BMP Alternative Summaries
No Phosphorus Fertilizer

Description:
Fertilizers high in phosphorus are frequently used in home lawn care; however, in most lawns in Eastern Nebraska, phosphorus fertilizer is not needed to grow healthy grass. Excess phosphorus application can be a problem. Phosphorus within the water system causes dangerous algae blooms, excessive aquatic plant growth, and a decrease in dissolved oxygen availability for aquatic life. Excess aquatic plants and the water quality problems that occur when they decompose can kill fish and other organisms. When applied to a lawn, fertilizer can easily spill onto driveways and sidewalks. It can be washed into storm drains and flow over surfaces during a rainstorm or snow-melt and settle into waterways and lakes. Homeowners can buy a no/low phosphorus fertilizer through a local garden, farm, or hardware store to help reduce this problem.

Source: http://www.scotts.com/

Proposed Location:
- City of Carter Lake.
- Portion of City of Omaha within the Carter Lake watershed.

Advantages:
- This alternative targets phosphorus loads to Carter Lake, which is the leading cause of blue-green algae growth.
- Very low costs associated with the policy once education has been completed. Continuing education and posting of signs in public areas will increase the effectiveness of the program

Disadvantages:
- Requires a continual public education and involvement process.
- Compliance is difficult to enforce.

Pollutant Removal	
Phosphorus	◗
Sediment	○
Bacteria	○
PCBs	○
Metals	○
Oil/Grease	○

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	Positive
Aesthetics	Positive
Boating	N/A
Fishing	N/A
Water Clarity	Positive

Cost Data	
Capital Costs	Low
Maintenance Costs	Low

OLSSON ASSOCIATES

BMP Alternative Summaries
Pet Waste Management

Description:
If not picked up, pet waste will eventually be washed into the street, down the gutter, or into a storm drain eventually making its way into Carter Lake. Bacteria, viruses, and parasites found in pet waste can pose health risks to humans and other animals, and result in the spread of disease. The release of nutrients, such as phosphorus, from the decay of pet waste promotes weed and algae growth in lakes, limiting light penetration and the growth of aquatic vegetation. This in turn can reduce oxygen levels in the water, affecting fish and other aquatic organisms. Implementation of information/education programs to inform citizens about the impact of pet waste on the lake will help improve the water quality of Carter Lake.

Source: http://www.petsmart.com/ps/main.jsp

Proposed Location:
- City of Carter Lake.
- Portion of City of Omaha within the Carter Lake watershed.

Advantages:
- Very low costs associated with the policy once education has been completed. Continuing education and posting of signs in public areas will increase the effectiveness of the program.

Disadvantages:
- Requires a continual public education and involvement process.
- Compliance is difficult to enforce.

Pollutant Removal	
Phosphorus	○
Sediment	○
Bacteria	◗
PCBs	○
Metals	○
Oil/Grease	○

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	Positive
Aesthetics	Positive
Boating	N/A
Fishing	N/A
Water Clarity	Positive

Cost Data	
Capital Costs	Low
Maintenance Costs	Low

OLSSON ASSOCIATES

BMP Alternative Summaries
Wet Detention Ponds

Description:
Wet detention is typically a constructed pond or a pond incorporated into a stormwater treatment system. They are generally considered "end-of-the-pipe" BMPs. Ponds can be modified to increase their storage capacity and enhanced with vegetation to increase their water-quality treatment effectiveness. The primary pollutant removal mechanism in wet detention is sedimentation (settling), with a moderate to high potential for removing metals, nutrients, and organics. Since wet ponds have the capability of removing soluble pollutants, they are suitable for sites where nutrient or pollutant loads are expected to be high.

Source: City of Lincoln and the LPSNRD Alternative Stormwater BMP Guidelines, 2006

Proposed Location:
- Rehab/expand existing pond at the northwest corner of Carter Lake in Levi Carter Park.
- Rehab the existing pond at the Golf course.

Advantages:
- Create additional shoreline and aquatic habitat.
- Can provide recreational opportunities.
- Aesthetically pleasing.
- Capture pollutants and prevent them from entering Carter Lake.

Disadvantages:
- Requires usable land space – limited number of available sites.
- May require maintenance at regular intervals to remove deposited sediment.
- If not designed and maintained correctly, could become a mosquito breeding habitat.

Pollutant Removal	
Phosphorus	◗
Sediment	●
Bacteria	◗
PCBs	◗
Metals	◗
Oil/Grease	○

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	Positive
Aesthetics	Positive
Boating	N/A
Fishing	N/A
Water Clarity	Positive

Cost Data	
Capital Costs	High
Maintenance Costs	Medium

OLSSON ASSOCIATES

BMP Alternative Summaries
Bioretention

Description:
Bioretention (sometimes called rain gardens) facilities are designed to capture and retain the storm water quality volume in a shallow, offline, vegetated retention area. They are typically used to treat small (0.25 to 1.0 acre), highly impervious drainage areas such as parking lots. Bioretention facilities are intended to promote infiltration, evaporation and evapotranspiration of the water quality volume. Bioretention basins have an under drain connected to the storm drain if native soils are not sufficiently permeable. Careful landscaping and planting can provide a positive aesthetic appeal. Bioretention is well-suited for use where a vegetated buffer area may provide screening and an aesthetic element is desirable to adjacent property owners.

Source:
http://www.ence.umd.edu/~apdavis/Bioinstallations.htm

Proposed Location:
- Adjacent to commercial or industrial areas within the watershed.

Advantages:
- Pollutant removal effectiveness is typically high, accomplished primarily by physical filtration of particulates through the soil profile; and absorption of constituents by the soil.
- It can provide an aesthetic vegetated appearance.

Disadvantages:
- In areas with prolonged dry periods, maintenance of trees, shrubs and grass between rainfalls may require irrigation.
- As with any infiltration/filtration facility, clogging can cause water ponding and associated nuisance and mosquito problems.
- It takes time for bioretention facilities to become established while vegetation develops, though filtering still occurs.
- Regular vegetation management is required.

Pollutant Removal	
Phosphorus	●
Sediment	●
Bacteria	●
PCBs	◗
Metals	●
Oil/Grease	◗

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	Positive
Aesthetics	Positive
Boating	N/A
Fishing	N/A
Water Clarity	Positive

Cost Data	
Capital Costs	Medium
Maintenance Costs	Low

OLSSON ASSOCIATES

BMP Alternative Summaries
Prefabricated Stormwater Filter

Description:
The prefabricated stormwater filter is a passive filtration system that effectively removes pollutants from overland storm water runoff. These systems are constructed underground in concrete vaults and target a full range of pollutants in urban runoff, including sediment, soluble heavy metals, oil and grease, organics and nutrients. The system removes pollutants through mechanical filtration, ion exchange, and absorption.

Source: CONTECH Stormwater Solutions Inc.

Proposed Location:
- Concrete channel inflow into southeast portion of Carter Lake.
- Appropriate locations throughout the watershed.

Advantages:
- Small land requirement, not highly visible.
- It is a dry sump system, which means no water to remove during maintenance.
- Surface cleaning mechanism extends maintenance intervals.
- Individual pollutants can be targeted based on the specific site.

Disadvantages:
- Initial installation costs are much higher than natural mechanisms that provide similar functions.

Pollutant Removal	
Phosphorus	◗
Sediment	●
Bacteria	◗
PCBs	○
Metals	●
Oil/Grease	●

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	N/A
Aesthetics	N/A
Boating	N/A
Fishing	N/A
Water Clarity	Positive

Cost Data		Approximate Estimate
Capital Costs	High	*$10,000 - $20,000
Maintenance Costs	Medium	$1,000

*Cost per system.

OLSSON ASSOCIATES

BMP Alternative Summaries
Septic System Rehab/Disconnection

Description:
Approximately 200 households in Omaha, north of Carter Lake, run on septic systems. Septic systems need to be maintained in order to prevent failure. Systems in urban environments like the City of Omaha are often not maintained due to a lack of education or resources. Failure in any of the systems would result in phosphorus-rich waste seepage into the ground water, which generally flows towards Carter Lake. A systems check and necessary repairs would prevent septic system seepage from entering Carter Lake.

Source: USDA NRCS

Proposed Location:
- Omaha (north of Carter Lake)

Advantages:
- Repair of a failed system would significantly reduce the pollutants it was emitting.

Disadvantages:
- Existing pollutant loads from failed systems are likely a small source of the overall phosphorus load to the lake. Therefore, repair would not dramatically improve water quality.

Pollutant Removal	
Phosphorus	○
Sediment	○
Bacteria	○
PCBs	○
Metals	○
Oil/Grease	○

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	N/A
Aesthetics	N/A
Boating	N/A
Fishing	N/A
Water Clarity	Positive

Cost Data	
Capital Costs	Low
Maintenance Costs	Low

OLSSON ASSOCIATES

BMP Alternative Summaries
Vegetated Bioswale

Description:
Vegetated bioswales are drainage swales that are planted with vegetation. Bioswales accomplish many of the same functions provided by bioretention (i.e., rain gardens), while also providing conveyance of stormwater. This conveyance function is particularly important when managing concentrated flows and during severe storms events when stormwater needs to be directed to a destination, such as a wetland. Swales should be designed with native species, and can be augmented with check dams and other techniques to maximize their effectiveness at managing stormwater.

Source: City of Lincoln and the LPSNRD Alternative Stormwater BMP Guidelines, 2006

Proposed Location:
- Replace concrete lined inflow into southeast portion of Carter Lake.
- Throughout Levi Carter Park.
- Replace concrete channel leading to golf course pond from the east.
- Appropriate locations throughout the watershed.

Advantages:
- Provides effective stormwater flood control by slowing down runoff and storing water, including water infiltration into the soil.
- Improves water quality by filtering pollutants from stormwater (oils, greases, metals, and sediments that can be picked up from paved surfaces).
- Can be used as a system by itself or in conjunction with other BMPs.
- Easy to plan and build.
- Reduces erosion.
- Flexible to incorporate existing natural features.
- Preserves natural/native vegetation and provides habitat for wildlife.
- Although periodic cleaning may be required, swales should never need to be replaced, in contrast to conventional stormwater systems.

Disadvantages:
- May require planning and stakeholder acceptance depending on location.
- Not the fastest conveyance method—carefully design and place swales to minimize risk of flooding.
- Swales can only treat a limited area.

Pollutant Removal	
Phosphorus	◗
Sediment	◗
Bacteria	●
PCBs	○
Metals	◗
Oil/Grease	◗

○ Low ◗ Medium ● High

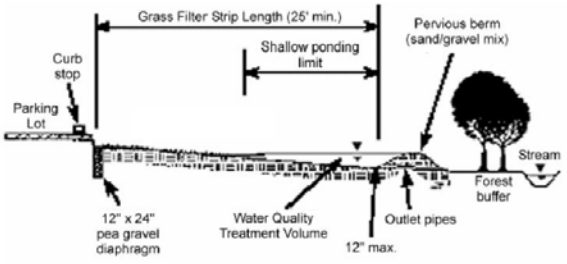
Other Benefits and/or Impacts	
Habitat	Positive
Aesthetics	Positive
Boating	N/A
Fishing	N/A
Water Clarity	Positive

Cost Data	
Capital Costs	Low
Maintenance Costs	Low

OLSSON ASSOCIATES

BMP Alternative Summaries
Vegetated Filter Strips

Description:
Filter strips are densely-vegetated areas that accept sheet flow runoff from adjacent surfaces. They slow runoff velocity, which minimizes erosion; filter out sediment and other pollutants; and enhance infiltration of surface water runoff. Filter strips are well suited to areas adjacent to parking lots and other impervious surfaces where runoff can be conveyed and filtered before it is discharged into swales, stormwater systems, streams, or lakes. Filter strips are also appropriate for construction sites and developing land to filter sediment from overland sheet flow.



Source: City of Lincoln and the LPSNRD Alternative Stormwater BMP Guidelines, 2006

Proposed Location:
- Appropriate locations throughout the watershed (adjacent to parking lots, roads, and other large impervious surfaces).

Advantages:
- Provides effective stormwater flood control by slowing down runoff and storing water, including water infiltration into the soil.
- Improves water quality by filtering pollutants from stormwater (oils, greases, metals, and sediments that can be picked up from paved surfaces).
- Can be used as a system by itself, or in conjunction with other BMPs.
- Easy to plan and build.
- Reduces erosion.
- May help maintain temperature of receiving waters.
- Flexible to incorporate existing natural features and a variety of vegetation types.
- Preserves natural/native vegetation and provides habitat for wildlife.
- Protects adjacent properties.

Disadvantages:
- Need to maintain vegetative cover for controlling erosion and reducing particulates in the runoff.
- Extreme care must be taken during construction to grade gentle slopes and eliminate formation of gullies.
- Requires maintenance to remove trash.

Pollutant Removal	
Phosphorus	◗
Sediment	●
Bacteria	○
PCBs	○
Metals	◗
Oil/Grease	◗

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	N/A
Aesthetics	Positive
Boating	N/A
Fishing	N/A
Water Clarity	Positive

Cost Data	
Capital Costs	Medium
Maintenance Costs	Low

OLSSON ASSOCIATES

BMP Alternative Summaries
Grass Swales

Description:
Grassed swales are low-cost alternatives to conventional hard-engineered conveyance in residential and commercial neighborhoods. They consist simply of a shallow turf-grass channel, or swale, that conveys water down a slight gradient away from its source. As runoff travels down the swale, suspended solids and pollutants are settled or filtered out, preventing them from entering streams or lakes.

Source: City of Lincoln and the LPSNRD Alternative Stormwater BMP Guidelines, 2006

Proposed Location:
- Appropriate locations throughout the watershed to replace pipes, concrete channels, and eroded ditches wherever possible.

Advantages:
- Less expensive than conventional, hard-engineering conveyance practices, in both the initial construction and maintenance phases.
- Encourages infiltration.
- Provides some minor filtration of sediment and other particles.

Disadvantages:
- Less effective than vegetated bioswales (filter strips) at filtering pollutants and reducing rates and volumes of runoff.
- Swales can only treat a limited area.

Pollutant Removal	
Phosphorus	○
Sediment	◗
Bacteria	○
PCBs	○
Metals	◗
Oil/Grease	●

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	N/A
Aesthetics	Positive
Boating	N/A
Fishing	N/A
Water Clarity	Positive

Cost Data	
Capital Costs	Low
Maintenance Costs	Low

OLSSON ASSOCIATES

BMP Alternative Summaries
Vegetated Buffer Strips

Description:
Vegetated buffer strips are relatively flat, vegetated areas that accept sheet flow from storm water runoff. Removal mechanisms include filtration and infiltration. Buffer strips can also be planted around the perimeter of parking lots, parallel to streams or ditches that convey stormwater, and around the shoreline of lakes to filter out sediment and phosphorus and minimize erosion of runoff that enters the lake as overland flow from the surrounding area. One of the primary benefits of buffer strips is to maintain a thick stand of vegetation between water bodies and paved or fertilized areas.

Source: Minnesota DNR

Proposed Location:
Adjacent to drainage swales and ditches and around the perimeter of Carter Lake wherever possible, particularly at the golf course.

Advantages:
- Requires relatively small amount of land space and incorporates well into the environment.
- Protect sensitive areas from erosion.
- Generally inexpensive relative to other BMPs to operate and maintain.
- Offer aesthetic value to the landscape

Disadvantages:
- Buffer strips do not function properly unless sheet flow is maintained. Care must be taken during design and construction to maintain flat, gentle slopes with no gullies.
- Maintenance requirements include regular inspection for erosion and adequate vegetative cover. If acceptable cover is not achieved, re-seeding or some type of erosion control will be needed.

Pollutant Removal	
Phosphorus	○
Sediment	◗
Bacteria	○
PCBs	○
Metals	○
Oil/Grease	◗

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	Positive
Aesthetics	Positive
Boating	N/A
Fishing	N/A
Water Clarity	Positive

Cost Data	
Capital Costs	Low
Maintenance Costs	Low

OLSSON ASSOCIATES

BMP Alternative Summaries
Drain Inlet Inserts

Description:
Inceptors are stainless steel baskets that suspend from drain inlet grates. The frame is lined with fabric mesh and contains an oil-absorbing filter pillow. The filter removes pollutants small stormwater flows that occur several times a year. Large flood flows bypass the filter by overtopping the basket.

Source: CalTrans BMP Manual, 2006

Proposed Location:
- At drain inlets throughout the watershed.

Advantages:
- There are a wide range of sizes that can be fitted to most grate inlets.
- They are easy to install and clean.
- Maintenance can be simple and quick.

Disadvantages:
- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.
- If located along a shoulder or median, maintenance activities may require traffic control.
- If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required. Manufacturer recommends annual replacement of filter pillow.
- Phosphorus removal is low.

Pollutant Removal	
Phosphorus	○
Sediment	◗
Bacteria	○
PCBs	○
Metals	◗
Oil/Grease	◗

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	N/A
Aesthetics	N/A
Boating	N/A
Fishing	N/A
Water Clarity	Positive

Cost Data		Approximate Estimate
Capital Costs	Medium	*$100-$2,000
Maintenance Costs	Medium	$100/yr

*Price per inlet.

OLSSON ASSOCIATES

BMP Alternative Summaries
Street Sweeping

Description:
Lakes receive a large amount of sediment from stormwater running off of streets. Street sweeping allows for the collection and removal of litter, leaves, and other visible debris that gather in gutters. This debris can block storm drain facilities, causing localized flooding during heavy rains. Establishing a street sweeping program or revising existing street sweeping schedules will assist in reducing the amount of coarse sediment entering the lake by means of stormwater runoff. An equally important, but less visible benefit of street sweeping is the removal of metal particles and other hazardous waste products left by passing vehicles. To be effective, street sweeping should be conducted once per week, especially during winter and spring months.

Source: http://www.wheaton.il.us/

Proposed Location:
- Streets located within the watershed.

Advantages:
- Cleaner streets as well as fewer pollutants introduced to the lake.

Disadvantages:
- Significant ongoing cost to both cities.

Pollutant Removal	
Phosphorus	○
Sediment	◗
Bacteria	○
PCBs	○
Metals	◗
Oil/Grease	◗

○ Low ◗ Medium ● High

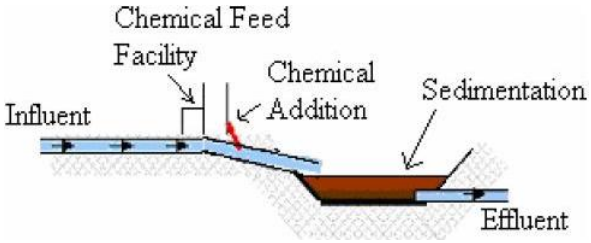
Other Benefits and/or Impacts	
Habitat	N/A
Aesthetics	Positive
Boating	N/A
Fishing	N/A
Water Clarity	Positive

Cost Data	
Capital Costs	High
Maintenance Costs	Medium

OLSSON ASSOCIATES

BMP Alternative Summaries
Alum Stormwater Injection

Description:
Alum can be injected into major storm sewer lines before they discharge to lakes or streams. When added to stormwater, alum forms non-toxic precipitates that combine with phosphorus, suspended solids and heavy metals, causing them to be rapidly removed from the treated water and settled out in a detention basin, or in the bottom of the lake. In a typical alum storm water treatment system, the coagulant is injected into the storm water by a variable-speed chemical metering pump on a flow-weighted basis so the same dose is added regardless of the storm sewer discharge rate.



Source: CalTrans BMP Manual, 2006

Proposed Location:
- As part of the pond rehabilitation near the northwest corner of the lake in Levi Carter Park.

Advantages:
- Alum treatment achieves high nutrient, heavy metal, and fecal coliform removals.
- Alum injection into the stormwater system will significantly reduce external phosphorus loads to the lake.
- The observed accumulation rate of alum floc in the receiving waters (lake or pond) is low due to consolidation and incorporation of alum floc into bottom sediment.

Disadvantages:
- High capital costs prohibit treatment of every outfall location.
- Sludge removal frequency and method will have to be studied.
- Safety issues related to the chemical storage facility need to be considered.
- Appropriate mixing must be provided at the point of chemical addition.
- Optimum alum dose may vary with each storm.
- Mechanical equipment must be inspected and maintained on a regular basis.
- Crews must be trained to maintain chemical addition system.
- May require access to electricity.

Pollutant Removal	
Phosphorus	●
Sediment	●
Bacteria	●
PCBs	○
Metals	●
Oil/Grease	○

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	N/A
Aesthetics	Positive
Boating	N/A
Fishing	N/A
Water Clarity	Positive

Cost Data		Approximate Estimate
Capital Costs	High	*$200,000 - $400,000
Maintenance Costs	High	$10,000 - $20,000/yr

*Price per system.

OLSSON ASSOCIATES

BMP Alternative Summaries
Shoreline Stabilization

Description:
Protection of the lake shoreline will prevent erosion and create less sediment deposition into the lake. Eroding shorelines are not aesthetically pleasing and make lake access difficult. Shoreline stabilization can be accomplished using several different methods. Regrading eroded shorelines to stable slopes and lining with rock riprap is a very common method. Structures, such as offshore breakwaters and jetties, protect the shoreline from wave impacts. Bio-engineering techniques are also available, such as use of geotubes or coconut fiber logs. The use of geotubes would provide the additional benefit of PCB containment.

Source: Olsson Associates (Holmes Lake)

Proposed Location:
- Shorelines of Carter Lake.

Advantages:
- Prevent erosion of shorelines.
- Aesthetic improvements from existing conditions.
- Create additional angler access locations.
- Increased water clarity.

Disadvantages:
- Hard armor techniques such as riprap and articulated concrete may not be aesthetically pleasing to some.
- Natural techniques may require periodic maintenance until vegetation is fully established.
- Placement of structure in the water body may create some limitations for boating in high boating use areas.

Pollutant Removal	
Phosphorus	◗
Sediment	◗
Bacteria	○
PCBs	○
Metals	○
Oil/Grease	○

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	Positive
Aesthetics	Positive
Boating	Negative
Fishing	Positive
Water Clarity	Positive

Cost Data	
Capital Costs	Medium
Maintenance Costs	Low

OLSSON ASSOCIATES

BMP Alternative Summaries
Fish Renovation

Description:
Carp and bullhead are known for stirring up sediment from lake bottoms due to their feeding and swimming habits. Renovating the fish population and eliminating these fish species will reduce internal pollutant loads, and also rebalance the fish species population. The renovation process often involves lake draw down to reduce the total volume of water and to concentrate the fish. At this point a chemical called rotenone is applied to the lake, which affects the fish's ability to utilize its body's energy and the fish expires. While the lake is down it is also an excellent opportunity to add additional habitat and fishing structures to the lake. The lake is then restocked with more desirable species, resulting in improved water quality and fishing opportunities.

Source: Nebraska Game & Parks
Iowa Department of Natural Resources

Proposed Location:
- Carter Lake.

Advantages:
- Reduction of sediment re-suspensension from bottom-feeding fish resulting in lower internal pollutant load.
- Increases water clarity.
- Provides a high quality fishing location, which would draw a new group of lake users.
- Removes fish tissue that may have bio-accumulated PCBs over the years.
- Increases the abundance of desirable rooted aquatic vegetation that competes with free floating algae (green and blue/green species) for available phosphorus (reduces size and extent of algae blooms).
- Rooted aquatic vegetation stabilizes bottom sediments and protects shorelines from wave action.

Disadvantages:
- Requires temporary draw down and rotenone application to the lake to remove existing fish population.
- Lake must be restocked.

Pollutant Removal	
Phosphorus	◗
Sediment	◗
Bacteria	○
PCBs	◗
Metals	○
Oil/Grease	○

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	Positive
Aesthetics	Positive
Boating	N/A
Fishing	Positive
Water Clarity	Positive

Cost Data		Approximate Estimate
Capital Costs	High	$190,000-$210,000
Maintenance Costs	High	$6,500/ yr

OLSSON ASSOCIATES

BMP Alternative Summaries
Targeted Dredging

Description:
Dredging in strategically selected locations that have experienced high sediment deposition will increase lake depth in shallow areas. Locations near storm sewer outfalls would be high priority areas for targeted dredging. Shallow areas south and west of the island, and in the northeast corner of the lake, would also be high priorities for targeted dredging. The removal of lake bottom material will help reduce organic sediment and attached pollutants (especially phosphorus) available for resuspension into the water column in these shallow areas. This technique would also increase water clarity and enhance fish habitat. A portion of the dredged material would be pumped into the deep hole near the island in the southeast corner of the lake. Additional dredged sediments could be pumped to Coronado Keys to attempt to reduce suspected seepage issues there.

Targeted Dredging Areas (circled in red)

Proposed Location:
- Shallow areas in Carter Lake, especially near storm sewer outfalls and other shallow areas (areas less than 8 feet deep).

Advantages:
- Reduces sediment and phosphorus resuspension to the water column.
- Increases lake depth in targeted areas.
- Dredged materials can be pumped into the large hole near the island adjacent to Abbott Drive in an attempt to seal potential seepage from the lake.

Disadvantages:
- Dredging can create disturbance to aquatic ecosystems (during dredging activity).
- Dredged sediment must be tested for toxic chemicals to avoid adverse effects on the disposal areas.
- The process of dredging often dislodges chemicals residing in benthic substrates and injects them into the water column.
- Dredging can release toxic chemicals (including heavy metals) from bottom sediments into the water column.
- Only slight increase in water volume and moderately low overall impact on water quality.

Pollutant Removal	
Phosphorus	◗
Sediment	◗
Bacteria	○
PCBs	◗
Metals	○
Oil/Grease	○

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	Positive
Aesthetics	Positive
Boating	Positive
Fishing	Positive
Water Clarity	Positive

Cost Data		Approximate Estimate
Capital Costs	High	$500,000 - $1.5 million
Maintenance Costs	Low	

OLSSON ASSOCIATES

BMP Alternative Summaries
Sediment Forebays

Description:
A sediment forebay is a small pool located near the inlet of a storm basin. These devices are designed as initial storage areas to trap and settle out sediment and heavy pollutants before they reach the main basin or lake. Sediment forebays could be constructed from rock riprap, or by installing a geotube barrier near stormwater outfall. Geotubes are large, synthetic tubes of water-permeable geotextile filled with dredged material from the bottom of the lake, which will still allow water to drain through.

Source: Olsson Associates (Holmes Lake)

Proposed Location:
- Northeast corner of Carter Lake at large culvert inlets.
- Other stormwater outfall locations around the lake.

Advantages:
- Creates additional time for the sedimentation process to occur.
- Geotubes provide location to place dredge material.
- Wetland vegetation will likely establish and provide additional treatment.

Disadvantages:
- Will require periodic maintenance to remove silt and sediment from the forebay.

Pollutant Removal	
Phosphorus	◗
Sediment	◗
Bacteria	○
PCBs	○
Metals	○
Oil/Grease	○

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	Positive
Aesthetics	Positive
Boating	Negative
Fishing	Positive
Water Clarity	Positive

Cost Data	
Capital Costs	Med
Maintenance Costs	Med

OLSSON ASSOCIATES

BMP Alternative Summaries
Wetland Enhancement

Description:
Wetlands are shallow marsh systems planted with emergent vegetation that are designed to treat stormwater runoff. While they are one of the best BMPs for pollutant removal, stormwater wetlands can also mitigate peak rates and even reduce runoff volume to a certain degree. They also can provide considerable aesthetic and wildlife benefits. Wetlands use a relatively large amount of space and require an adequate source of inflow to maintain the permanent water surface. Wetlands may be used in connection with other BMP components, such as forebays and vegetated bioswales

Source: City of Lincoln and the LPSNRD Alternative Stormwater BMP Guidelines, 2006

Proposed Location:
- Boys Club Wetland (southeast portion of lake).
- Wetland forebays near stormwater outfalls.
- At the outlet of the overflow swale from the golf course pond.

Advantages:
- Removal of pollutants through settling, filtration, and uptake.
- Enhancement of biological diversity and wildlife habitat in urban areas.
- Rooted vegetation will compete with floating algae for phosphorus uptake, which will help reduce the frequency and severity of algal blooms.
- Aesthetic enhancement and valuable addition to community green space.
- Relatively low maintenance costs.

Disadvantages:
- May be difficult to maintain vegetation under a variety of flow conditions.
- May require larger land requirements that other BMPs.
- Pollutant removal efficiencies may be low until vegetation is established.
- Relatively high construction costs.
- If not designed properly, wetlands may not receive favorable community attention.
- Pollutant removal efficiency can vary from site to site, and can vary seasonally.

Pollutant Removal	
Phosphorus	◗
Sediment	●
Bacteria	●
PCBs	●
Metals	◗
Oil/Grease	◗

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	Positive
Aesthetics	Positive
Boating	N/A
Fishing	Positive
Water Clarity	Positive

Cost Data	
Capital Costs	Medium
Maintenance Costs	Medium

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BMP Alternative Summaries
Watercraft Management

Description:
Watercraft management would involve implementation if no-wake zones and other boating limitations within the lake. Motorboats at high speeds cause sediment to be stirred up from the lake bottom in shallow areas. Shoreline erosion due to waves from the boat wake also occurs. Introducing no wake zones would reduce the internal pollutant loads by limiting the area impacted by high-speed motorboats and personal watercraft.

Source: http://www.boatsdetails.info/

Proposed Location:
- No wake zones in strategic areas of Carter Lake.
- No personal water craft use in strategic areas of Carter Lake.

Advantages:
- Reduces shoreline erosion.
- Less sediment stirred up from the lake bottom, resulting in improve water clarity. Less re-suspension of sediment, therefore internal phosphorus load may be moderately reduced.
- Implementation of this alternative would enhance the efficiency and longevity of in-lake alum application of both alternatives are included.

Disadvantages:
- Must implement an enforcement policy – enforcement can be difficult.
- Policy may not be well received by boat and personal watercraft users.
- No direct removal of phosphorus from the lake.

Pollutant Removal	
Phosphorus	◗
Sediment	◗
Bacteria	○
PCBs	○
Metals	○
Oil/Grease	○

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	Positive
Aesthetics	Positive
Boating	Negative
Fishing	Positive
Water Clarity	Positive

Cost Data	
Capital Costs	Low
Maintenance Costs	Low

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BMP Alternative Summaries
In-Lake Alum Application

Description:
In-lake alum treatment involves the addition of aluminum sulfate (alum) to the water column of a lake. After alum is injected just below the water surface, it bonds with phosphates to form a floc, and precipitates (settles) to the bottom of the lake. The alum floc removes phosphorus and other pollutants from the water column as it settles, and forms a thin layer on the top of the sediment. This layer acts as a barrier to prevent the release of phosphorus to the water column from the sediment. The pH of the lake must be maintained with a range of 5.5 to 9.0 to prevent formation of dissolved aluminum, which can be toxic to aquatic life. If necessary, the addition of liquid sodium aluminate is used to control changes in pH. Carter Lake is well-buffered, and pH control is not expected to be a problem.

Source: Ontario, Canada County Planning Department

Proposed Location:
- Just below the water surface throughout Carter Lake (from a boat/barge).

Advantages:
- Removes phosphorus and other pollutants from the water column and locks it into the sediment.
- Acts as a barrier to prevent the release of phosphorus to water column from sediment, which reduces internal phosphorus loading
- Large improvements to water clarity.
- Results are visible within days to weeks.
- Alum treatment achieves high nutrient, heavy metal, and fecal coliform removals.
- Alum is not toxic, rather it "locks up" the food supply required for algae growth.
- Alum application does not destroy the benthic community of the lake.

Disadvantages:
- The period of effective treatment is uncertain, with successful applications lasting 6-10 years (or more).
- The lake will have a "milky" appearance for a 5-10 days after application. The lake should not be used for boating during this time to allow the floc to settle.
- If external phosphorus and sediment inputs to the lake are not controlled, the settled alum floc will become buried beneath new sediment that is rich in phosphorus, and thus, the effect of the alum treatment is would be lost.
- Because Carter Lake is relatively shallow, partial re-suspension of alum due to boating may cause the binding sites to fill more quickly. This must be considered in the estimation/calculation of dosing requirements.
- Application crew must be trained and have access to specialized equipment to conduct a successful application.

Pollutant Removal	
Phosphorus	●
Sediment	◗
Bacteria	◗
PCBs	○
Metals	◗
Oil/Grease	○

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	N/A
Aesthetics	Positive
Boating	N/A
Fishing	Positive
Water Clarity	Positive

Cost Data		Approximate Estimate
Capital Costs	High	$500,000 - $700,000
Maintenance Costs	Medium	Repeat every 6-10 years

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BMP Alternative Summaries
Whole-Lake Dredging

Description:
Extensive dredging is an option for addressing water quality problems in lakes with high internal pollutant loads. The removal of lake bottom material will reduce the amount of sediment and attached pollutants available for re-suspension into the water column. Extensive dredging throughout the lake will also increase the overall lake depth and volume. Because of shallow sand layers at the bottom of Carter Lake, extensive dredging will necessitate sealing the bottom of the lake afterwards. This can be done using a layer of fine dredged material or by applying a polymer sealant.

Source: South Dakota Lakes and Streams Association (http://www.sdlakesandstreams.com/)

Proposed Location:
- Throughout Carter Lake.

Advantages:
- Reduces sediment and phosphorus re-suspension to the water column.
- Increases lake depth.
- Increases lake volume (dilution).
- Removes existing pollutants contained in bottom sediments, including phosphorus and PCBs
- Dredged materials can be pumped into the large hole near the island adjacent to Abbott Drive, and into the Coronado Keys area, in an attempt to seal possible seepage from the lake.

Disadvantages:
- May break the clay liner and induce seepage. Therefore, it will be necessary to seal the lake. There is a risk that achieving a good seal is not obtained and the lake continue to lose water.
- Dredging can create disturbance to aquatic ecosystems – benthic community is removed.
- Dredged sediment must be tested for toxic chemicals to avoid adverse effects on the disposal areas. The process of dredging often dislodges chemicals residing in benthic substrates and injects them into the water column.
- Dredging can release toxic chemicals (including heavy metals from bottom sediments into the water column.
- Dredging process may limit use of the lake for a long period of time (months to years).
- High costs result in a low likelihood of funding.

Pollutant Removal	
Phosphorus	●
Sediment	◗
Bacteria	○
PCBs	◗
Metals	○
Oil/Grease	○

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	N/A
Aesthetics	Positive
Boating	Positive
Fishing	Positive
Water Clarity	Positive

Cost Data		Approximate Estimate
Capital Costs	High	$10 million - $20 million
Maintenance Costs	Low	

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BMP Alternative Summaries
Polymer Seepage Control

Description:
A polymer sealing agent such as ESS-13 could be used in conjunction with whole-lake dredging, or to seal suspected seepage locations such as Coronado Keys. ESS-13 is a vegetable oil based resinous polymer emulsion that works with the soil to permanently seal the lake. It can be applied to an empty or full lake. ESS-13 is pumped or poured directly into the water at a pre-determined application rate. . The application typically initially reduces seepage by 80% to 90% and the rate continues to improve with time. The majority of the sealing action takes place in the first 72 hours. After this 72 hour period the water will remain hazy white for several days to several weeks.

Source: http://ss-13.com/construction.htm

Proposed Location:
- All of Carter Lake if whole-lake dredging is performed.
- Coronado Keys and other suspected seepage locations

Advantages:
- Provides a seal or barrier to minimize seepage loss from Carter Lake

Disadvantages:
- Very high costs to seal the entire lake. ($1 to $6 million for the entire lake; $100,000 to $400,000 for the two keyway areas)
- No direct pollutant removal or water quality improvement.

Pollutant Removal	
Phosphorus	N/A
Sediment	N/A
Bacteria	N/A
PCBs	N/A
Metals	N/A
Oil/Grease	N/A

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	N/A
Aesthetics	N/A
Boating	Positive
Fishing	N/A
Water Clarity	N/A

Cost Data		Approximate Estimate
Capital Costs	High	$1 million – $6 million
Maintenance Costs	Low	

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BMP Alternative Summaries
Sediment Layer Seepage Control

Description:
If targeted dredging is performed on the lake, the sediment may be pumped from shallow areas to locations of suspected seepage losses such as the deep hole near the island off of Abbott Drive and Coronado Keys. Because pumped sediment spoils must be disposed of if any dredging takes place, this alternative may help reduce seepage losses from Carter Lake without adding significant additional costs over and beyond those spent on dredging.

Source: South Dakota Lakes and Streams Association (http://www.sdlakesandstreams.com/)

Proposed Location:
- All of Carter Lake if whole-lake dredging is performed.
- Coronado Keys and other suspected seepage locations if targeted dredging is performed.

Advantages:
- Provides a seal or barrier to minimize seepage losses from Carter Lake.
- Provides a limited amount of economical dredged sediment storage.

Disadvantages:
- No direct pollutant removal or water quality improvement.
- In Coronado Keys, which is already shallow, the allowable/acceptable depth of this sediment layer may be small.
- If dredged material is high in phosphorus (which is likely), the water quality improvements of the dredging associated with this alternative would be reduced.
- If the dredged material is high in silt/sand, rather than clay, the "sealing" properties of the material will be low and have a reduced impact on seepage.

Pollutant Removal	
Phosphorus	N/A
Sediment	N/A
Bacteria	N/A
PCBs	N/A
Metals	N/A
Oil/Grease	N/A

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	N/A
Aesthetics	N/A
Boating	Positive
Fishing	N/A
Water Clarity	N/A

Cost Data		Approximate Estimate
Capital Costs	High	*
Maintenance Costs	Low	

*** Included in dredging costs**

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BMP Alternative Summaries
Increase Inflow

Description:
Introducing additional low-nutrient water sources to a lake would result in increased volume. This increase would help dilute existing pollutants as well as help maintain a higher water surface elevation and greater lake depths. Potential sources of additional water include rerouting existing stormwater systems from the neighboring cities or the airport into the lake or installation of a supplemental ground water well.

Source: www.mvpc.org

Proposed Location:
- Carter Lake.

Advantages:
- High water levels and greater lake depths.
- Potential dilution IF additional inflow is "clean" water.

Disadvantages:
- No direct removal of pollutants and very large amounts of additional water must be introduced to the lake in order to increase water quality.
- Coordination with agencies (some may be unwilling to cooperate) to reroute their systems.
- Current ground water well at the Kiwanis Pond recycles approximately 40% of its pumped flow from Carter Lake. It would be necessary to install any new well(s) at a greater distance from the lake.

Pollutant Removal	
Phosphorus	○
Sediment	○
Bacteria	○
PCBs	○
Metals	○
Oil/Grease	○

○ Low ◗ Medium ● High

Other Benefits and/or Impacts	
Habitat	N/A
Aesthetics	Positive
Boating	Positive
Fishing	N/A
Water Clarity	Positive

Cost Data		Approximate Estimate
Capital Costs	High	*$2 million
Maintenance Costs	High	**$30,00 to $100,000

*Cost of pump.
**Annual pumping costs.

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