6 Identification of Alternative Solutions

6.1 Introduction

This chapter of the Lake Whatcom Comprehensive Stormwater plan outlines possible alternatives that could be used to address the surface water problems identified in Chapter 5. The alternatives identified in this chapter are described in detail and are assessed for their relative cost and effectiveness. Then, these alternatives are rated according to their cost-effectiveness for both phosphorus and water quantity. This rating is then used in later sections as a basis to recommend one or more solutions to the identified surface water problems. Chapter 7 describes the recommended alternatives. A summary of all recommendations and an outline of next steps and action items are included in Chapter 9.

6.2 Importance of Source

The 14 sources identified in Chapter 5 of this plan have relative degrees of influence over phosphorus inputs to Lake Whatcom and altered hydrology throughout the watershed as identified in Table 5-2 of this plan. Table 6-1 lists the 14 problem sources and identifies and evaluates potential solutions.

The take-home message on sources is that multiple sources contribute to the problems. Because of the variety of sources involved, one solution will not fix the problems. Rather, a suite of solutions targeting different sources and different aspects of sources is the most appropriate and effective strategy.

Once phosphorus enters stormwater, through which it then enters a creek or lake system, it is difficult to remove. Targeting the source of the phosphorus is most effective solution because it keeps phosphorus out of the system to begin with, rather than worrying about removing it after the fact. In addition to source control, efforts to control stormwater flows, for volumes and peak flow rates, may lead to reductions in phosphorus inputs to Lake Whatcom. This is because a reduction in flow is a reduction in the “erosive capacity” and “carrying capacity” of the system. Controlling flows and source control are the most effective methods to reduce phosphorus inputs to Lake Whatcom.

6.3 Alternative Solutions – Descriptions and Expectations

The 14 problem sources identified in Chapter 5 each have an associated set of alternative solutions. Table 6-1 lists the alternative solutions possible for each of the 14 sources. Each of the alternative solutions is described with a solution category—either capital (structural) or programmatic (non-structural). Many of the solutions are the same from source to source but are listed here separately under each source for clarity. The purpose of this section is to provide information on specific solutions identified in Table 6-1 and on the expected and reasonable effectiveness of these solutions.

TABLE 6-1. ALTERNATIVE SOLUTIONS TO ADDRESS SOURCES

Source	Significance of Source[1, 2]		Alternative Solutions to Address Source (42)	Alternative Solution Category	Cost	Effectiveness[2]	
	Phos-phorus	Water Quantity (hydrology)				Phos-phorus	Water Quantity (hydrology)
1) Roads	H	H	Detention	Capital	H	L	M
			Treatment	Capital	H	M	L
			Decrease road surface (impervious surface reduction)	Capital and Programmatic	H	M	H
			Replace with pervious pavement	Capital	H	H	H
2) Vehicles	H	L	Education (promote mass transit, alternate methods of transportation)	Programmatic	L	M	L
			Promote federal requirements to replace phosphorous and toxic material such as zinc and copper in automotive products with less harmful materials	Programmatic	L	M	L
			Capital fixes (infrastructure for alternate methods of transportation)	Capital	H	L	L
3) Yards (and yard-care activities)	H	L	Education	Programmatic	L	M	L
			Regulatory	Programmatic	L	M	L
			Inspection / enforcement	Programmatic	M	M	L
4) Septic Systems	M - H	L	Education	Programmatic	L	M	L
			Maintenance	Programmatic	M	M	L
			Capital fixes (septic system fix or sewer hook-up)	Capital	H	H	L
5) Existing Stormwater Facilities	L	H	Education	Programmatic	L	L	M
			Maintenance	Programmatic	M	L	H
			Capital fixes (retrofits, additional capacity)	Capital	H	L	M

TABLE 6-1. ALTERNATIVE SOLUTIONS TO ADDRESS SOURCES

Source	Significance of Source[1, 2]		Alternative Solutions to Address Source (42)	Alternative Solution Category	Cost	Effectiveness[2]	
	Phos-phorus	Water Quantity (hydrology)				Phos-phorus	Water Quantity (hydrology)
6) Existing Stormwater Conveyance Systems (man-made and natural)	H	H	Education	Programmatic	L	L	L
			Maintenance	Programmatic	M	H	H
			Capital fixes (detention, retention, velocity reduction, infiltration, channel stabilization, stream buffer restoration, high flow by-pass, natural drainage systems restoration)	Capital	H	H	H
7) Groundwater Interception	L	M	Detention	Capital	H	L	H
			Infiltration	Capital	H	L	H
8) Building Materials	L	L	Education	Programmatic	L	M	L
			Regulatory	Programmatic	M	M	L
			Capital fixes (retrofits)	Capital	H	M	L
9) Pets and Livestock	M	L	Education	Programmatic	L	M	L
			Regulatory	Programmatic	M	M	L
			Inspection/enforcement	Programmatic	M	M	L
10) Wildlife	L	L	Education	Programmatic	L	L	L
11) Construction Activities	H	L	Education	Programmatic	L	M	M
			Inspection/enforcement	Programmatic	M	M	M
			Regulatory	Programmatic	M	H	M

TABLE 6-1. ALTERNATIVE SOLUTIONS TO ADDRESS SOURCES

Source	Significance of Source[1, 2]		Alternative Solutions to Address Source (42)	Alternative Solution Category	Cost	Effectiveness[2]	
	Phos-phorus	Water Quantity (hydrology)				Phos-phorus	Water Quantity (hydrology)
12) New Development (land clearing)	H	H	Regulatory (limitations on impervious surface, promoting low-impact development (LID), restricting new development, requiring onsite retention, requiring infiltration)	Programmatic	M	H	H
			Land purchase	Capital	H	H	H
			Detention	Capital	H	M	H
			Treatment	Capital	H	M	L
			Require no net loss of forest cover	Programmatic	L	H	H
			Require zero discharge of stormwater	Programmatic	L	H	H
			Work with State Legislature to allow collection and beneficial use onsite of rooftop runoff in residential and office structures	Programmatic	L	M	H
			Require pervious pavement for all new roads, walkways, driveways and parking areas	Programmatic	L	H	H
13) Atmospheric Deposition	L	L	Source Control	Capital	H	L	L
14) Recreation in Watershed	M - H	M	Education	Programmatic	L	M	M
			Regulatory	Programmatic	M	M	M

[1] Significance of source, as determined in Chapter 5 of this Plan, as listed in Table 5-2.
[2] L = low, M= medium, H = high

This list of alternative solutions includes those that have been implemented in other locations in the country and the world; all of them may not be appropriate for use in the Lake Whatcom Watershed for a variety of reasons. The feasibility of any one alternative solution depends on physical constraints such as available space, applicability given local hydrologic and soil conditions, and on public acceptance. In addition, applicability is a function of how effective the solution can be given constraints such as limitations on existing technology.

6.3.1 Programmatic Solutions

6.3.1.1 Education

Description

Education targets the human-influenced sources of phosphorus inputs to the lake, water quality declines, increasing stormwater flows and volumes, and aquatic habitat degradation. Education is a form of source control that has the most influence over human activities conducted on a single-lot scale such as yard maintenance, tree removal, car washing, or the use of phosphorus-containing detergents.

Education of both residents and visitors is imperative. In addition, since the City of Bellingham and much of unincorporated Whatcom County receive drinking water from Lake Whatcom, it is also important to educate both city- and county-wide in order to reach those ultimately influenced by lake water quality.

Education of visitors to the watershed, residents of the watershed, and Lake Whatcom drinking water consumers should include general information on sources of phosphorus to Lake Whatcom and causes of water quality degradation (shown on Figure 1-2).

Residents should be educated on the effects of car washing and the use of phosphorus-containing detergents within the watershed. Though regulations prohibit the use of phosphorus-containing fertilizers in the watershed (WCC Chapter 16.32), education should continue on the use of other landscaping materials that may contain elevated levels of phosphorus (such as beauty bark or bark dust). A Lake-Friendly Gardening Kit is available and geared towards Lake Whatcom Watershed homeowners. Education of residents should cover proper disposal methods for yard wastes. Additional education on natural yard care techniques, especially for homeowners, landscapers, and property managers, should be conducted. Proper disposal of yard waste should be encouraged. Yard waste pickup is available for City of Bellingham residents but not for Whatcom County residents within the watershed.

The importance of tree retention should be explained.

Education should be conducted regarding proper storage, use, and disposal of automotive chemicals, hazardous cleaning supplies, and other hazardous materials.

Residents should be educated on responsibilities to keep culverts under driveways clear of obstructions and to keep yard waste out of drainage infrastructure such as ditches, culverts, catch basins, and storm system inlets. Education should include appropriate and prudent onsite drainage practices such as dispersion and infiltration.

Homeowners associations and/or private homeowners should be educated about responsibilities of maintenance to privately owned stormwater facilities such as ponds or onsite dry wells. In some cases, this may require informing the homeowners association or residents about pond (or other facility) location and maintenance requirements.

Education on green building materials and less-detrimental methods to build and remodel should be conducted for residents, builders, and contractors working in the watershed. Education of contractors should include sessions for both the "bosses" and the "workers" and those in between. In addition, those residents conducting remodels should be educated on the benefits of green building, including controlling waste streams and using environmentally friendly products.

Visitors to and residents of the watershed should be educated on proper disposal of pet waste and barbeque and bonfire ash. In addition, visitors and residents should not feed the birds and waterfowl at public parks or along the lakeshore. Manicured lawns attract birds and geese and feeding them exacerbates the problem.

Residents should be educated on proper BMPs for hobby farms, such as keeping livestock out of ditches that eventually discharge to creeks and to Lake Whatcom.

The Whatcom County Health Department recommends an inspection interval of 1 year for septic tanks and drainfields and a septic tank pumping interval of once every 3 to 5 years. Education on these recommended intervals and on signs that might indicate septic tank and drainfield failure should be conducted. These warning signs of failure include odors, soggy spots with lush grass growing, plumbing backups, slow-draining fixtures, and gurgling sounds in the plumbing system. Education of residents should include proper maintenance and inspection of onsite septic systems.

The Solid Waste Division of Whatcom County Public Works performs public education such as brochures, classroom presentations, and household newsletters for 84,000 homes, performs litter pickup for illegal dump cleanups, and organizes Adopt-a-Road programs. Garbage pickup and disposal is contracted out for the Lake Whatcom Watershed area.

Education is an NPDES Phase II requirement, as is tracking and monitoring the results of that education.

The Whatcom County Water Resources PIE program implements programs in watershed planning, management of Lake Whatcom, and recovery of endangered and threatened fish species.

Effectiveness

Education can be an effective tool in stormwater management. However, it requires that the group receiving the education has the desire or other motivation to implement or apply what has been learned. Education of the less willing may be difficult. Education may be supplemented by regulatory action.

6.3.1.2 Public Involvement and Participation

Description

Public involvement in environmental stewardship activities should be increased. Groups targeted should include children, students, adult residents, and visitors. Volunteers can perform stream buffer planting, form stream watches, and plant trees both on their own property and in common spaces. Master gardener program efforts can be staffed with volunteers, as well as with watershed-watcher programs.

Public involvement is a form of source control. Residents and visitors to the watershed could aid in surface problem identification by using a 24-hour phone hotline. This type of public involvement maximizes the number of eyes on the watershed and increases the chances of

preventing a problem from increasing in scope and severity. A single hotline can be used for spill response or other types of surface water issues.

Public involvement is an NPDES Phase II requirement within Phase II areas of the watershed.

Effectiveness

Educations and public involvement can promote awareness of and foster a sense of responsibility for the health of the watershed. In addition, engaging citizens in the reporting and documenting of surface water problems through phone hotlines increases detection of problems. Public involvement can be effective, particularly when combined with a strong regulatory program that includes inspections and enforcement and when acceptable alternatives are available.

6.3.1.3 Regulatory

Description

Ecology's Phase II NPDES Municipal Stormwater Permit lists programmatic solutions for permittees. This Phase II Permit applies to a portion of the Lake Whatcom Watershed. Chapter 3 of this plan covers the Phase II Permit requirements in greater detail.

Many of the solutions listed in the Phase II Permit are described in other sub-sections in Chapter 6, such as public education and public involvement. Other solutions, such as controlling runoff from new development, redevelopment, and construction sites and illicit discharge detection and elimination, are described in this sub-section because their implementation generally requires regulatory action by the permit holder. Inspections and enforcements are discussed in later sub-sections on the topic.

Whatcom County has land clearing restrictions. Land clearing is defined in the WCC as any destruction (by any method) of vegetation that results in exposed soils. The County has established thresholds for requiring County review and permitting for the entire Lake Whatcom watershed, as it is designed a Water Resource Special Management Area. Chapter 2 of the Whatcom County development standards has additional requirements for the Lake Whatcom Watershed. Clearing activities must comply with specific phasing, soil stabilization, tree canopy retention, and seasonal restrictions (WCC 20.80). Seasonal land clearing restrictions minimize potential for erosion. Clearing activities greater than 500 square feet are prohibited between September 1 and April 30, with limited exceptions for emergencies and maintenance of erosion and sediment control structures (WCC 20.80.735).

No stormwater management development standards were in place before 2002, so single-family residential developments that were platted before 2002 are not required to implement onsite stormwater management for quality or quantity. Because developments platted before 2002 are not required to implement onsite stormwater management, ongoing and future development may not have to implement stormwater quantity or quality controls. Pierce County, Washington, passed legislation that required stormwater controls for areas that had already been platted under previous less stringent requirements. Regulations can be used in Whatcom County for this same purpose.

Regulations requiring tree retention during and after development and preventing tree removal help preserve the natural canopy. Preserving natural forest soils promotes infiltration.

Financial or other incentives can be given for onsite retention, infiltration, or other LID measure. Also, incentives can be given for restoring and maintaining natural buffers.

Erosion and sedimentation controls aid in stormwater management at construction sites. These controls are described in the county development standards.

Once a stormwater facility is implemented on private property, maintenance of that facility is the responsibility of the property owner (or homeowners association, in some cases). Regulations could be implemented that require a maintenance "primer" or other educational materials regarding responsibilities that are associated with the facility. This could be done when a property is bought and sold. In addition, requirements to maintain private facilities should be heightened by using regulatory means followed up with inspection and enforcement (see Inspection and Enforcement sub-section below).

Regulation of activities within the watershed, such as fertilizer use and the use of other landscaping materials such as bark dust, may reduce phosphorus inputs to Lake Whatcom. These efforts can supplement WCC Chapter 16.32, which prohibits the use of phosphorus-containing fertilizers in the watershed. In addition, regulations prohibiting car washing unless using commercially operated car washes would reduce possible phosphorus inputs to Lake Whatcom.

Responsible management of barbeque and bonfire ash would also keep phosphorus out of Lake Whatcom. Outdoor burning is currently banned in all UGAs in Washington State. There are no permanent ban areas located within the unincorporated portion of the Lake Whatcom Watershed, but all residential, farm, orchard, and land-clearing burning beyond these UGAs requires a permit from the County fire marshal or Ecology. Recreational fires larger than 2 feet by 3 feet outside UGAs also require a permit. Where residential burning is permitted, only one pile of unprocessed vegetation smaller than 4 feet by 4 feet by 3 feet is allowed at a time. The County fire marshal is designated to investigate and enforce outdoor burning regulations.

BMPs can be required for hobby farms to control the potential for waste streams away from property. In addition, BMPs can be required for recreation within the watershed, such as ORV use.

Whatcom County should effectively prohibit non-stormwater, illegal discharges and/or dumping into the storm sewer system to the maximum extent allowable under state and federal law, according to the NPDES Phase II Permit requirements.

Reducing road widths in future developments is possible through regulatory means. (Reducing road widths of already-constructed streets and developments can be performed with capital projects and is discussed later in this section). Infiltration requirements can also be implemented via regulatory means. Regulations promoting and/or requiring LID can benefit Lake Whatcom.

Minimum lot sizes and maximum building footprint requirements are already used by Whatcom County. These requirements could be expanded to regulate where on a property a structure is to be built (e.g., requiring a setback for dispersion) and allowable driveway length. The Whatcom County zoning code limits density and promotes clustering.

Regulations requiring zero stormwater discharge, a minimum of 65 percent forest retention and less than 10 percent total impervious surface (TIA) in new development can be used as an effective regulatory means of stormwater control for new development. LID strategies can be used to achieve this. Preventing the channelization of drainage courses via ditches and pipes and promoting onsite retention and flow dispersion will minimize the effects of development. This and other alternatives are discussed in Section 6.4 in this chapter, Opportunities and Constraints for LID Implementation in the Lake Whatcom Watershed.

Chapter 3 of this plan discusses applicable regulatory requirements in greater detail.

Effectiveness

Regulatory actions are effective means of stormwater controls. Strengthening development standards to promote responsible stormwater management has significant positive impacts, as do seasonal clearing restrictions and zoning and development restrictions such as minimum lot size and maximum impervious surface coverage. The zoning code for Whatcom County in many cases specifies maximum building footprint coverage but does not specify a maximum impervious surface. Driveways (even gravel or dirt) contribute to impervious surface coverage.

Onsite stormwater management can be promoted by requiring LID measures, requiring (and enforcing) maintenance of onsite systems, and by requiring zero discharge and tree canopy retention. Financial incentives can also be given to residents who promote these measures above and beyond regulatory requirements as a means of heightened effectiveness.

6.3.1.4 Maintenance

Description

Whatcom County Public Works maintains the roads within the public right of way, including the drainage system within that right of way. Maintenance standards, procedures, and approach are described in detail within Chapter 4 of this plan. Public Works conducts road maintenance as necessary and appropriate to maintain road function. It is funded by the road fund and taxes. Occasionally, additional maintenance related to the drainage system is conducted upon request or in emergency situations.

The drainage system primarily consists of roadside ditches and culverts throughout the watershed. The roadside ditches and culverts are maintained by the County as needed to protect the roadway and to provide a safe transportation facility. (Cleaning culverts underneath driveway aprons, however, is the responsibility of the private owner of that driveway). The ditch and culvert system should continue to be maintained by the road program.

Maintenance of privately owned stormwater facilities is the responsibility of the local homeowners association or private property owners. Once a stormwater facility is implemented on private property, maintenance of that facility is the responsibility of the property owner (or homeowners association, in some cases). It is a requirement of the approved surface water plan submitted to and approved by Whatcom County Planning and Development Services that these facilities be maintained. Maintenance is not the responsibility of Whatcom County Public Works M&O Division.

Maintenance of stormwater structures (including ditches, inlets, catch basins, and culverts) on private roads is not the responsibility of Whatcom County. This includes the private road network inside Sudden Valley. Whatcom County is, however, responsible for the County-owned roads near Sudden Valley. Sudden Valley should enhance its stormwater infrastructure inspection and maintenance program, concentrating on culverts and catch basins. In addition, education and other efforts should be made to increase homeowner knowledge of the onsite stormwater detention systems that are located on each single-family residential parcel in Sudden Valley. Individual homeowners are required to maintain these facilities. However, many owners may not be aware of the existence of these facilities.

Publicly owned stormwater facilities implemented by Whatcom County, such as those implemented in the Cable Street area, are the responsibility of the County. Maintenance of these facilities will be performed by a private contractor.

The NPDES Phase II Permit requires permittees to develop and implement an M&O program that includes training and has the ultimate goal of preventing or reducing pollutant runoff from operations.

Street sweeping is conducted within the Lake Whatcom watershed as a joint effort between the City of Bellingham and Whatcom County. Sweeping is performed using a regenerative air sweeper.

Chapter 4 of this plan discusses O&M in greater detail.

Effectiveness

Maintenance of roads, ditches, culverts, and bridges can be a highly effective method of stormwater management. For instance, ditches cleared of accumulated sediment and mowed can promote drainage. Optimization of ditch cleaning, catch basin cleaning, and street sweeping can lead to water quality benefits.

Street sweeping is an effective method of keeping pollutant-laden particles out of stormwater runoff. However, pollutant capture is dependent upon type of sweeper used. Whatcom County has a regenerative air sweeper and has a contract for a second. Whatcom County should look into the availability and affordability of a high-efficiency sweeper, considered to be the most efficient sweeper technology available.

Regenerative air sweepers are much more effective at picking up particles, especially the finer particles that tend to have the most pollutants associated with them, than are traditional mechanical sweepers. Traditional mechanical sweepers can only remove coarser particles, generally greater than 400 microns (μm). The most efficient sweeper technology available is a vacuum-assisted or high-efficiency sweeper. This technology was first used by the coal industry to remove coal and coal dust around railroad tracks, and is efficient at removing fine particles and preventing their escape back into the air, a pitfall of traditional sweepers. This sweeper uses a mechanical sweeper and a strong vacuum to collect dirt. Some are combined with an air-filtration system that can filter particles to 2.9 μm and are operated dry, while others use spray water to control dust.

Street sweeping activities should be conducted not long after storm events when sand/grit is applied to street surfaces. Current efforts to do this should be enhanced because sand, grit, and other solids have the potential to contribute contaminants to Lake Whatcom. Heavy metals and nutrients, among other pollutants, can adsorb to particles and be transported downstream directly to the lake.

6.3.1.5 Inspection and Enforcement

Description

Inspections are conducted during construction activities to ensure compliance with existing requirements. In Whatcom County, these inspections occur at less-than-ideal frequency due to lack of manpower. In addition, enforcement is difficult because of a less-than-ideal tracking and recording system.

A program should be established to inspect private stormwater facilities such as stormwater ponds. This program would be most effective if paired with an education program for property owners and homeowners associations that may not be aware that maintenance is their responsibility or even that the facility exists. (Or Whatcom County could take on the responsibility for maintaining these privately owned facilities.)

The County should conduct inspections of existing and new development for adherence to existing Whatcom County regulations, including those for buffer requirements, dispersion trenches, and other stormwater management strategies. Post-construction follow-up will help ensure continued compliance with requirements long after construction.

Whatcom County should implement and/or increase inspections targeted at existing regulations such as those for dumping. Also, enforcement actions should be taken as allowable under these existing regulations. (If enforcement is not practical and "easy," regulations should be modified.)

The Whatcom County Health Department has been developing and expanding its onsite sewage system program. The Public Works Department should coordinate with the Health Department. The Health Department recommends that homeowners have their septic tank and drainfield inspected yearly and septic tank pumped once every 3 to 5 years. These efforts should be coordinated with education of warning signs of failure (as discussed earlier in this section).

Information regarding improper discharges to the stormwater system should be provided to community groups. If citizens notice suspicious pipes discharging to a ditch or stream they should contact Whatcom County Public Works (or use a designated hotline number to be determined). Similarly, if a citizen notices odors, sheens, colors, or turbidity, they should make this contact. This would require coordination and/or training for Public Works staff.

Effectiveness

Inspection and enforcement can be highly effective tools of stormwater management that target the source of pollutants. However, inspections and enforcements do only as much good as how often they occur. Optimizing these activities is difficult but important.

6.3.1.6 Illicit Discharge Detection and Elimination

Illicit discharge detection and elimination is an NPDES Phase II Permit requirement. The permit requires the permittee to have an ongoing program to detect, remove, and prevent illicit connections, discharges, and improper disposal, including spills, into the stormwater system. The permit requires full implementation of an illicit discharge and elimination program.

Whatcom County is conducting an illicit discharge and elimination pilot project within the Lake Whatcom Watershed. The goal of this pilot project is to identify potential illicit discharges and locations and phosphorus hotspots in watershed sub-basins in order to focus source control or treatment measures.

6.3.1.7 Monitoring

Monitoring for water quality and water quantity is not a solution in itself. However, monitoring can provide information to quantify the extent and location of surface water problems and can be used in many cases to quantify the effectiveness of implemented solutions.

A question to resolve is how the monitoring information would be used to adapt management actions. Monitoring data may possibly be used to show effectiveness of programmatic solutions recommended in this plan. Monitoring results can also be used to determine the real-life effectiveness of capital projects such as stormwater BMPs within the Lake Whatcom watershed. Results of this assessment can be used to determine which BMPs to use.

Any monitoring program should be long-term in order to identify trends. The monitoring program should be adjusted periodically to increase its value but care should be taken to sustain a program in a consistent format so that data can be compared and trends identified.

Much monitoring has already occurred within Lake Whatcom itself and within major tributaries. Whatcom County, The City of Bellingham, Ecology, WWU, and others have conducted water quality sampling in the lake and in the tributaries to the lake.

Other monitoring projects are ongoing. This ongoing monitoring will be key in identifying where the phosphorus is coming from and how phosphorus varies both during wet-weather events and from event to event. Whatcom County, in partnership with City of Bellingham and the Lake Whatcom Water and Sewer District, has recently launched a water quality monitoring project to characterize five wet-weather events at up to six different lake tributaries over a one-year period. Ongoing, routine sampling will occur at 11 lake tributaries. In addition, continual turbidity and conductivity sampling will occur on six lake tributaries to develop surrogates for TSS and TP.

In addition to water quality monitoring, other monitoring should be implemented and continue to be conducted within the Lake Whatcom Watershed. Habitat assessments should be conducted in sensitive areas. In addition, "stream corridor walks" should be conducted to identify priority stream corridors and areas of stream erosion or other issues. Stream characteristics should be logged and recorded manually and with the aid of cameras and/or video equipment.

6.3.2 Structural Solutions

Structural (i.e., capital) solutions have the potential to reduce phosphorus inputs to the lake, affect stormwater volumes and peak flows, improve water quality, and restore aquatic habitat. Structural solutions are grouped in terms of targeted driving factors of water quantity, phosphorus inputs, water quality, and aquatic habitat.

6.3.2.1 Water Quantity

Alternatives meant to address altered hydrology (i.e., water quantity) include programmatic solutions discussed previously and the structural solutions of detention, retention, impervious surface reduction, velocity reduction, infiltration, stream buffer restoration, and land purchase. The effectiveness of any of these alternatives can be limited by physical space constraints. The effectiveness of any of these alternatives for water quantity is limited by available technology.

Infiltration is an extremely effective method to reduce stormwater runoff volumes and peak flows. Under pre-development conditions, a significant portion of the annual precipitation infiltrates into the ground. After development and the corresponding increase in impervious surfaces that prevent infiltration, much more of the annual precipitation runs off as stormwater. Promoting infiltration is a method to reduce the impacts of development by mimicking natural hydrologic processes.

Infiltration effectiveness is a function of soil infiltration capacity. Many areas of the Lake Whatcom Watershed have top soils conducive to infiltration (Figures 2-3 and 2-4). When local soils aren't conducive to infiltration, soils amended with organic material can be brought in and placed over native soils. Even if the native underlying soils have low infiltration capacity, the infiltrated water will use the storage available in the soil column of the amended soil layer until infiltration into the underlying layer is possible. Moisture retained in the amended soil layer is available for plant uptake, including lawns.

During construction activities, it is common for the native top layer of soil to be stripped away. In this case, amended soils should be introduced rather than relying on the remaining native soils. Planting, then maintaining, a lawn on the remaining native soil will require watering and

fertilizing that would not be necessary if the native top layer were still in place or if amended soils were brought in.

Regional detention is a plausible structural solution. Regional detention could be used to detain peak flows and increasing volumes of stormwater runoff. (Onsite detention and other site-specific measures are discussed earlier under programmatic solutions.)

Reductions in impervious surface can reduce runoff volumes and velocities. LID regulations can promote reduced widths of newly constructed roadways, but retrofitting existing infrastructure is a structural solution. Pilot projects for reducing road widths and using permeable pavements can be implemented within the watershed.

Stormwater runoff velocities can be reduced using check dams and vegetation in existing ditches. In addition, high-flow bypass facilities can be installed in areas that are prone to erosion under high flow regimes. Stream buffer restoration can reduce stormwater volumes via plant uptake.

Existing stormwater facilities can be retrofitted to promote capacity and capability.

Land purchase can be an effective method to reduce developed land surface and therefore reduce impervious surface, promote infiltration, and retain the natural tree canopy.

6.3.2.2 Water Quality (Including Phosphorus)

Alternatives primarily meant to address phosphorus inputs to the lake and increase water quality include programmatic solutions discussed previously and the structural solutions of treatment, sewer hook-ups from septic, and channel stabilization. In addition, alternatives geared towards reducing volumes and peaks of stormwater runoff also have positive impacts on phosphorus inputs by reducing erosion and erosive capabilities of stormwater and by reducing total stormwater inputs to the lake. These solutions include detention, retention, impervious surface reduction, velocity reduction, infiltration, stream buffer restoration, and land purchase.

The most effective methods to reduce phosphorus inputs to Lake Whatcom are controlling phosphorus at the source and controlling stormwater flows (i.e., peak flows and volumes). Much of the source control measures are programmatic in nature rather than structural.

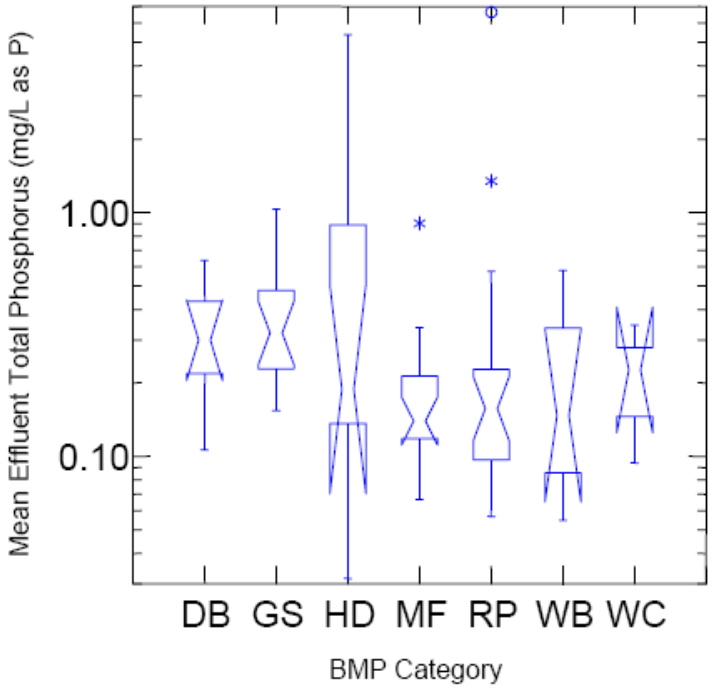
The effectiveness of treatment as an alternative is limited by available technology. Particulate-bound phosphorus can be removed via treatment, but dissolved phosphorus is difficult to remove. The portion of TP in particulate form depends on pH, hydrology, concentration of calcium and magnesium, particulate solids present, and a variety of other factors. The portion that is particulate bound can vary from 20 to 90 percent, with more than 80 percent in particulate form at a pH of 6 and less than 1 percent in particulate form at a pH of 8 (Strecker, et al., 2005). Though particulate-bound phosphorus can be removed using sedimentation and filtration, dissolved phosphorus requires adsorption, precipitation, biological uptake, or separation.

The dissolved phosphorus removal capabilities of stormwater treatment is dependent upon the concentrations of phosphorus (and other constituents) entering the treatment facility. The lower the influent concentration of phosphorus, the harder it is to remove. The term “irreducible limits” refers to the concentration at which no more of a constituent can be removed. The “irreducible limit” depends on available technology. The higher the influent concentration, the easier the constituent is to remove.

Different BMPs can be used for water quality treatment. Methods include detention basins, biofilters, media filters, retention ponds, wetland basins, and wetland channels. Figure 6-1 shows

the mean effluent TP concentrations by BMP category based on data from the International Stormwater BMP Database. This figure shows that while some of the data points show higher removal rates for some BMPs over others, the mean removal does not show a significant difference between treatment strategies.

FIGURE 6-1
Mean Effluent Total Phosphorus concentrations by BMP category



BMP Category		Number of BMPs
DB	Detention Basin	8
GS	Biofilter	15
HD	Hydrodynamic Device	9
MF	Media Filter	17
RP	Retention Pond	20
WB	Wetland Basin	7
WC	Wetland Channel	3

Source: Critical Assessment of Stormwater Treatment and Control Selection Issues, Final Report (Strecker, et al., 2005), Figure A-4

Any one treatment alone is not as effective as combining treatments into "treatment trains," where any one technology can be used to target different constituents or different states of the same constituent.

Treatment can only potentially remove the phosphorus within stormwater runoff and cannot prevent phosphorus already in a stream channel from reaching Lake Whatcom.

Channel stabilization can be used to reduce channel erosion propagated by increasing stormwater peak flows and volumes. This structural solution can prevent significant erosion and minimize the risk of increasing channel incision (i.e., down-cutting).

Disconnecting homes from septic systems and connecting them to piped sewers is a structural solution aimed at reducing the risk of malfunctioning septic systems affecting lake water quality.

6.3.2.3 Aquatic Habitat

Structural solutions aimed at aquatic habitat restoration include replacing culverts that block fish passage, restoration of physical features of creek channels, and stream buffer restoration and

protection. Any of these solutions can aid in aquatic habitat restoration. Whatcom County has conducted a culvert inventory, identifying fish-blocking (and partially blocking) culverts. Restoring physical features of creek channels and protecting and restoring stream buffers also have water quantity and water quality benefits, in addition to aquatic habitat benefits.

6.4 Opportunities and Constraints for LID Implementation in the Lake Whatcom Watershed

Low-impact development refers to a set of management practices that effectively reduce impervious surface and maximize infiltration of rain on development sites. Reducing peak flow rates could also reduce or eliminate stream channel erosion, which is a major source of phosphorous to the lake. Infiltration of stormwater runoff into a proper soil mix (appropriate organic content and a healthy soil biological community) would also provide the best treatment available to remove pollutants. Thus, LID can be more effective at protecting aquatic resources and reducing phosphorous discharges than the current practices of conveyance, detention and treatment.

Experience indicates that LID measures would be effective at reducing total annual runoff volumes and peak flow rates in the streams surrounding Lake Whatcom if either implemented in areas with conducive native soils or if amended soils are used. The feasibility of using individual types of LID measures would have to be analyzed based on conditions in the immediate area of any planned project. For instance, biofiltration swales may not be effective if constructed with a profile greater than about 8 percent slope, and pervious pavement has similar limitations on its use. The quality and depth of native soils on individual sites will determine the amount of imported soil or soil amendments needed to allow infiltration and treatment of stormwater.

One set of challenges to implementing LID in the watershed is created by state and local regulations. This section addresses the regulatory challenges and opportunities for LID. Current Whatcom County regulations and requirements could be updated to reflect requirements for LID in new and redevelopment situations. For instance, a certain depth (such as 12 inches) of amended soils could be required on all pervious surfaces in new developments.

There is no discharge of stormwater from an old growth forest. Therefore, if the goal is to minimize the impact of development, there should be zero discharge of stormwater from developed sites. This can be accomplished through aggressive application of LID concepts, even at urban densities; on high density sites, this may require that rooftop runoff is collected and used onsite for irrigation, flushing toilets, and clothes washing, for example.

Implementing LID measures provides an opportunity to go above and beyond current development practices. Previous analysis for a development on poor soils in the Birch Bay Watershed indicated that implementing LID in a residential development could reduce the required detention volume for a development by about 88 percent based on the 100-year event and may eliminate the need for detention for smaller storms. Detention requirements for new development could be amended to allow “credits” to developers for the implementation of LID measures in the form of reduced detention requirements in addition to those allowed credits in the Ecology *Stormwater Management Manual for Western Washington*, 2005.

Specific regulatory opportunities to allow and encourage LID are recommended including:

1. Amend Zoning Code

a. Reduce maximum impervious surface allowed on residential lots.

b. Increase landscape and native vegetation requirements within existing codes.

c. Evaluate the potential for transfer of residential density credit standards and procedures for projects achieving a zero discharge of stormwater as an incentive.

2. Create Planned LID Chapter of WCC

a. Provide references to the integrated management practices from the *Low Impact Development Technical Guidance Manual for Puget Sound* (January 2003).

b. Allow no net loss of forest in the watershed; require advanced mitigation.

c. Allow no net increase in effective impervious surface in the watershed.

d. Limit impervious area to 10 percent of the site and require forest retention on at least 65 percent of the site on all sites outside of the UGA.

e. Allow no net expansion of the UGA.

f. Create a credit trading system for loss of forest cover and any increases in impervious area.

3. Clearing and Grading Chapter

a. Integrate the Washington State Department of Community Trade and Economic Development Model Clear and Grade chapter or equivalent; inspect and enforce on all sites.

4. Public Works Standards

a. Allow zero discharge of stormwater runoff from all new development.

b. Road standards should be amended to reduce residential streets to no more than 16 feet wide.

c. Pervious pavement should be mandatory for all streets (with speed limits of 35 mph or less), driveways, parking areas and walkways.

d. Stormwater management regulations and the drainage code should allow the integrated management practices found in the Low Impact Development Technical Guidance Manual for Puget Sound (Puget Sound Action Team, January 2005) and the BMPs found in the latest Ecology Stormwater Management Manual for Western Washington.

e. Adopt design standards for LID practices (see City of Bellevue Design Standards for Natural Drainage Systems, 2007)

6.5 Rating of Identified Alternative Solutions

The appropriate solution for any one problem depends on both the significance of the source that the solution addresses and its effectiveness and cost. Weighing cost with effectiveness provides a picture of which solutions give the most bang for the buck The most cost-effective solutions will be prioritized and recommended for implementation to address the most influential sources in the short term, while the projects that provide less benefit per dollar spent and address less important sources may be recommended for implementation later as funds allow.

The highest-priority driving factors are phosphorus inputs into Lake Whatcom and the altered hydrologic regime within the watershed. The effectiveness of any of the 42 solutions in reducing phosphorus inputs into the lake or in positively influencing hydrologic regime is summarized in Table 6-1. The table also includes a measure of relative cost (rated high, medium, and low). Once a general cost and effectiveness measure was given to each solution, these solutions were placed within a matrix with cost on one axis and effectiveness on the other. Table 6-2 shows the cost-benefit matrix for phosphorus and Table 6-3 shows the cost-benefit matrix for water quantity.

The most cost-effective solutions are those with relatively high effectiveness at a relatively low cost. There are highly effective and low cost alternative solutions for both phosphorus removal and altered hydrology.

There are four regulatory mechanisms that target new development:

- Require no net loss of forest cover
- Require zero discharge of stormwater
- Allow collection and beneficial use of onsite rooftop runoff in residential and office structures
- Require pervious pavement for all new roads, walkways, driveways, and parking areas

Besides the four listed above, other solutions can be cost-effective. For phosphorus, the following solutions are cost-effective:

- Low cost, medium effectiveness:
  - Education to reduce vehicle use, to change behaviors of use of yards and yard care, and to change the use of building materials, septic systems, pets and livestock, construction activities, and recreation within the Lake Whatcom Watershed
  - Regulatory efforts on yards and yard care
- Medium cost, medium effectiveness:
  - Regulatory efforts on building materials, pets and livestock, and recreation within the Lake Whatcom watershed
  - Maintenance on septic systems
  - Inspection/enforcement on yards and yard care, pets and livestock, and construction activities
- Medium cost, high effectiveness
  - Maintenance of existing stormwater conveyance systems
  - Regulatory efforts on construction activities and on new development

For phosphorus, capital fixes are all high-cost solutions with varying degrees of effectiveness. The structural fixes of sewer system hookup, capital fixes of existing stormwater conveyance, and land purchase to prevent new development are all high-cost but highly effective solutions. Structural solutions with medium effectiveness and high cost include treatment of stormwater

TABLE 6-2. BENEFIT-COST MATRIX – PHOSPHORUS (42 SOLUTIONS)

Relative Cost	Relative Effectiveness - Phosphorus		
	Low[a]	**Medium**[a]	**High**[a]
High	Roads (1) - Detention (capital)	Roads (1) - Treatment (capital)	Roads (1) – Impervious pavement (capital)
	Vehicles (2) - Alternatives Infrastructure (capital)	Roads (1) - Decrease Road Area (capital/programmatic)	Septics (4) - Sewer System Hookup (capital)
	Existing SW Facilities (5) - Capital fixes	Building Materials (8) - Capital fixes	Existing SW conveyance (6) - Capital fixes
	Groundwater Interception (7) - Detention (capital)	New Development (12) – Detention (capital)	New Development (12) - Land Purchase (capital)
	Groundwater Interception (7) - Infiltration (capital)	New Development (12) – Treatment (capital)	
	Atmospheric Deposition (13) – Source control		
Medium	Existing SW facilities (5) - Maintenance	Yards (and yard care) (3) - Inspection/Enforcement	Existing SW conveyance (6) - Maintenance
		Septics (4) - Maintenance	Construction Activities (11) - Regulatory
		Building Materials (8) - Regulatory	New Development (12) – Regulatory (require LID)
		Pets and Livestock (9) - Regulatory	
		Pets and Livestock (9) - Inspection/Enforcement	
		Construction Activities (11) - Inspection/Enforcement	
		Recreation in Watershed (14) - Regulatory	
Low	Existing SW facilities (5) - Education	Vehicles (2) - Education	New Development (12) – Regulatory – zero discharge
	Existing SW conveyance (6) - Education	Vehicles (2) – Regulatory (reduce use of P and Cu in parts)[b]	New Development (12) – Regulatory - no loss of forest
	Wildlife (10) - Education	Yards (and yard care) (3) - Education	New Devel. (12) – Regulatory – require pervious
		Yards (and yard care) (3) - Regulatory	
		Septics (4) - Education	
		Building Materials (8) - Education	
		Pets and Livestock (9) - Education	
		Construction Activities (11) - Education	
		New Devel. (12) – Regulatory – allow rooftop coll/reuse	
		Recreation in Watershed (14) - Education	

[a] Source is designated according to the 14 sources described in Table 6-1: 1 = Roads ; 2 = Vehicles; 3 = yards and yard care activities; 4 = septic systems; 5 = existing stormwater facilities; 6 = Existing stormwater conveyance system; 7 = groundwater interception; 8 = building materials; 9 = pets and Livestock; 10 = wildlife (birds, waterfowl; 11 = construction activities; 12 = new development (land clearing); 13 = atmospheric deposition; 14 = recreation in watershed

[b] P=phosphorus, Cu=copper

TABLE 6-3. BENEFIT-COST MATRIX – WATER QUANTITY (42 SOLUTIONS)

Relative Cost	Relative Effectiveness - Hydrology		
	Low[a]	**Medium[a]**	**High[a]**
High	Roads (1) - Treatment (capital)	Roads (1) - Detention (capital)	Roads (1) - Decrease Surf. Area (capital/programmatic)
	Vehicles (2) - Alternatives Infrastructure (capital)	Existing SW Facilities (5) - Capital fixes	Roads (1) – Impervious pavement (capital)
	Septics (4) - Sewer System Hookup (capital)		Existing SW conveyance (6) - Capital fixes
	Building Materials (8) - Capital fixes		Groundwater Interception (7) - Detention (capital)
	New Development (12) – Treatment (capital)		Groundwater Interception (7) - Infiltration (capital)
	Atmospheric Deposition (13) – source control (capital)		New Development (12) - Land Purchase (capital)
			New Development (12) – Detention (capital)
Medium	Yards (and yard care) (3) - Inspection/Enforcement	Construction Activities (11) - Inspection/Enforcement	Existing SW facilities (5) - Maintenance
	Septics (4) - Maintenance	Construction Activities (11) - Regulatory	Existing SW conveyance (6) - Maintenance
	Building Materials (8) - Regulatory	Recreation in Watershed (14) - Regulatory	New Development (12) – Regulatory (require LID, etc.)
	Pets and Livestock (9) - Regulatory		
	Pets and Livestock (9) - Inspection/Enforcement		
Low	Vehicles (2) - Education	Existing SW facilities (5) - Education	New Development (12) – Regulatory – zero discharge
	Vehicles (2) – Regulatory (reduce use of P and Cu in parts)[b]	Construction Activities (11) - Education	New Development (12) – Regulatory -no loss of forest
	Yards (and yard care) (3) - Education	Recreation in Watershed (14) - Education	New Devel. (12) – Regulatory – allow rooftop coll/reuse
	Yards (and yard care) (3) - Regulatory		New Devel. (12) – Regulatory – require pervious pavement
	Septics (4) - Education		
	Existing SW conveyance (6) - Education		
	Building Materials (8) - Education		
	Pets and Livestock (9) - Education		
	Wildlife (10) - Education		

[a] Source is designated according to the 14 sources described in Table 6-1: 1 = Roads ; 2 = Vehicles; 3 = yards and yard care activities; 4 = septic systems; 5 = existing stormwater facilities; 6 = Existing stormwater conveyance system; 7 = groundwater interception; 8 = building materials; 9 = pets and livestock; 10 = wildlife (birds, waterfowl); 11 = construction activities; 12 = new development (land clearing); 13 = atmospheric deposition; 14 = recreation in watershed

[b] P=phosphorus, Cu=copper

from roadways, the retrofit of decreasing road surface area, capital fixes to retrofit for building materials, and detention and treatment for new development.

For hydrology, the following solutions are also cost-effective:

- Low cost, medium effectiveness:
  - Education regarding existing stormwater facilities, construction activities, and recreation within the Lake Whatcom watershed
- Medium cost, medium effectiveness:
  - Regulatory efforts on construction activities, and on recreation within the Lake Whatcom watershed
  - Inspection/enforcement on construction activities
- Medium cost, high effectiveness
  - Maintenance of existing stormwater conveyance systems and of existing stormwater facilities
  - Regulatory efforts on new development

For hydrology, all structural solutions are high cost. High-cost and highly effective solutions include decreasing surface area of already-existing roads, capital fixes of existing stormwater conveyance systems, detention and infiltration for intercepted groundwater, capital projects consisting of detention for new development, and land purchase.

Education intended to reduce vehicle use and education on yard and yard-care activities, septic systems, existing stormwater conveyance systems, wildlife, pets and livestock, and building materials, and regulatory efforts on yards and yard care activities provide low effectiveness for hydrology, but at a low cost.

Chapter 5 contains a discussion of the relative contribution of each of the 14 sources on phosphorus inputs to the lake and on alteration of hydrologic regime. Many of the sources are not as major as the most influential sources, namely roads, vehicles, the existing stormwater conveyance systems, and new development (i.e., land clearing). The less influential sources, such as atmospheric deposition and building materials, are included in these analyses; however, solutions are prioritized in this plan based on significance of source, along with the cost and effectiveness of each solution as discussed in this chapter. These analyses into the relative cost and effectiveness of each solution, paired with the relative significance of each source, inform the decision on which solution is most appropriate for each identified problem.