depressional pool volume and the ratio between pool area and contributing upslope drainage area. Moreover, installation costs will minimized if an existing (presumably drained) depression already exists and requires minimal design and excavation. A set of automated GIS tools was used to analyze terrain suitability for several types of structural BMPs and is discussed in detail later in this section.

6.2.2. **Best Management Practice Selection**

BMPs were selected based on inclusion in the 2014 Iowa Nutrient Reduction Strategy (INRS) as well as input from residents of the watershed and from emerging research. Soil organic matter, grassed waterways and saturated buffers are specific practices that were added to those found in the INRS. Urban BMPs were selected based on input received by City of Ames Municipal Engineer Tracy Warner.

While the selection of BMPs uses many of the widely accepted practices in place today, we acknowledge that the field is rapidly evolving and new practices are being researched constantly. For the purpose of our analysis we used practices that had available performance and cost information. We encourage the use of emerging technologies to address nutrient reduction.

BMPs to be evaluated for applicability in the Squaw Creek Watershed are split into the following four major categories:

In-field Practices

The first grouping of practices include nutrient management practices as well as conservation practices associated with changes in in-field management practices; use of conservation crops, no-tillage techniques and increasing soil organic matter.

Nutrient Management Practices

These practices are grouped together for purpose of the evaluation. They generally represent changes in the type or timing of nutrient application and are low cost (if not cost-positive) practices that can be implemented by individuals across the watershed.

Reduce nitrogen application rate to the MRTN: Reduce the nitrogen application to the level which maximizes yield vs. fertilizer costs which is expressed as the Maximum Return To Nitrogen (MRTN). In the Squaw Creek Watershed the MRTN rate is 133 lb N/ac on Corn/Soy and 190 lb N/ac on Cont.

Use a nitrification inhibitor: Nitrification inhibitors slow the microbial conversion of ammonium-nitrogen to nitrate-nitrogen. The practice specifically uses nitrapyrin and applies only to fall application of anhydrous ammonia.

Eliminate fall anhydrous nitrogen application: Moving fall anhydrous N fertilizer application to spring pre-plant prevents denitrification and leaching during late fall, winter and spring.

Sidedress all spring applied nitrogen: Sidedressing applies nitrogen during the periods of plant demand (late spring/early summer) rather than the spring which reduces the risk of loss from early spring rainfall/leaching events.

Reduce phosphorus application rates: Reduce phosphorus application rates in fields that have high to very high soil test phosphorus content. This practice minimizes phosphorus fertilizer over-application. In general the soils in the Squaw Creek Watershed have high P soil concentrations.

Manure injection/ Phosphorus banding: Manure injection/phosphorus fertilizer banding involves injecting liquid manure and banding solid inorganic fertilizers within all no-till acres. Placing phosphorus at the root zone can increase phosphorus availability and allow for reduced application rates.

Cover crops: Although there are many options available for cover crop species the analysis uses fall-planted rye. Cover crops reduce soil erosion and limit the amount of nitrate-N leaching from the soil during the late fall-winter-early spring.

Convert intensive tillage to conservation tillage: The practice consists of switching from moldboard to chisel plowing which leaves at least 30% crop residue on the fields before and after planting to reduce soil erosion.

Convert conservation tillage to no-till: The practice consists of switching existing chisel plowing to no-till where the ground is not tilled as to not disturb the soil. This increases

Soil Health

America's soil and water conservation districts, along with their traditional partner, the Natural Resources Conservation Service (NRCS) have made soil health a long-term priority. As it gains momentum, the soil health movement has embraced all landscapes, from crop and grazing lands to forests and even urban settings. Agriculture producers and their conservation partners are on a mission. Their goal is to grow robust crops and enrich soil health and reduce input costs. These producers have pioneered soil health principles that include no-till, cover crops, increased plant diversity and minimum soil disturbance. Soil health is site specific and local champions are the keys to adoption of soil health systems. Soil health systems build resilience to weather extremes, including droughts and flooding.

water infiltration, organic matter retention, nutrient cycling, and reduction of soil erosion.

Increasing organic matter: For analysis purpose it is assumed that the organic matter is increased by 100% which would take the soils in the watershed from an estimated 3% to 6%. Increased organic matter provides both greater water and nutrient retention preventing leaching and increasing soil fertility. Soil organic matter and is a major factor in the productivity and sustainability of agronomic systems. Currently, the primary practices for building SOM are planting cover crops, reducing tillage and applying manure rather than commercial fertilizer. Applying manure was not considered in this analysis because without more specific guidance on application rates, methods and timing, increases in nitrogen and phosphorus loading may result. Instead, cover crops in conjunction with no-till were incorporated into the BMP scenario analysis. This BMP was not included within the INRS BMP list but was added after discussions with the project's technical advisors and input received from watershed residents. Percentage reduction of nitrogen was estimated based on SWAT model simulations whereby available soil water storage and soil carbon were increased to reflect the doubling of organic matter.

Edge-of-Field Practices

These practices are typically larger, sometimes structural practices that are terrain dependent. In contrast to the in-field practices, these BMPs can only be installed in areas that support them. This siting was done through use of the ACPF tools as described below.

Nutrient Removal Wetlands: This BMP is a shallow depression created in the landscape where aquatic vegetation is typically established. Nutrient removal wetlands can be a cost-effective approach to reducing nitrogen loadings in watersheds dominated by agriculture and tile drainage. A 0.5% to 2% range in wetland pool-to-watershed ratio permits the wetlands to efficiently remove nitrogen runoff from large areas and data has shown that 40% to 90% of the nitrate flowing into the wetland can be removed. These wetlands and surrounding grassland buffers also provide environmental benefits beyond water quality improvement such as increases in wildlife habitat, carbon sequestration, and flood water retention (Crumpton et al., 2006).

Denitrification bioreactors: These are trenches in the ground packed with carbonaceous material such as wood chips that allow colonization of soil bacteria that convert nitrate in drainage water to nitrogen gas. Installed at the outlet of tile drainage systems, bioreactors usually treat 40-60 acres of farmland. Note that the performance numbers shown for this practice account for the assumption that only 50% of the available runoff gets routed into the practice.

Water and Sediment Control Basins (WASCOBS): These are small earthen ridge-and-channel or embankments built across a small watercourse or area of concentrated flow within a field. They are designed to trap agricultural runoff water, sediment and sediment-borne phosphorus as it flows down the watercourse; this keeps the watercourse from becoming a field gully and reduces the amount of runoff and sediment and phosphorus leaving the filed. WASCOB's are usually straight slivers that are just long enough to bridge an area of concentrated flow and are generally grassed. The runoff water detained in a WASCOB is released slowly, usually via infiltration or a pipe outlet and tile line (Minnesota Department of Agriculture).

Riparian Buffers: These are vegetated zones immediately adjacent to a stream and are generally designed to trap sediment and phosphorus laden surface runoff, which is important but not uniformly opportune along streams. However, different designs and vegetation can improve water quality in different ways. Where vegetation roots can interact with the water table, carbon cycling and denitrification may be enhanced. In areas where the water table depth and overland runoff is high, stiff-stemmed grasses may be beneficial to intercept and reduce runoff and sediment from reaching the stream. Where appreciable amounts of neither runoff nor groundwater can be intercepted, benefits such as stream bank stabilization may be possible (Tomer et al. 2013).

Controlled Drainage: Controlled drainage describes the practice of installing water level control structures within the drain tile system. This practice reduces nitrogen loads by raising the water tables during part of the year, thereby reducing overall tile drainage volume and nitrate load. The water table is controlled through the use of gate structures that are adjusted at different times during the year. When filed access is needed for planting, harvest or other operations, the gate can be opened fully to allow unrestricted drainage. When the gate is used to raise local water table levels after spring planting season, this may allow more plant water uptake during dry periods, which can increase crop yields. Controlled drainage may be used on field with flat topography, typically one percent or less slope.

Grassed Waterways: These are constructed channels that are seeded to grass and drain water from areas of concentrated flow. The vegetation slows down the water and the channel conveys the water to a stable outlet at a non-erosive velocity. Grassed waterways should be used where gully erosion is a problem. These areas are commonly located between hills and other low-lying areas on hills where water concentrates as it runs off the field (NRCS, 2012). The size and shape of a grassed waterway is based on the amount of runoff that the waterway must carry, the slope, and the underlying soil type. It is important to note that grassed waterways also trap sediment entering them via field surface runoff and in this manner perform similarly to riparian buffer strips.

Grassed waterways were not included as part of the INRS BMP list but were added as in-field sediment/particulate P trapping alternative. Note that the percent reduction in this analysis was estimated based on riparian buffer percent reduction as both BMPs' trapping mechanisms are similar. However, reductions due to decreased gully development were not evaluated; consequently reductions used in this study could likely by *under* estimations of grassed waterway effects.

Saturated Buffers: Saturated buffers are a vegetated area, typically a riparian area along a stream or ditch where draintile water is dispersed in a manner that maximizes its contact with the soils and vegetation of the area. Draintile lines that typically discharge directly to the ditch or stream are intercepted and routed into a new draintile pipe that runs parallel to the ditch or stream. This allows drain water to exfiltrate and saturate the buffer area. The contact with soil and vegetation results in denitrification. Note that the performance numbers shown for this practice account for the assumption that only 50% of the available runoff gets routed into the practice.

Land Use Changes

The following practices involve taking agricultural land out of production. As is noted in the cost section these are fairly high-cost practices primarily as a result of the loss of income that results. The analysis that is provided assumes that these practices, if implemented, would be targeted to the hot-spots identified by the SWAT modeling. The practices would be further targeted by looking into the yield history of the specific fields so that the practices would only be placed in low-yield areas. This would help to minimize the cost per acre of the practices.

Perennials/Energy Crops: The practice consists of converting Corn/soybean lands to perennial or energy crops. Perennial Crops are CRP long-term (10-15 years) program intended to reduce soil erosion by converting land to perennial crops. Energy Crops are perennial crops, such as switchgrass, that produce biomass that can be used as bio-energy feedstock. These crops improve soil cover, reduce soil erosion, and reduce nitrogen and phosphorus loss.

In the combined scenario analysis that follows, we have used the '10% of the watershed' approach that is being championed by the Science-based Trails of Rowcrops Integrated with Prairie Strips (STRIPS) program - http://www.leopold.iastate.edu/news/strips-video

Pasture/Land Retirement: This practice removes land from agricultural production and converts it perennial vegetation to limit soil erosion. This is a long-term CRP program (10-15 year). The established vegetation is a near natural system that has animal habitat and soil improvement benefits.

Extended Rotation: is a rotation of corn, soybean, and at least three years of alfalfa or legume-grass mixtures managed for hay harvest. These crops provide soil cover, reduce soil erosion, and reduce phosphorus loss.

Urban Practices

Urban BMPs are part of the approach to address runoff impacts. Urban runoff management is somewhat different from agricultural settings in that the added impervious surfaces are a large factor. In those cases, the nutrient concentrations are higher than natural or background conditions, plus the compounding factor of much higher runoff volumes. Modern stormwater standards, such as those employed by the City of Ames, require runoff volume reductions along with nutrient treatment. To conceptualize this in the urban setting, new development and redevelopment were segregated were generalized based on their different settings and driver for implementation:

- New development – BMPs as part of urban development that must meet current City standards
- Re-development – BMPs required as part of redevelopment per City standards
- Voluntary/incentive-based retrofitting – public/city-led retrofits and cost share programs to incentivize existing businesses and homeowners

It is important to note that in urban settings like Ames, often the reductions are internalized into the permitting and development process. In this manner, the impacts of development pay their own way to protect water quantity and quality. Since the costs for development and redevelopment are internalize via permitting, those costs are not shown here as external costs to be funded. For voluntary or incentive-based retrofits, there will need to be some funding provided to implement possible city or watershed projects and to provide incentive payments to those wishing to improve their existing site. Generalized urban BMPs and estimated reductions are presented in Table 6-1. These BMPs, reductions and costs were determined based on EOR's experience in urban BMP planning.

Urban BMP scenarios were split into three general areas and the following assumptions on level of implementation:

- New development BMPs from conversion of agricultural land; applied to the City of Ames comprehensive plan's estimation of an additional 2,500 acres by the year 2030
- Redevelopment BMPs for an assumed 10% of existing development by 2030
- Voluntary/Incentive based BMPs for an assumed 10% of existing development by 2030

SWAT modeling predicts roughly equivalent phosphorus yields between Squaw Creek watershed urban and agricultural areas (~0.7 lbs/ac/yr) with urban areas comprising about 5% of the total watershed area and contributing approximately 5% of the total watershed P load. Urban landuse is primarily concentrated in the City of Ames where low density residential comprises over 70% of the area (from 2006 National Land Cover Dataset).

The following examples of BMPs currently being installed in Ames was provided by Tracy Warner, City of Ames Municipal Engineer. New development/post construction stormwater BMPs being implemented currently include:

- rain gardens
- enhanced rain gardens
- bioretention cells
- bio-swales/vegetated swales
- soil quality restoration
- native landscape/turf/plantings

- Pervious/Porous pavement

Voluntary BMPs that are funded by cost-share or rebate include:

- Rain Barrels
- Rain Gardens
- Native Landscape
- Trees
- Soil Quality Restoration

The community can also implement additional BMPs, sometimes at a regional scale to address past development impacts and to meet new stormwater non-degredation standards. The watershed should work cooperatively with the city to identify additional publically or grant funded projects that can mitigate impacts to water quality, volume, and flooding. These will likely be driven by both local problem areas along with sites that become opportunities that present themselves.

6.2.3. **BMP Performance**

Nitrogen and phosphorus reductions associated with BMPs were compiled from existing research and prior experience. Most of the reduction estimates came from the 2014 Iowa Nutrient Reduction Strategy (INRS, 2014). Although much variability in BMP effectiveness exists across studies, average values were used to provide estimates of expected outcomes and were necessary to calculate and analyze cost-effectiveness. The average removal rate for each practice is found in Table 6-1.

Removal rates for nitrogen are highest in BMPs that either convert agricultural land to pasture or perennials or where agricultural land is treated at the edge of field through de-nitrification BMPS such as nutrient removal wetland, denitrification bio-reactors, and saturated buffers.

Phosphorus removal rates are highest for no-till, and practices that are aimed at trapping sediment since phosphorus is generally tied to sediment particles. Moderate to high rates of phosphorus removal are also seen in land retirement practices.

6.2.4. **BMP Costs**

Agricultural BMP costs were based on analysis from the INRS and data from the EQIP database which accounts for the installation costs and lost revenues associated with each practice. The costs and cost-effectiveness values presented in Table 6-1 are based on costs per year per acre. These calculated costs are straight-forward for nutrient management BMPs but costs for edge-of-field and land use change BMPs are primarily related to initial installation costs which can be substantial compared to the nutrient management costs. Therefore, nutrient removal wetland, sediment basin and bioreactor BMPs were assumed to have a 20 year life span whereby installation costs are spread across 20 years. Similarly, riparian buffers, grassed waterways and land use change BMPs were assumed to have a 5 year life span – this reduced life span takes into account that these BMPs may be more easily re-introduced to agriculture if so desired than the aforementioned BMPs.

Moreover, edge-of-field BMP costs are associated with the BMP itself – the area doing the treatment: the wetland or sediment basin, bioreactor, riparian buffer or grassed waterway strip – not the upslope area treated. Therefore, to calculate cost per year per acre, the cost was divided by the upslope treatment area. Treatment areas for nutrient removal wetlands and sediment basins were assumed to be 100 times the impoundment pool area (using Tomer 2013 guidelines); 40 acres per bioreactor; 25 times the grassed waterway and riparian buffer areas (based on the ACPF analysis described later).

This cost division across multiple years and treated acres makes these BMPs much more cost-effective and viable alternatives or supplements to the nutrient management BMPs.

The costs of urban BMPs represents two aspects. As discussed previously, the costs of treating runoff from urban development is absorbed into the development process, or internalized, by meeting the City of Ames stormwater standards in the ordinances, as it done in most communities. For voluntary retrofits, there would be a cost to implement those. Costs of retrofits can vary greatly based on which BMP is used, how it fits the local situation, the intensity of the development being treated (residential, commercial, industrial, etc.) and if land or easement purchase is needed. A very generalized and approximate cost was used that represents some typical low impact practices, such as raingardens, at a moderate level of development imperviousness, approximately 40% impervious, and not factoring land costs, was used to approximate urban BMP costs. The installation cost of the practice was divided by 20 years to get an annual cost. Some additional on-going maintenance costs were included based on recently summarized data by a Ramsey-Washington Metro Watershed District study of raingarden maintenance costs with raingarden costs in the range of $200/yr for a raingarden treating a few urban residential lots. In reality, actual costs will vary greatly, so these values serve as a placeholder until better information is available through a feasibility study of specific sites.

It is important to note that the cost estimates for these BMPs do not take into account any potential cost savings or economic benefit that may be provided by the practice. For instance, increasing soil organic matter may eventually reduce fertilizer need and increase yield.

The cost of nutrient removal BMPs ranges widely from the zero to positive cost nutrient management BMPs to the very high cost of the land retirement practices. Note that with land retirement practices there would be an attempt to focus only on the lowest yield fields which would reduce the overall cost of the practice from what is reported.

Table 6-1. Selected BMPs, estimated reductions per unit area and costs

	Category	Practice	% N	% P	Est. Cost $/ac/yr
In-field Practices	Nutrient Management Practices	Reduce nitrogen application rate to MRTN	10	0	(2.00)
		Use a nitrification inhibitor	9	0	(3.00)
		Eliminate fall anhydrous nitrogen	6	0	(35.00)
		Sidedress all spring applied nitrogen	7	0	0.00
		Reduce phosphorus application rates	0	17	(12.00)
		Manure injection/Phosphorus	0	24	14.55
		Cover crops	31	29	77.78
		Convert intensive tillage to conservation tillage	0	33	26.00
		Convert conservation tillage to no-till	0	90	18.58
		Increase soil organic matter	10	0	NA
Edge-of-Field Practices		Nutrient Removal Wetlands[1, a]	52	58	9.41
		Denitrification Bioreactors[2, a]	43	0	29.61
		Sediment Basins[1, a]	0	85	5.90
		Riparian Buffers[3, b]	91	58	6.78
		Controlled Drainage [a]	33	0	0.74
		Grassed Waterways[3, b]	0	58	30.58
		Saturated Buffers [a]	50	0	7.52
Land Use Changes		Perennials/Energy Crops[c]	72	34	698
		Pasture and/or Land Retirement [c]	85	75	585
		Extended alfalfa rotations[c]	42	59	71
Urban Practices		New Development	0	65	N/A
		Existing Development: Re-	0	50	N/A
		Existing Development: Voluntary (Rebates/Incentives)	0	50	3,000

[1] Assumed 1:100 ratio between pool area and upslope drainage area for /acre/yr costs
[2] Assumed one bioreactor treats 40 acres for /acre/yr costs
[3] Assumed 1:25 ratio between vegetated treatment area and upslope drainage area for /acre/yr costs
[a] Assumed lifespan of 20 years for /acre/yr costs
[b] Assumed 5year commitment for /acre/yr costs
[c] Assumed 5year commitment for /acre/yr costs

6.2.5. **Terrain Suitability**

Beyond the conceptual and modeled estimates of removal potential from applying various BMPs to the watershed, the task of determining where the BMPs should actually be placed is an important step. To place BMPs on inappropriate locations will reduce their effectiveness (increase costs) and likewise, targeting BMPs to locations where they will provide the most benefit will increase their effectiveness (decrease costs). In a large agricultural watershed like this, a prioritization and targeting framework is warranted to ensure efficient use of resources and avoid an inefficient “shotgun effect.”

The ACPF features an ArcGIS toolbox that helps optimize the placement of structural BMPs on the landscape by evaluating terrain suitability using high-resolution digital elevation data (LiDAR). These BMPs are referred to here as “terrain-dependent” as the terrain in which they are placed affects both cost and effectiveness.

With assistance from the ACPF authors, the GIS toolbox was implemented for the seven HUC-12 subwatersheds in the Squaw Creek watershed. Five terrain-dependent, structural Ag BMPs were analyzed and included: grassed waterways (GWWs), nutrient removal wetlands (NRWs), water and sediment control basins (WASCOBs), riparian buffers, and controlled tile drainage. LiDAR with a 3 meter resolution was used as the topographic input data for the GIS tools used to assess potential sites.

The primary numerical output from the GIS analyses necessary for BMP scenario reduction analyses was the upslope drainage area calculation for each sited BMP aggregated at the HUC-12 subwatershed level. These cumulative drainage areas represented the source areas to be treated for which the BMP percent reductions were applied.

Based upon the outcomes of the Agricultural Conservation Planning Framework (ACPF) Toolbox, there are numerous potential opportunities in the Squaw Creek Watershed to install best management practices to improve water quality:

- The total length of potential grassed waterways is 1,483 km with a total drainage area of 40,069 HA comprising 83% of the agricultural land.
- The total nutrient removal wetland drainage area of 24,020 HA comprising 50% of the agricultural land.
- The total water and sediment control basin (WASCOB) total drainage area of 4,684 HA comprising 10% of the agricultural land.
- Critical zone riparian buffers have a drainage area of 4,207 HA (9% of agricultural land), multi-species buffers have a drainage area of 13,204 HA (27% of agricultural land), stiffed-stem grasses have a drainage area of 14,471 HA (30% of agricultural land)
- Deep-rooted vegetation buffers have a drainage area of 2,132 HA (4% of agricultural land).

Results of the ACPF GIS analyses are presented for each HUC-12 subwatershed in Appendix 4: Agricultural Conservation Planning Framework Findings. The results generally show an abundance of potentially suitable sites for all the analyzed BMPs except controlled drainage, which was found to have a negligible amount of suitable drainage area. The field-scale maps of potential BMP locations are useful for watershed planning but require on-site inspection to validate their suitability.

6.2.6. BMP Scenarios and Reduction Results

BMP scenarios were developed to assess the potential reductions available in the Squaw Creek Watershed from single BMPs and combinations of BMPs. Single BMP scenarios were taken directly from those outlined in the Best Management Practice Selection section and serve as a benchmark for the performance of individual BMPs on applicable N and P source areas in the watershed. The findings of the single BMP analysis illustrates the uppermost reduction that each practice can provide in the watershed. Since no single BMP is realistically going to be applied across the entire watershed, we have developed combined BMP scenarios that focus on most cost-effective BMPs combined in sequence – upslope to downslope – in shared treatment areas and in-parallel at relatively low levels of adoption. These combined scenarios form the basis for the plan's overall BMP implementation recommendations.

Single BMP Scenarios

Twenty one scenarios were developed each focusing on a single BMP, based on those outlined BMP Selection section above, to illustrate the maximum impact a given BMP can have. The scenarios combine a single practice with a treatment area for which to estimate nutrient reductions. For non-structural BMPs, the existing extents of continuous corn and corn/soybean and specific tillage practices were used as treatment extents whereas terrain-dependent BMP scenarios were based on results of the ACPF terrain analyses so treatment extent was equivalent to the cumulative upslope drainage areas delineated for individual sited practices. In the case of non-structural BMPs, *existing* implementations of practices were estimated in the INRS for the Squaw Creek region; for structural BMPs it was assumed none were currently implemented.

BMP scenarios were evaluated at the HUC-12 subwatershed scale based on the SWAT simulated spatial distributions of existing nutrient loading. The general procedure for calculating scenario reductions is summarized in the following figure:

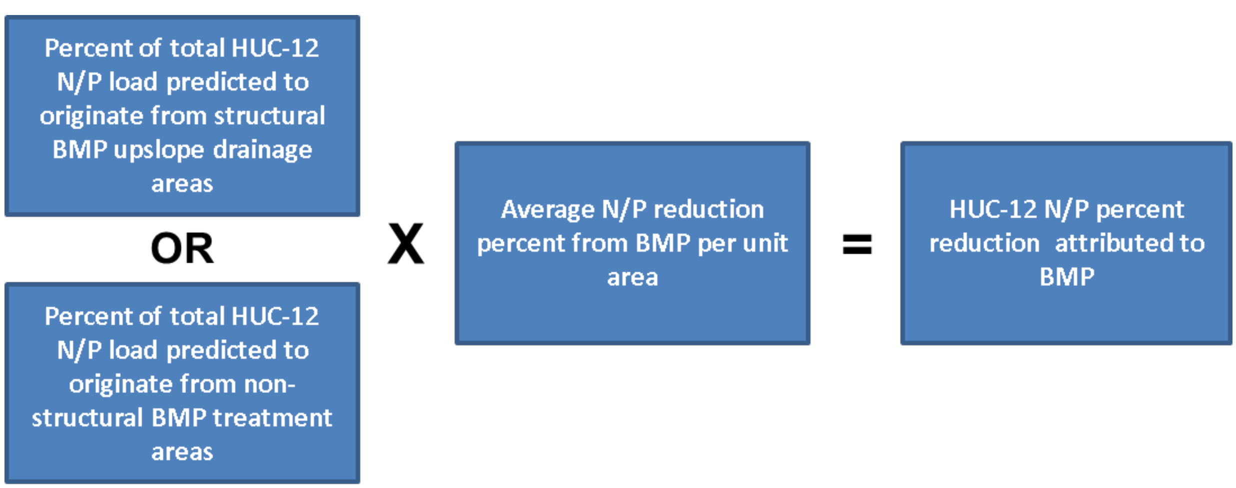


Figure 6-1. BMP scenario reduction analysis procedure for HUC-12 subwatersheds

Scenario results for each of the seven HUC-12 subwatersheds were aggregated for the entire Squaw Creek watershed and presented in Table 6-2. This table presents several pieces of information for each BMP scenario:

- BMP (from Table 6-1) and description/extent of scenario
- BMP effectiveness expressed as percent reduction per unit area (from Table 6-1)
- Scenario treatment acres and percentage of total Ag acres (determined based on estimates of existing conditions from INRS or ACPF terrain analyses)
- Percentage of Squaw Creek total N and P loads originating from scenario treatment area (from SWAT model)
- Percent reduction of total Squaw Creek watershed N and P loads resulting from scenario

Table 6-2 shows a wide range of N and P watershed-wide reductions. Generally, N and P nutrient management BMPs offer significant reductions without any terrain dependent constraints; however, because of issues producing consistent corn and soybeans yields with some of the most effective non-structural BMPs such as non-till (82% P reduction) and cover crops (30% N reduction), widespread adoption could be relatively impractical unless the science and management of these BMPs is advanced or funding sources are in place to reimburse farmers.

Structural (terrain dependent) BMPs offer some advantages in that their placement can be constrained so as to limit the amount of productive farm land taken out of production necessary for their installation and maintenance; this is particularly true with field edge riparian buffers. The ACPF terrain analyses showed great potential for treating large portions (~60%) of farm land with nutrient removal wetlands and buffers both of which show very strong reduction effectiveness for both nitrogen and phosphorus.

In terms of watershed-wide reduction goals, the N and P reduction goals of 41% and 29%, respectively, could be achieved with riparian buffers draining roughly half the total watershed (about 1/3 less than amount scoped by the ACPF toolset). Similar to riparian buffers, full implementation of no-till on all continuous corn (CC) and corn/soybean (CS) acres would far surpass the phosphorus goal and the extent could be scaled back by almost 2/3.

Reduction results from Table 6-2 can be easily modified to reflect implementations at less than 100% (i.e., reduce CC or CS acres treated by 50% per se) by multiplying the desired fraction by the N and/or P watershed load reduction percentage. In fact, reducing the implementation treatment extent will likely result in a more efficient scenario <u>if</u> the reduced area is targeted to hotspots from the SWAT modeling maps. This is because predicted N and P yields were not normally distributed but were skewed toward the higher loads; therefore selecting the top 25% of treatment area in terms of hot spots will likely target much more than 25% of the total watershed load. Table 4-2 shows the range of predicted concentrations at ranges 0-25%, 25-75% and 75-100% and can used as a guide to optimize selection of treatment areas.

Table 6-2 also illustrates the scale of urban BMP reductions with the respect to the entire Squaw Creek watershed P load. While the urban BMPs make a significant impact on Ames P loading, their effect is very small when compared to the whole watershed P load. Several assumptions are utilized to make these planning-level estimates and assessing the progress of implementation in the near future should be used to guide and update what is a realistic adoption rate.

Table 6-2. Illustrative compilation of maximum application of each Ag BMP as physically feasible, excluding interactions between BMPs

			BMP Effectiveness		BMP Scenario Treatment Areas				Squaw Watershed-wide Scenario Results	
		Scenario	N reduction % per unit area	P reduction % per unit area	Treated acres	Treated %	Treated % of total N load	Treated % of total P load	Total N load reduction %	Total P load reduction %
In-field Practices	Nutrient Management Practices	Reduce nitrogen application rate to the MRTN	10%	0%	118,657	100%	97%	92%	10%	0%
In-field Practices	Nutrient Management Practices	Sidedress all spring applied nitrogen	7%	0%	118,657	100%	97%	92%	7%	0%
In-field Practices	Nutrient Management Practices	Use a nitrification inhibitor	9%	0%	29,664	25%	24%	23%	2%	0%
In-field Practices	Nutrient Management Practices	Eliminate fall anhydrous nitrogen application	6%	0%	29,664	25%	24%	23%	1%	0%
In-field Practices	Nutrient Management Practices	Reduce phosphorus application rates	0%	17%	118,657	100%	97%	92%	0%	16%
In-field Practices	Nutrient Management Practices	Manure injection/ Phosphorus banding on all current no-till acres	0%	24%	9,493	8%	8%	7%	0%	2%
In-field Practices		Increase soil organic matter by 100% (3% to 6%)	10%	0%	118,657	100%	97%	92%	10%	0%
In-field Practices		Cover crops (rye) on all corn/soybean and cont. corn acres	31%	29%	118,657	100%	97%	92%	30%	27%
In-field Practices		Cover crops (rye) on all no-till acres	31%	29%	9,493	8%	8%	1%	2%	0%
In-field Practices		Convert all existing tillage to no-till	0%	90%	109,164	92%	90%	91%	0%	82%
In-field Practices		Convert all existing intensive tillage to conservation tillage	0%	33%	57,857	53%	48%	45%	0%	15%
Edge-of-field Practices		Denitrification Bioreactors on all tile drained acres	43%	0%	83,462	70%	86%	64%	37%	0%
Edge-of-field Practices		Nutrient Removal Wetlands on applicable tile drained areas	52%	58%	59,258	50%	61%	45%	32%	26%
Edge-of-field Practices		Sediment Basins on all applicable acres	0%	85%	11,575	10%	10%	9%	0%	8%
Edge-of-field Practices		Riparian Buffers on all applicable acres	91%	58%	84,051	71%	69%	65%	63%	38%
Edge-of-field Practices		Grassed Waterways on all applicable acres	0%	58%	99,013	83%	81%	77%	0%	44%
Edge-of-field Practices		Controlled Drainage on all applicable tile drained acres	33%	0%	500	0%	0%	0%	0%	0%

		BMP Effectiveness		BMP Scenario Treatment Areas				Squaw Watershed-wide Scenario Results	
	Scenario	**N reduction % per unit area**	**P reduction % per unit area**	**Treated acres**	**Treated %**	**Treated % of total N load**	**Treated % of total P load**	**Total N load reduction %**	**Total P load reduction %**
	Saturated Buffers on all applicable tile drained acres	50%	0%	83,462	70%	86%	64%	41%	0%
Landuse Changes	Perennial crops on 10% of Agricultural Land	72%	34%	11,865	10%	20%	20%	14%	6.8%
Landuse Changes	Pasture/Land Retirement on 10% of Agricultural Land	85%	75%	11,865	10%	20%	20%	17%	15%
Landuse Changes	Double the amount of extended rotation acreage	42%	59%	3,560	3%	3%	3%	1%	2%
	New development BMPs	0%	65%	1,000	0.5%	0.5%	0.5%	0%	0.3%
	Redevelopment BMPs	0%	50%	1,000	0.5%	0.5%	0.5%	0%	0.3%
	Voluntary/Incentive based BMPs	0%	50%	2,500	1.3%	1.3%	1.3%	0%	0.7%

Combined BMP scenarios

In most cases, using multiple BMPs to accomplish reductions is the most logical, practical approach and is one of the primary themes of the Tomer field-to-stream continuum. Different individual BMPs may be implemented on different treatment areas -- i.e., in parallel -- or different individual BMPs may combined within a single treatment area, positioned in sequence from field downslope to the receiving stream or lake -- i.e., in series. However, in the case of serial scenarios, simply summing reduction percentages is not appropriate as multiple BMPs working in series (i.e., “treatment train”) are not additive. Most likely a more conservative, multiplicative type of approach (i.e., multiplying each BMP reduction percentage by the next one downslope until the stream is reached) would give reasonable cumulative reductions for multiple BMP scenarios. In this way, countless combinations of scenarios could be developed to achieve nutrient reduction goals.

Several combined scenarios were analyzed for this study that took into account multiple BMPs applied in-series, in-parallel and both. As mentioned, many combinations are possible; however, this analysis focused on those BMPs with the greatest potential cost-effectiveness for reducing both nitrogen and phosphorus. The resulting scenario was intended as a general framework as to which BMPs were the most cost-effective and the estimated level of adoption and associated costs needed to achieve the WMA established objectives for nitrogen and phosphorus reductions in the watershed.

As such, these results represent a set of practicable recommendations that can serve as a starting point for looking at many different possible scenario strategies.

Several criteria steered the combined scenario formulation:

- All scenarios contained adoption of in-field nutrient management BMPs that optimize nutrient application rates and timings and that have been demonstrated to result in a net profit for continuous corn and corn/soybean rotations.
- Tile drained areas were the focus of all the scenarios due to their disproportionate contribution of nitrogen and comparable contribution of phosphorus relative to non-tiled drained areas.
- BMPs that addressed both nitrogen and phosphorus were emphasized over those addressing one or the other.
- Scenarios containing structural BMPs were constrained as to not exceed the actual number of potential treatment sites and their upslope drainage areas as determined by the terrain suitability analysis (ACPF).
- The cumulative effects of BMPs placed in series are not additive; therefore a step-wise, field-to-stream calculator was developed to provide estimates assumed reasonable.

Approach to Meeting the WMA Nutrient Reduction Objectives

An approach to meet the WMA nutrient reduction objectives was developed in order to illustrate the magnitude of BMPs that would be needed in the watershed. The approach is presented in Table 6-3. The process to develop this approach was an iterative analysis aimed to determine combinations of cost-effective BMPs and factoring in the estimated level of BMP adoption as described above.

The approach achieves the 41% nitrogen reduction goal, exceeds the 29% P reduction goal and initiates increases in soil organic matter on 20% of the agricultural land. It consists of the following:

- Implementing nutrient management BMPs on 40% of the agricultural land in the watershed
- Implementing cover crops plus no-till on half of these acres (i.e., 20% of total agricultural acres)
- Installing edge-of-field structural BMPs to treat runoff from 40% of the total agricultural area
- Adopting perennials/pasture/land retirement BMPs on 4% of agricultural land targeted on lands with the highest nutrients yields per the hot-spots analysis
- Installation of appropriate BMPs to treat 45% of the urban area
- All of these BMPs are assumed to be placed in areas of drain-tile

Table 6-3. Approach to Meet Squaw Creek WMA Nutrient Reduction Objectives

	BMP	Treatment Area				Squaw Creek Watershed-wide Reductions	
		% of watershed	Acres	% of Ag	% of N/P	% N reduc.	% P reduc.
In-Field Practic	Nutrient Management	32%	47,463	40%	49%/36%	9%	6%
	Cover Crops	16%	23,731	20%	29%/18%	10%	4%
	No-Till	16%	23,731	20%	29%/18%	0%	16%
Edge-of-field Practices	Nutrient removal wetlands[1,2] Riparian buffers [1,2,3] Bioreactors Sediment Basins Grassed Waterways Saturated Buffers	32%	47,463	40%	49%/36%	20%	13%
Land Use Changes	Perennial energy crops Pasture/Land retirement Alfalfa/corn rotations	3%	4,746	4%	5%/4%	4%	1%
	Urban BMP Category/Practice	**% of watershed**	**Acres**	**% of Urban**		**% N reduc.**	**% P reduc.**
Urban	New & Existing Development BMPs	3%	4,500	45%	2%/2%	0%	1%
					TOTAL REDUCTIONS:	**43%**	**41%**

[1] BMPs are assumed to be implemented upslope to downslope -- within the same area

[2] These BMPs were emphasized in the analysis because of high N and P reduction potential

The gross cost <u>per year</u> for this scenario is roughly $2,400,000 with a cost <u>per acre per year</u> of $45. When EQIP cost-sharing (roughly 50% depending on BMP) is factored in, these numbers decrease to roughly $1,200,000 and $23 <u>per acre per year</u>, respectively. These are planning-level cost estimates and should be used with that consideration in mind.

As described in the watershed hot-spots description above, 33% of the total agricultural nutrient loads originate from 20% of the agricultural lands. Targeting these areas will effectively lower the overall cost because less land would be necessary to achieve reduction goals (or, a higher reduction could be achieved for the same cost).

Additional cost-share and incentive programs beyond EQIP may be available (e.g., CRP, CREP, etc.) for farmers to implement practice and grant sources may be available to the WMA to provide assistance in implementing practices.

For Urban implementation BMPs in terms of costs, a what-if scenario was done. The voluntary/incentive retrofit improvements that are external and will likely need public funding to implement. A very general look at voluntary retrofits considers the existing developed land of Ames of approximately 7,000 acres, times the potential scale of implementation of 10%, divided by the 15 years of the planning horizon of this plan. While the values could vary widely due to many assumptions, the estimated scale of costs was around $2,100,000 per year. Since that is along the scale of all the agricultural implementation costs discussed below, whereas the proportion of contribution in this case is less than 5% of pollutants (runoff volume could be higher). Therefore these values are not included in the proposed cost totals. This does, however, point to a trend being discussed nationally about funding from urban areas being used upstream on agricultural settings to provide outcomes that benefit the urban areas, somewhat akin to pollutant credit trading. Since the cost/lb pollutant removed can be much more effectively spent upstream, this may make sense. The other aspect is the pragmatic approach that problems in urban areas (flooding, water quality degredation, stream erosion) may be more effectively solved upstream, due to lower costs per unit benefit and where other funding mechanisms are very limited.

6.2.7. **Streambank Erosion Load**

Estimating nutrient load contributions in river systems from streambank erosion is an area of active research. It is a difficult parameter to estimate since stream erosion is variable, the nutrient content of the soils varies significantly, the ability of that nutrient to leach out of the sediment phase varies, and in-stream dynamics of sediment transport and biological uptake complicates the net transport of nutrients downstream. While progress is being made in the literature, we did not have an accurate way to account for this input, so it was not separately quantified or added to the estimates. That said, it is still an area of concern and likely contributor to overall loadings and impacts to stream health and downstream streams and reservoirs. So while not explicitly quantified, there are several strategies within the implementation section and BMPs that address streambank erosion and these should be a priority so as to establish a more stable streambank. Efforts have already been started by the City of Ames on stream stability.

6.2.8. Priority Bacteria Reduction Strategies

Many of the conservation practices/BMPs described above have a dual benefit of removing bacteria from runoff or preventing it from becoming washed off in the first place but there are several additional practices that apply specifically to bacterial pollution. The following are the strategies to specifically address bacteria pollution in the Squaw Creek Watershed.

Manure Management

The following is a general approach to addressing bacterial pollution to the stream as a result of animal manure.

- Identify known sources that are directly contributing bacteria to waterbodies (e.g. areas where livestock have access to streams), using local knowledge; windshield surveys, interviews with landowners, etc.
- Continue baseline monitoring of the stream reach and add additional monitoring stations along the stream reach and tributaries to help pin point potential sources of bacteria.
- Promote the use of manure injection or incorporation of manure on all land where manure is applied.
- Promote good manure application practices such as:
    - Applying manure to relatively dry fields
    - Avoiding steep sloping areas
    - Avoiding areas near water bodies or drain tile intakes
    - Avoiding vulnerable locations for spreading manure
    - Avoiding areas prone to flooding
    - Avoiding applying on frozen soil
- Conduct education and outreach to ensure that good manure management practices are understood and followed.

Private Septic System Management

An intensive inspection of private septic systems could be conducted throughout the Watershed to determine the location of any illicit discharges/straight pipes and to assess the condition of all septic systems. This effort, commonly referred to as a sanitary sweep, could be eligible for grant funding. Following the identification of failing septic systems a course of action to correct these systems will need to be coordinated with the landowners, the Counties and Iowa DNR.

Education/Outreach

Education efforts focus on bringing greater awareness to the issues surrounding bacteria contamination and methods to reduce loading and transport of bacteria. Education efforts targeted to the general public are commonly used to provide information on the status of impacted waterways as well as to address urban and rural sources of bacterial contamination. Education efforts may emphasize aspects such as cleaning up pet waste or managing the landscape to discourage nuisance congregations of wildlife and waterfowl. Education can also be targeted to municipalities, wastewater system operators, land managers, producers, and other groups who play a key role in the management of bacteria sources.

Urban Education

In urban areas, residents should be provided education on sources of bacterial contamination in urban stormwater, and how urban stormwater affects local water quality. For example, education should focus on reducing bacterial sources from pet and wildlife waste. Providing guidelines to reduce bacterial contamination in urban settings should include:

- Maintaining taller vegetation around ponds and creeks which may deter geese as well as filter stormwater runoff
- Pet waste collection on/ near impervious surfaces, in dog parks, and within riparian areas.
- Discouraging wildlife feeding, especially in riparian areas.

Rural Education

Sources of bacterial contamination in waterbodies in rural areas are most often due to livestock production (including feedlot and pasture management), manure and septage management, and failing septic systems. Training and educational materials should be provided to producers and landowners on the importance of reducing bacterial contamination in waterbodies from these sources. Some examples of education that can be provided are listed below.

- Ensure livestock producers are aware of appropriate manure management practices
- Encourage producers to work with grazing specialists on feedlot/ pasture management particularly in riparian areas
- Provide information on and encourage the use of agricultural BMPs, such as buffer strips and fencing around riparian areas,
- Provide education on how to maintain individual septic systems, as well as inspect for or detect leaks

Pet Waste Control

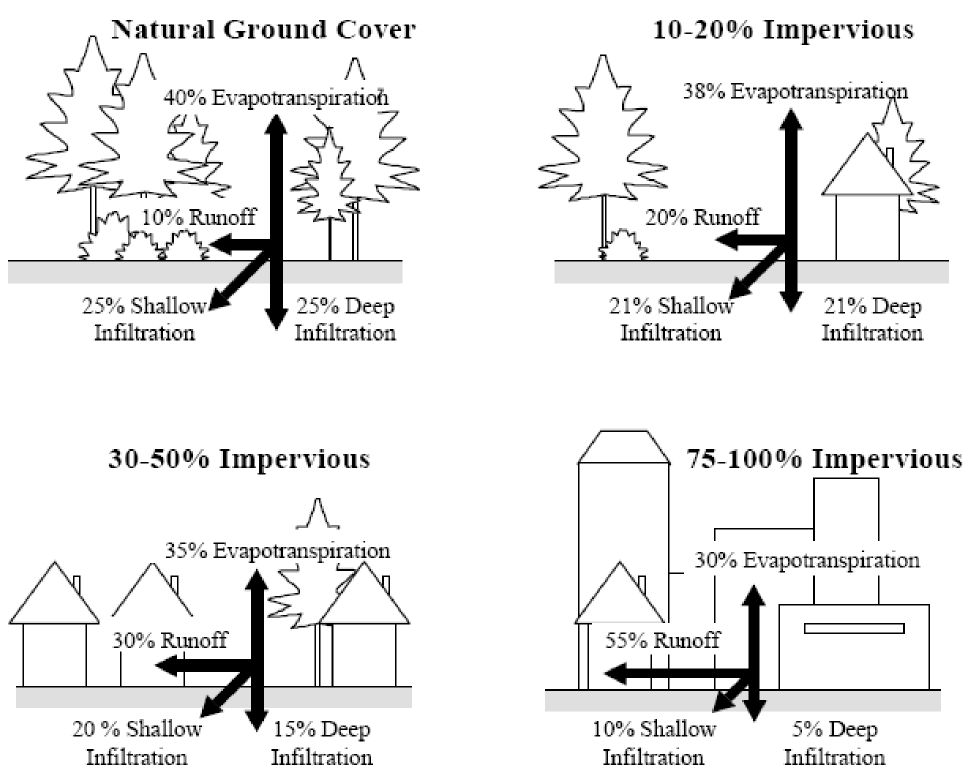
The City of Ames has an ordinance that requires proper disposal of pet waste and litter in a timely manner as a method for reducing bacterial pollution in urban areas. This ordinance could be extended to other developed areas within the Watershed.

6.3. Hydrology Strategies

The following describes the recommended strategies for meeting the objectives of the goal to reduce the effects associated with altered hydrology (Goal 5.2) within the watershed.

6.3.1. Background on Restoring Natural Hydrology in a Watershed

The study of runoff management and how best to control impacts of human activities on the land has consistently over the past 5-10 years focused more and more on the differences in volume of runoff between land uses. The extra volume generated when land uses are converted, whether it be from forest to row crop agriculture or agriculture to urban, is significant (Figure 6-2). The extra runoff water tends to carry increased loads of pollutants (nutrients, sediment, other contaminants), either originating from the new land use or simply because the extra power of the additional water is more efficient at washing off the pollutant, rather than being trapped in the natural vegetation and porous soils. Many studies are now also showing the dramatic effects and negative impacts on the stability and erosion in streams and rivers due to increased runoff. The bank erosion that occurs impacts streams in two ways: it adds more pollutants (sediment and nutrients) to the water and it makes the stream configuration less natural which lacks habitat for things that live in the stream. Added to that, stream erosion also takes away upland and can threaten structures.



Source: Adapted from Arnold and Gibbons, 1996

Figure 6-2 Changes in hydrology associated with land use changes

6.3.2. Recommended Approach for Restoring Hydrology

While for many years the discussion was about controlling the peak flow rate (that maximum flow at a given instant in time) and less on the volume of flow (total water over a longer time period), and how to capture pollutants at the "end of the pipe/system" that is no longer the emphasis. The problems were too large to address, the solutions were not always very effective, and the costs were becoming so high, that the management of runoff has been shifting more toward the source of the problem: increased volume of water.

The practices that are described in the Strategies for Improving Water Quality section of the plan have additional benefits of restoring natural hydrology for the watershed by reducing runoff volume. That reduction in runoff volume can then translate into less erosion/instability, better stream health, and reduced flooding. And while much attention is often given to the need to address flooding and larger storms, it is also important to understand that the stream in low flow ("base flow") can be significantly improved when the water is retained in the system and allowed to seep out slowly.

Many of the agricultural practices proposed not only are effective at having benefits of reducing nutrient and sediment contamination, but also aid in reducing runoff volumes and the flashy flows in a stream. This contributes to overall improvement to the stream. Some of those practices being considered that have a positive impact on reducing runoff volumes and/or significantly slow the runoff include, and a relative level of impact expected (Table 6-4):

A variant on volume control that has been adopted in the Iowa Stormwater Management Manual (http://www.iowadnr.gov/Environment/WaterQuality/WatershedImprovement/WatershedBasics/Stormwater/StormwaterManual.aspx) is extended detention. This is holding runoff in storage areas to the extent that it is slowly releasing runoff significantly long, thus partially mimicking the reduced, slow flows in a natural stream. By managing the flows in this way, the erosive power of the flashy, intense flows are lowered and stream stability is improved. An example of how this could be used effectively in the Squaw Creek watershed, would be to utilize

City of Ames Flood Mitigation Study

The City of Ames Flood Mitigation Study (Feb 2014) evaluated alternative to address flood damage associated with the Squaw Creek and Skunk Creek. The study involved updating hydrailic modeling, performing additional flood inundation mapping, and screening various mitigation alternatives including economic and environmental components. The Study determined that the highest ranking alternatives were; conveyance improvements, two regional storage reserviors and levees to provide 100-year flood protection.

low-lying flood plains and/or large natural depressions that are not actively cropped as a storage areas, and controlling the outflow with a control structure. This can be done in a way that delays flows, helping the stream and downstream, while not permanently flooding the flood plain areas. Similarly, nutrient removal wetlands can also be configured with an outlet to retain water and slowly release it. These situations need to be carefully designed, considering the effects upstream, on adjacent lands, and the basin itself to find a good fit that meets multiple needs.

Table 6-4. Volume control effectiveness of potential BMPs

	Category	Practice	Volume control effectivness
In-field Practices	Nutrient Management Practices	Reduce nitrogen application rate to MRTN	NA
		Use a nitrification inhibitor	
		Eliminate fall anhydrous nitrogen	
		Sidedress all spring applied nitrogen	
		Reduce phosphorus application rates	
		Manure injection/Phosphorus banding	
		Cover crops	Medium
		Convert intensive tillage to conservation tillage	Medium
		Convert conservation tillage to no-till	Medium
		Increase soil organic matter	High
Edge-of-Field Practices		Nutrient Removal Wetlands	Low
		Denitrification Bioreactors	Low
		Sediment Basins	Low
		Riparian Buffers	Low/medium
		Controlled Drainage	Medium/high
		Grassed Waterways	Low/medium
		Saturated Buffers	Low/medium
Land Use Changes		Perennials/Energy Crops	High
		Pasture and/or Land Retirement	High
		Extended alfalfa rotations	High

For urban areas, many of the impacts to urban runoff are difficult to control without first addressing the runoff volume. Many studies have shown that as the impervious areas (hard surfaces such as streets, roofs, parking lots, etc.) increase, there is a clear trend in decreasing stability and health of streams and rivers. Reflecting this trend, the City of Ames has a stormwater ordinance that explicitly has a volume control requirement. Many of the new urban stormwater practices being incorporated and required by the new city codes are aimed at reducing runoff volume, and thus reducing pollutants and volume impacts. Strategies for addressing the flooding that occurs in the lower part of the watershed are not expressly contained in this plan. A detailed assessment of the flooding issues has been conducted by the City of Ames and mitigation strategies have been developed.

6.4. Habitat Improvement Strategies

Within the Squaw Creek Watershed, improving the quality of stream and riparian habitats will be beneficial to native fish species, invertebrates that provide food for fish, as well as other wildlife that utilize the habitats. Maintaining healthy fish and wildlife populations increases recreational opportunities for anglers, hunters, birders, and other that enjoy viewing wildlife in a natural setting.

Natural resources such as remaining prairie and wetlands should be protected to prevent further loss and degradation. In addition to providing recreational opportunities such as hunting, fishing, hiking, and wildlife observation, these habitats provide a number of other services that often go overlooked. For example, wetlands increase water quality by filtering nutrients and pollutants prior to entering larger waterbodies. Wetlands also act as flood control reservoirs by storing water and slowly releasing it into the watershed.

Prairies are also a very important part of the landscape, as they once covered nearly 80% of what is now the state of Iowa. Prairies provide habitat for rare and endangered plant and animal species, as well as wildlife species that are prized for hunting, and invertebrate species that are critical for pollination of native and agricultural plants. Deep-rooted prairie plants prevent soil loss and erosion by holding the soil in place, which ultimately improves water quality. Prairie plants are also very important for sequestering carbon from the atmosphere which would help to mitigate climate change.

Restoration or rehabilitation, as well as habitat reconstruction are methods to increase and improve habitat. Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed; whereas, reconstruction is the process of rebuilding habitat on land that has been converted to other uses, such as agriculture. When done correctly and given an appropriate amount of time, restoration and reconstruction of habitats is often successful. When a degraded habitat has been restored, it is less likely to succumb to outside pressures such as invasive species.

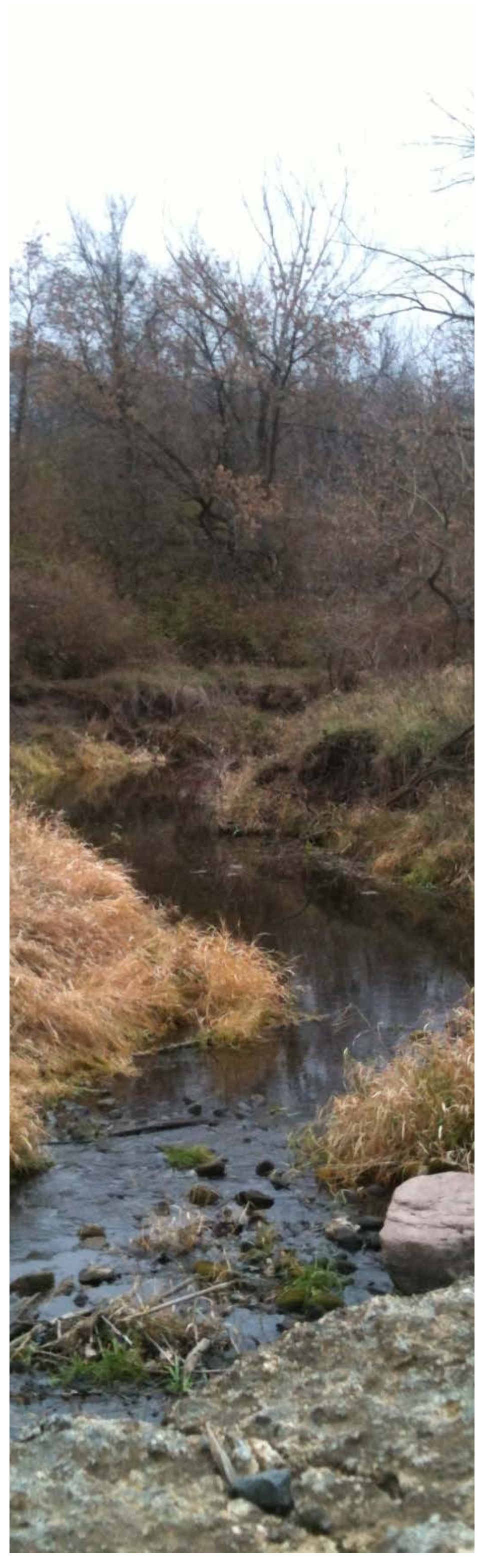
When choosing habitats to protect and restore, patches of land that connect one intact habitat to another are often the most valuable. These tracts of land are referred to as wildlife corridors because they allow wildlife species to move across the landscape with a reduced risk of interacting with humans. Wildlife corridors increase wildlife populations by reducing mortality, especially of species that are very vulnerable to habitat fragmentation. Many species do not have the capability to move through a human-modified landscape. Turtles, for example, have very high mortality rates due to roads.

Another way habitat can be increased is by engineering and design of low impact stormwater and drainage water management features rather than conventional structural approaches such as impervious surfaces.

6.5. Stream Restoration/Recreational Enhancement Strategies

The following section describes the general strategies for restoring streams in the watershed as well as more specific areas that are recommended for action.

6.5.1. General Strategies for Restoring Streams



Worle Creek, portions of Crooked Creek, Onion and Montgomery Creeks were all found to be in need of increased riparian buffers. Simply establishing vegetative cover in riparian zones areas will help reduce sediment load from stream banks. However targeting the outer bends of stream sections with poor riparian vegetation cover where most stream erosion occurs would increase the effectiveness of targeted buffer practices. In areas of excessive streambank erosion, loss of farmland or important fish habitat areas, streambank bioengineering may be called for. This practice uses vegetative materials in combination with structural tools, such as rock at the toe of the streambank. The ACPF tool described in above section identified the appropriate location and type of riparian buffers. Refer to Appendix 4 for maps of the types of riparian buffers possible for each subwatershed.

In the upper subwatersheds there is apparent need for grazing management and buffer establishment/ enhancement.

In channelized reaches (ditches) the development of more environmentally-friendly two-stage ditches would help reduce the downstream transport of sediment and nutrients, while improving fish habitat and reducing future maintenance costs. Two-stage ditches make the most sense where the drainage area is big enough that the pollutant removal is substantial, but not so big that natural stream forces of erosion overwhelm the channel. This is typically in the range of one – ten square miles in drainage area, give or take a few square miles. In the headwaters or middle reaches of Crooked Creek, Drainage ditch 159, Montgomery Creek and Onion Creek are examples of the appropriate setting for two-stage ditches.

Streams are significant sources of sediment in Squaw Creek. Sediment is important because it affects water quality and in-stream aquatic life and can influence flooding issues downstream. Therefore it should be a goal of the watershed management plan to reduce excessive bank erosion to protect farmland, improve in-stream fish habitat and to reduce downstream flooding issues. The Cox et al. (2011) study in Iowa showed that much of the sediment thought to be coming from sheet erosion in fields is actually coming from field gullies. The use of grassed waterways and improved water retention practices to reduce runoff are critical for gully control. The ACPF tools described in previous sections identified specific locations where grassed waterways could be sited. Refer to Appendix 4 for maps showing the locations of potential grassed waterways for each subwatershed.

Factors that influence the landowner adoption of management practices need to be better understood for management success. Despite evidence that water quality has decreased in the region over the past 50 years, landowners were found to have different perceptions of changes to stream water levels and water quality (Wagner and Gobster 2007). This indicates the need to connect with landowner concerns and values so that landowner identify with the issues being addressed and will more likely adopt the management practices. Refer to the Education/Outreach strategies for a discussion of the watershed efforts to engage and influence landowners and residents of the watershed.

6.5.2. **Specific Stream Protection and Restoration Approaches**

Data collected for the Squaw Creek Watershed Stream Assessment was analyzed to formulate 11 restoration priority sites. The stream assessment randomly selected sites based on land use types proportionately representative of the entire watershed. Approximately 58 miles of stream were surveyed, which is about one-third of total stream miles within the watershed. As a result, the following recommendations are based only on data collected from randomly selected sites.

Priorities were formulated based on the condition of riparian habitat, amount of permanent vegetation on banks, stream bank height, surrounding land use, and substrate embeddedness. Considerations were also based on a cost/benefit analysis and the perceived outcomes of restoration efforts. Sites that have the opportunity to yield many benefits from simpler restoration efforts, such as establishing a buffer from grazing, were also included in these lists. Sites characteristic of a reference reach (Table 6-5) require management strategies that emphasize enhancement and protection rather than restoration (Table 6-6).

Table 6-5. Stream sites prioritized for protection/enhancement efforts

Priority	Stream Name	Habitat Condition	Degradation	Restoration Recommendations
1	Upper Squaw Creek	Excellent	10-15’ high banks Low shade	Reshape banks Enhance gravel substrate
2	Lower Squaw Creek	Excellent	Log dammed channel Sandy substrate Unstable banks	Remove trees that cause channel instability Increase scouring Enhance habitat features
6	Upper Squaw Creek	Excellent	Unstable banks 60-80% bare ground Low shade	Reshape banks Enhance cobble substrate

Table 6-6. Stream sites prioritized for restoration efforts

Priority	Stream Name	Habitat Condition	Degradation	Restoration Recommendations
3	Bluestem Creek	Average	15'+ high banks 80-100% bare ground Unstable banks Low shade	Enhance gravel substrate Reshape and seed banks Fence off cattle
4	Middle Squaw Creek	Average	Silted substrate 6-10' high banks Low shade Unstable banks	Reshape banks Fence off cattle
5	Scott Drainage Ditch 292	Poor	Low shade 40-60% bare ground Silted substrate Moderately unstable banks	Enhance cobble substrate
7	Glacial Creek	Poor	Silted substrate Moderately unstable banks Low shade	Increase scouring Enhance gravel substrate
8	North Onion Creek	Poor	40-60% bare ground Unstable banks Heavily eroded pasture site Low shade	Fence off cattle Enhance gravel substrate Seed banks
9	Upper Squaw Creek	Average	Sandy substrate Unstable banks 60-80% bare ground Low shade	Reshape banks Increase scouring Seed banks
10	Montgomery Creek	Average	6-10' high banks 80-100% bare ground Unstable banks Sandy substrate	Reshape and seed banks Increase scouring
11	Clear Creek	Average	Debris dammed channel 80-100% bare ground Sandy substrate Unstable banks	Remove debris Increase scouring Seed banks

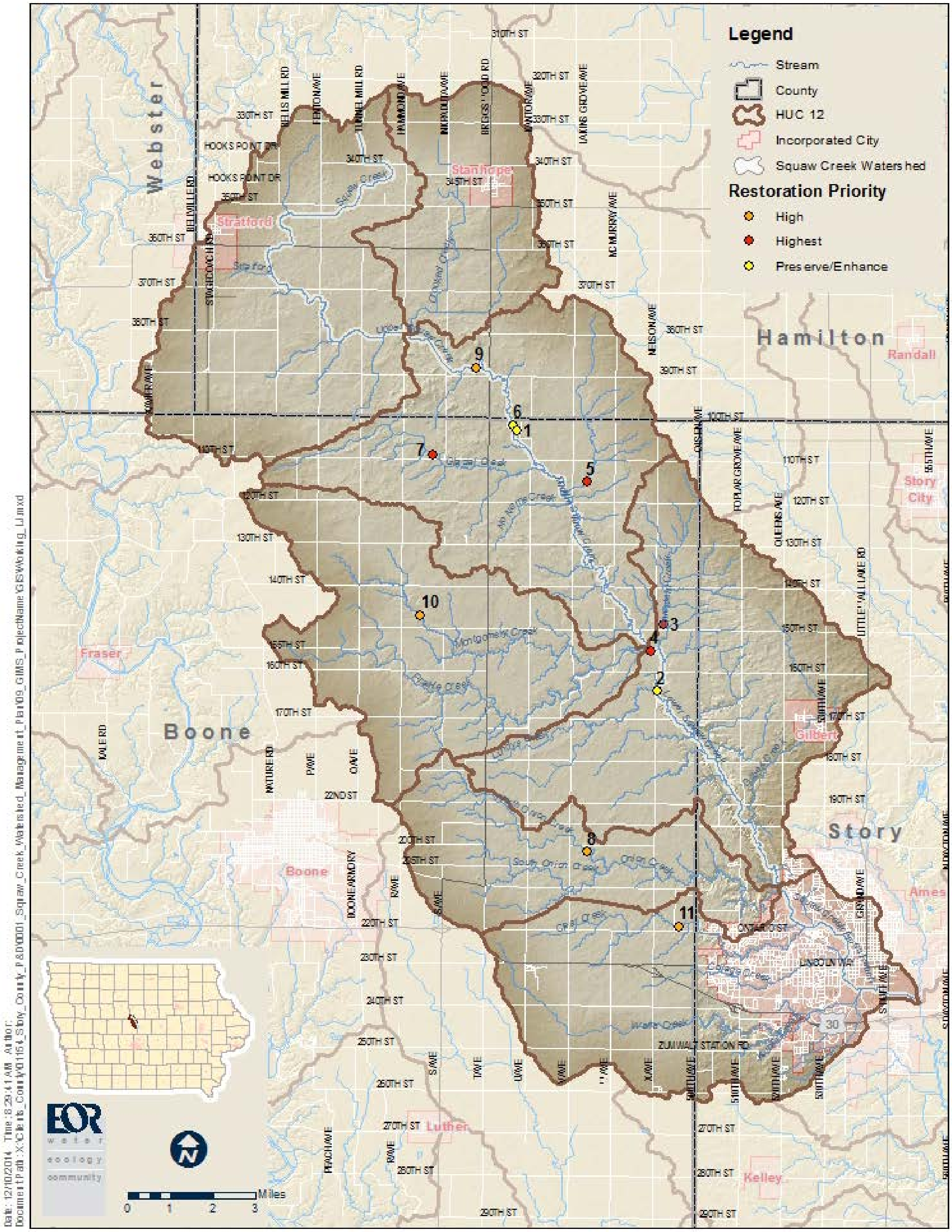


Figure 6-3. Priority Stream Restoration Sites

6.5.3. **Strategies to Enhance Recreational Opportunities**

As discussed in section 5.5, the lack of recreational uses of Squaw Creek and its tributaries was identified as an issue by residents of the watershed during the listening session. As a result, the WMA established a goal to enhance the recreational opportunities within the watershed. There are two primary approaches for increasing recreational values of the creek and its corridor. The first involves developing the recreational capacity of the stream itself for water-based recreation and the second involves creating a trail system throughout the riparian area adjacent to the stream.

Water Trail

Currently there are a several challenges to using Squaw Creek for water-based recreation like canoeing, kayaking, etc. Many of the challenges were noted at the listening session held in Ames in the spring of 2014. Beyond concerns about the quality of water within the stream, there are currently no formal access points and there are numerous stream-bank trees that have fallen into the stream making navigation difficult and potentially dangerous. The long term goal would be to create a water trail that would include the entire extent of the designated Recreation Use portion of the stream (mouth up to the confluence with Glacial Creek). Some additional assessment and planning will be needed before a water trail could be developed. In addition to address navigational issues involving obstacles within the stream, the condition of the various road crossings along the stream will need to be assessed and safety issues (access, flow, etc.) will need to be addressed. A communication system will be needed whereby users can determine whether or not the creek is at a safe, navigable condition.

Regional River Trail

As described in the education/outreach strategies section, a regional river trail system is envisioned for the Squaw Creek corridor. A trail master plan will need to be developed, in cooperation with the Counties and Cities within the watershed. The plan will identify feasible areas for trail development within the riparian corridor of the creek, connections to existing trails and roadways, and outline approaches for acquiring easements. The trail will be used to create a connection to the stream, both physically and from a stewardship standpoint. Education will be a critical component of the trail system. Signs describing watershed issues and messages aimed at what can be done to improve water quality in the watershed will be emphasized. Demonstration projects will be incorporated into the trail system so there will be highly visible examples of watershed management practice available to users of the trail. Potential demonstration projects to be tied to the trail system would be stream restorations, riparian or saturated buffers or a simple practice such as fencing to manage cattle access to the stream.

Crossing Study

A common analysis that can provide a wealth of information for watershed management is a crossing study. The study consists of a survey of crossings within a particular reach of stream. In the case of Squaw Creek watershed, a crossing study should be conducted on the recreation reaches of Squaw Creek (mouth to confluence with Glacial Creek). The crossing study would entail a physical measurement and description of each crossing and an assessment of the crossings role in allowing for fish passage, recreational use and hydraulics.

6.6. Strategies for Facilitating Partnerships

This work of implementing a successful watershed plan will not be done with one organization or with a few people. It will be most important to build partnerships and cooperate with existing groups and initiatives to successfully implement the watershed management plan. It is our intention from the beginning to build a collaborative, informed effort in order to accomplish our goals. Through these partnerships we will share a common bond in that we would like to see our watershed improve its' water quality and maintain or improve the quality of life. And in this case, quality of life refers mostly to the character of the area and access to clean air and water and outdoor recreation.

This goal also means a commitment to identifying yearly plans with a budget, building strategic plans for projects and setting goals each year. Our efforts should not be underfunded for the work ahead, and we commit to identifying significant resources each year to achieve our plans goals.

The key to effectively manage the watershed, and specifically to foster the types of partnerships that are necessary to achieve all of the goals of the watershed is to hire a watershed coordinator. This should be one of the first priorities of the watershed and should be accomplished by April 1, 2015.

Specific actions to be taken to hire a watershed coordinator include the following

- Develop a five-year budget with expenses for a watershed coordinator by Dec. 2014.
- Create a job description and job announcement by Feb. 1, 2015
- Post job announcement and interview in late Feb.-early Mar. 2015

Identifying and applying for state and federal grants will be a necessary component to managing the watershed and will be considered an on-going activity throughout the course of the watershed plan period.

Specifically the watershed coordinator will;

- Identify watershed grants that are targets for funding.
- Apply for at least one grant a year.
- Meet with partners and stakeholders to identify additional financial support needed yearly.

Working together with our partners is a priority and will be accomplished by meeting at least once a year to identify partnership efforts for the year.

Specifically, the following course of action will be taken;

- Identify planning meetings in the first quarter of each year to our partnership efforts.
- Follow-up each meeting with a plan for the year starting in the second quarter/year.
- Provide regular updates at the Management Board meetings on progress of plan.

An annual meeting to celebrate accomplishments and to bring attention to the watershed work will be held.

The following specific task will be conducted;

- Begin planning the Annual Meeting in the last quarter of each year.
- Hold the Annual Meeting in the first quarter of each year.
- Develop a "State of the Watershed Report" to be delivered at the Annual Meeting
- Make "Conservation Awards" at Annual Meeting