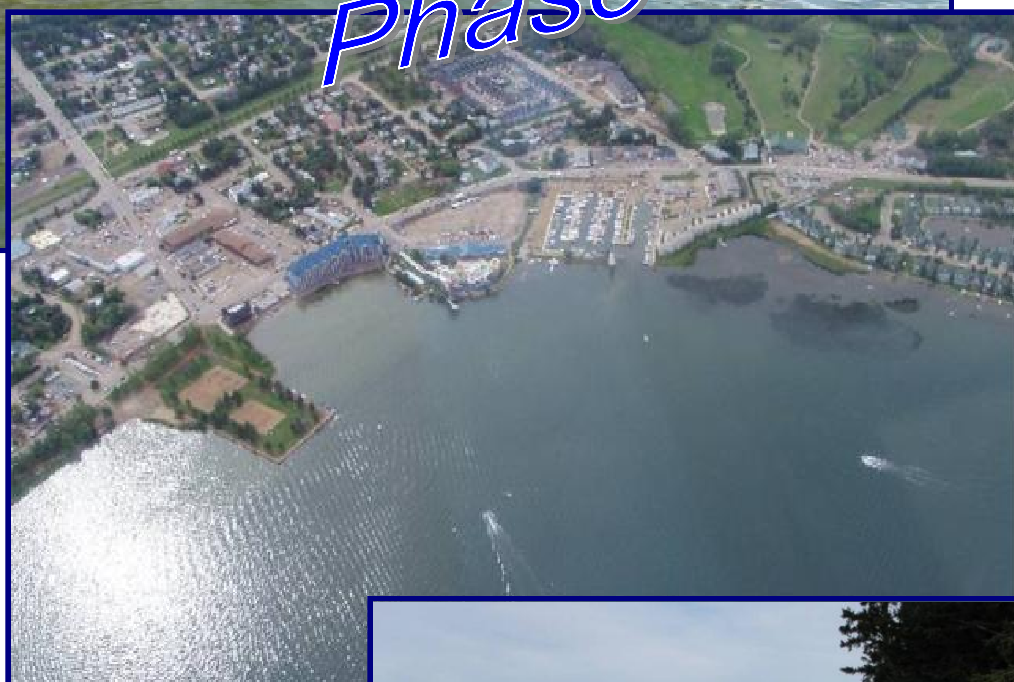
Sylvan Lake Cumulative Effects Management Plan

Phase 1



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Executive Summary

This document provides a management framework for the Sylvan Lake Watershed Cumulative Effects Management System (CEMS). It provides detailed background on general concepts associated with Cumulative Effects Management, and the specific vision, objectives and outcomes of the Sylvan Lake watershed as decided upon by all governing bodies and interest stakeholders. The Sylvan Lake watershed CEMS framework presented here will be a 'living document', one that is intended to be nurtured and developed to adapt to the needs within the watershed.

The original CEMS concept was formally proposed by the Government of Alberta to address cumulative effects in the Sylvan Lake watershed. The approach was embraced by the Sylvan Lake Management Committee (SLMC). The SLMC consists of eight municipalities, provincial and federal government representatives, and the Sylvan Lake Watershed Stewardship society. Their role is to share ideas, issues and concerns regarding land and watershed management surrounding the lake so as to develop an integrated approach to management within the watershed.

Throughout the development of this document members of the SLMC have provided advice, expertise, and guidance on what the framework should contain and what the vision for the watershed is. One resounding concept that has influenced the content of the framework is that it must complement and enhance already existing management plans such as the Sylvan Lake Management Plan (SLMP), the Government of Alberta's regional planning, the various Area Development Plans (ADP), Municipal Development Plans (MDP) and Inter-municipal Development Plans (IDP) that are already completed, underway or in preparation.

The CEMS framework for Sylvan Lake watershed has created a way to collaborate on decision making through the creation of a collective vision and mission which will be achieved through identified outcomes with supporting goals, implementation plans, and management frameworks. This initial phase one document examines the overarching framework for the cumulative effects management system. It does not contain information on implementation plans or any proposed actions.

The development, management and implementation of a Cumulative Effects Management Plan for the Sylvan Lake Watershed will be an on-going, evolving plan. It aims to assess, prioritize and address environmental, economic and social needs in the watershed through a collective mission and vision endorsed by the Sylvan Lake Management Committee.

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1. Introduction: Sylvan Lake – The Place

Sylvan Lake is located west of Red Deer in Central Alberta and is a part of the Red Deer River watershed. Due to its location the Sylvan Lake watershed continues to attract considerable interest from people wishing to pursue a variety of residential and recreational developments.

With this demand expected to only increase, many concerns have been raised including questions about lake capacity for recreational activities and surrounding shoreline developments, the ability to provide adequate public access for recreation and safety and the cumulative effects of many users within the watershed as a whole. As the watershed is governed by a number of different government authorities ranging from local government to federal government , it is recognized that these growth pressures need to be addressed on a cooperative basis to ensure the long term protection and sustainability of Sylvan Lake watershed.

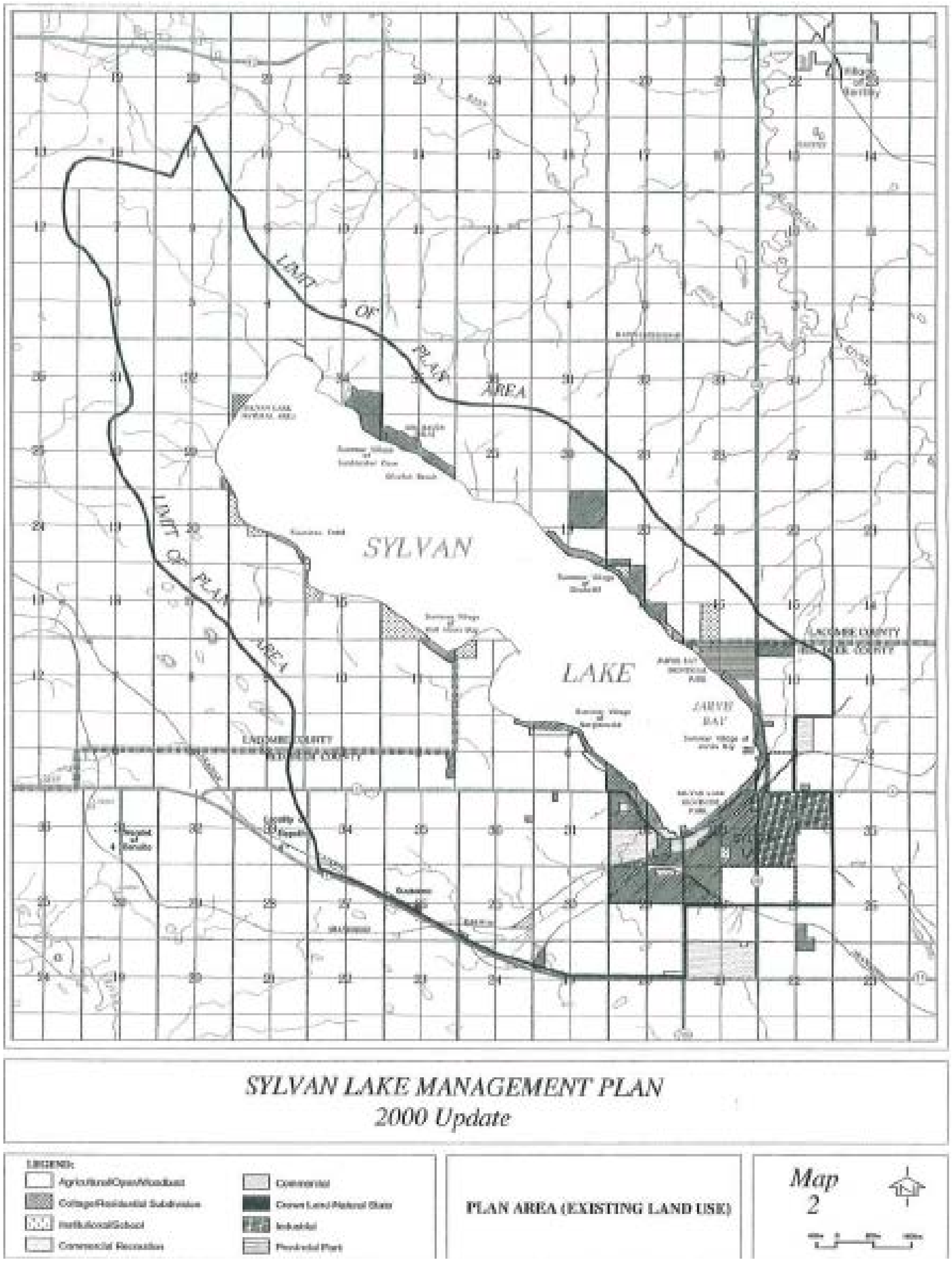
Amongst all of the governing bodies, residents and visitors to the area there is a shared interest maintaining the watershed as a common resource enjoyed by many. This interest extends to a desire to ensure that future generations are able to enjoy as high a quality experience as the present generation.

The Sylvan Lake Management Committee (SLMC) exists to share ideas, issues and concerns regarding land and watershed management surrounding the lake so as to develop an integrated approach between the 8 municipalities in the watershed. The key responsibility of the SLMC is to provide a coordinated approach to implement the Sylvan Lake Management Plan (SLMP) and to ensure the watershed remains a healthy and treasured asset in the future.

Table 1 – Members of Sylvan Lake Management Committee

Members of the Sylvan Lake Management Committee (SLMC)		
Voting Members		Resource Members
Summer Village of Norglenwold	Town of Sylvan Lake	Environment and Sustainable Resource Development
Summer Village of Birchcliff	Red Deer County	Sylvan Lake Watershed and Stewardship Society
Summer Village of Jarvis Bay	County of Lacombe	Fisheries and Oceans
Summer Village of Sunbreaker Cove		
Summer Village of Half Moon Bay		

Figure 1 – Sylvan Lake Watershed Boundaries



1.1 Background and History Planning in the Sylvan Lake Watershed

The first settlers arrived to Sylvan Lake in 1899, which at the time was referred to as Snake Lake due to the numerous garter snakes that were present in the area. The settlers were greeted to a watershed that was forested with trembling aspen of which today only about 10% of this area remains due to agricultural clearing and human development. Development in general throughout the watershed has been concern for many years, and numerous plans and studies have been undertaken to examine the risks and issues associated with such activities.

Regarding the management of Sylvan Lake Watershed the first of many milestones was undertaken in **1977**. At this time the first **Sylvan Lake Management Plan** was prepared by the Red Deer Regional Planning Commission with input from numerous agencies and stakeholders. The plan was not a legal and binding entity; however, five municipalities were in agreement with the goals and objectives for the Sylvan lake resource area. It was based on the regional lake philosophy of:

"Lakes are a public resource and consequently they should be planned and managed for the total public good as part of a regional open space and recreation area system, but this system must reflect the need for conservation, economics and private demands where compatible with the total public good, now and in the future. "

Following on from this publication in **1978** Alberta Environment and Sustainable Resource Development (AESRD) released the **Sylvan Lake Regulation Study** stating that Sylvan Lake was one of the most intensively developed lakes in Alberta. Then in **1990** a **Shoreline Habitat Assessment was** prepared by Environmental Management Associates for AESRD to study aquatic and upland habitat resources of the Sylvan Lake shoreline. This information baseline was to be used as a resource inventory tool in subsequent management plans for the Lake. It noted that key wildlife habitats were impacted by activities such as overgrazing, pollution, recreational motor boating, development and waterskiing.

In **1992** lake levels became the next big topic for concern and the **Sylvan Lake Advisory Committee** was established by the Minister of Environment, Ralph Klein, to work with the local community and local authorities to make recommendations on water management. This resulted in the **1994 Sylvan Lake – Cygnet Lake Study Level 1 Report.**

In **1997** preparation began on the **Sylvan Lake Inter-municipal Development Plan (IDP).** This included a comprehensive public involvement program within the eight municipalities around Sylvan Lake. The IDP was prepared by the IBI Group under the direction of elected and administrative officials. Numerous public submissions were gathered which included concerns for the environment, water quality, boat/noise pollution as well as opposition to conservation districts. Subsequently an IDP Steering committee was created with the eight participating municipalities to address the public concerns. Municipal elections were held in 1998 and in the following years the committee was unsuccessful in achieving the common IDP goals as the public and new Council members desired. Consequently, this led to the adoption of the plan as an integrated resource planning document for Sylvan Lake entitled **2000 Sylvan Lake Management Plan**. The plan's purpose is to promote responsible land use and development around Sylvan Lake. The intent of the municipalities was to monitor and assess the cumulative impacts of new development to ensure that future growth occurred in an environmentally responsible and sustainable manner.

As the cumulative effect on the environment around the lake mounted, the committee came to the realization that this eight municipality board could be used for the overall benefit of the lake environment. The committee asked representatives of Alberta Environment and Sustainable Resource Development, Fisheries and Oceans Canada and the Sylvan Lake Watershed Stewardship Society to become resource members of the committee and to join them in achieving the required actions to render the management plan a success.

Table 2 – Sylvan Lake Management Committee Accomplishments to Date

- Commissioned the Sylvan Lake Water Quality Assessment and Watershed Management Considerations 2005 AXYS Environmental Consulting report
- Supported continuation of the water quality sampling
- Support funds for a Master Thesis regarding Sylvan Lake groundwater
- Supported the Sylvan Lake Public Access Study 2003
- Improved marking of swimming areas
- Marked 30 m boat speed zone for 10km/hr in some lake locations
- Regional sewage system initiated
- Summer Villages convert from septic tanks to sewer systems
- 2012 Golder and Associates Flow Model
- Take It Off – Ice Hut Removal Program

1.2 Purpose and Approach to Cumulative Effects Management

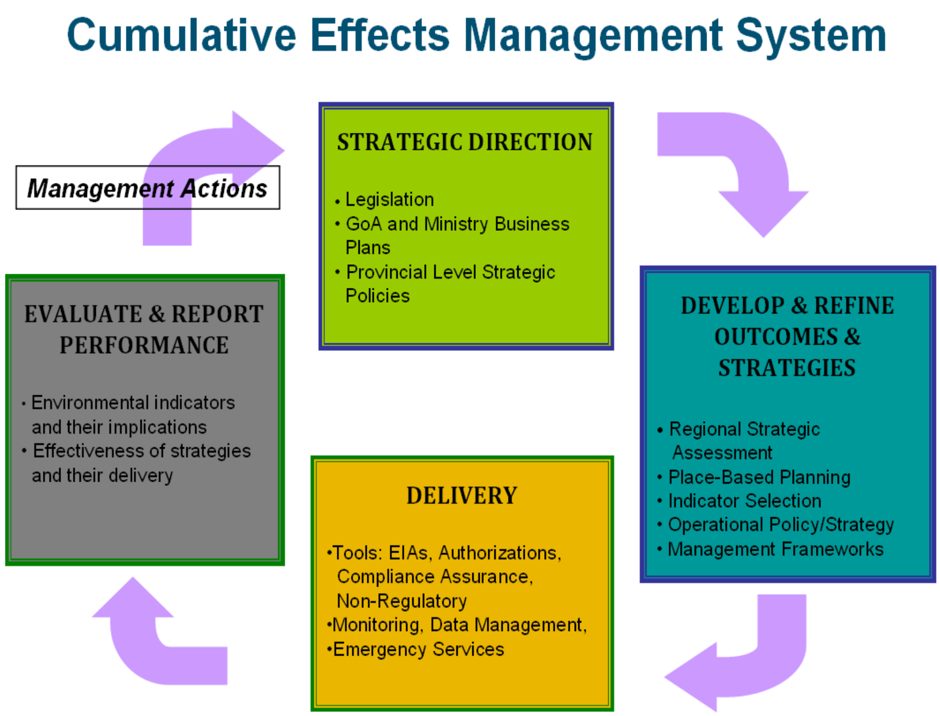
Cumulative effects are the combined impacts that occur over time from a series of individual impacts from previous, current, and reasonably foreseeable future actions.

The alternative practice to cumulative effects is to look at activities on a project-by-project basis. This has been the standard approach to assessing impacts for some time as it has allowed the approval processes to understand individual impacts. As our understanding has increased as well as growth in economic and development sectors it has been identified that the project-by-project approach does not describe the scenario adequately and to achieve a more well-rounded and informed decision we must examine the cumulative effects of an action.

The CEMS model is a structured 'Adaptive Management' approach. The fundamental components of CEMS are shown below in Figure 2.

> ***'Adaptive Management'*** *is defined as a systematic, rigorous approach for deliberately learning from management actions with the intent to improve subsequent management policy or practice.*

Figure 2 – Cumulative Effects Management System

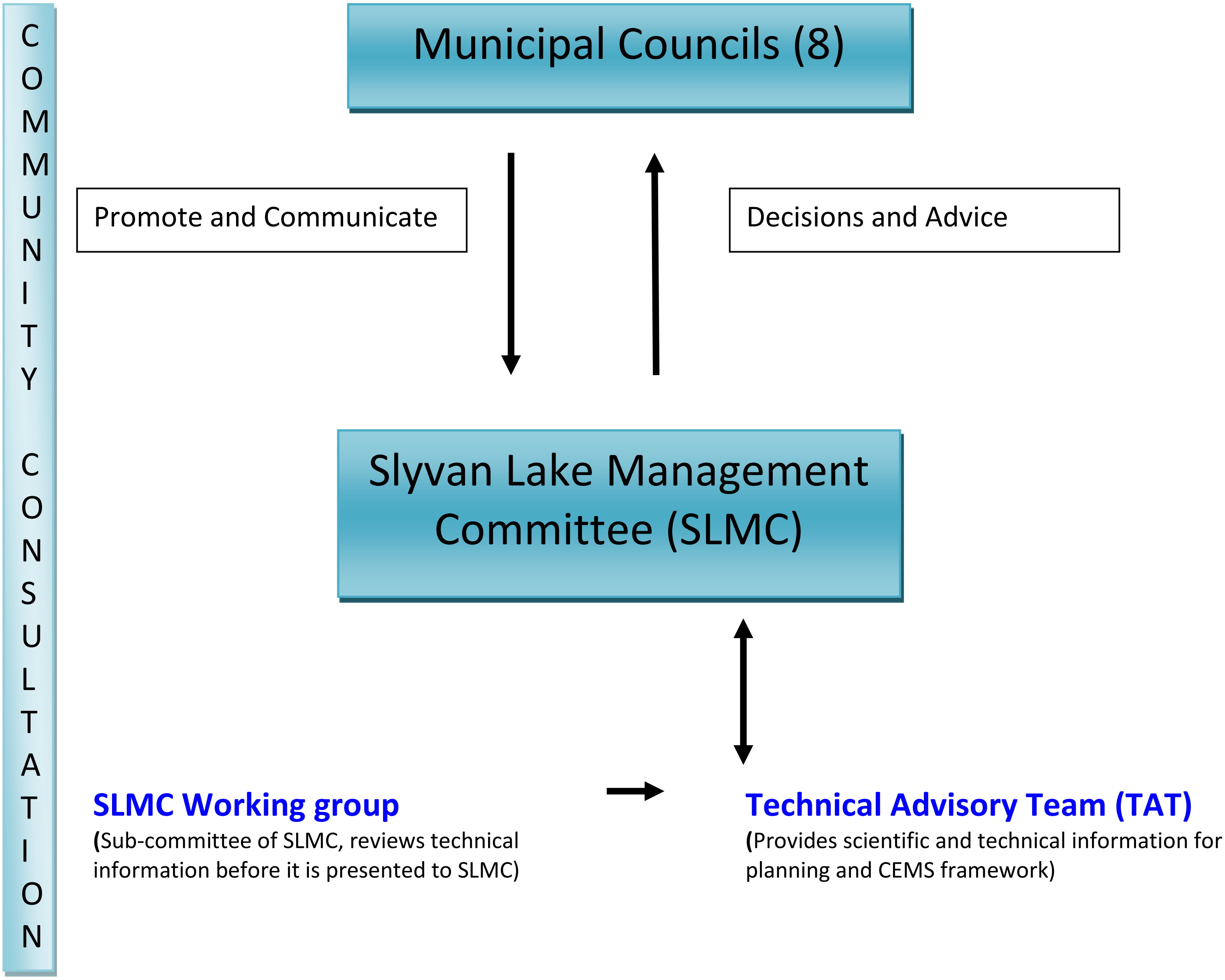


The concept of assessing cumulative effects is not new and has been practiced in varying forms in an ad hoc basis. The reason we are now seeing more about cumulative effects management is that we are focusing on areas where we have a human footprint, most acutely in areas of high population density since in these areas we see the most pressures on increasingly stressed resources such as water supply and air quality.

Leading the way, the Alberta government is committed to managing cumulative effects at the regional level, through the Land-use Framework (LUF), and the development of Regional Plans. The *Alberta Land Stewardship Act* (*ALSA)* gives authority to the LUF and establishes the basis for development of regional plans, based on major river watershed boundaries.

In the context of the Sylvan Lake watershed which is part of the Red Deer River watershed it will become governed by the Red Deer Regional plan. The Red Deer Regional plan will be one of seven regional plans developed in the province.

In order to update our environmental management systems currently administered in the province to provide greater assurance of environmental, social, and economic security and well-being over the long term the (*ALSA*) was enacted.


COMMUNITY CONSULTATION
Municipal Councils (8)
Promote and Communicate
Decisions and Advice
Slyvan Lake Management Committee (SLMC)
SLMC Working group
(Sub-committee of SLMC, reviews technical information before it is presented to SLMC)
Technical Advisory Team (TAT)
(Provides scientific and technical information for planning and CEMS framework)

A cumulative effects management approach establishes outcomes for an area, balancing environmental, economic and social considerations, and then implements appropriate plans and tools to ensure those outcomes are met.

Cumulative effects management is:

- **Outcomes-based:** clearly defining, desired end-states.
- **Place-based:** meeting the differing needs of regions within the province.
- **Performance management based:** using adaptive approaches to ensure results are measured and achieved.
- **Collaborative:** building on a culture of shared stewardship, using a shared knowledge base.
- **Comprehensively implemented:** using both regulatory and non-regulatory approaches.

2. Vision, Mission, Outcomes and Goals

The vision, mission, outcomes and associated indicators were developed collaboratively with the members of the SLMC and community consultation. For more information on the results from workshops please refer to the CEMS data collection report.

2.1 Vision

Sylvan Lake and its watershed are a healthy, treasured resource where a responsible, collaborative planning approach achieves a balance between development, nature, and recreation.

2.2 Mission

A Cumulative Effects Management system (CEMS) will be implemented for Sylvan Lake and its watershed. CEMS addresses a series of impacts that occur from past, current and foreseeable future actions on and around Sylvan Lake. The CEMS model takes an adaptive management approach of continually assessing and improving on policies and practices through collaborative governance with federal, provincial, and municipalities. The process is supported by a voluntary collaborative governance approach involving federal, provincial, municipal governments and other stakeholder organizations.

2.3 Outcomes

The mission and vision will be realized through established outcomes and each outcome will be achieved through short, medium and long term goals. Three outcomes have been developed for the Sylvan Lake CEMS framework. These include:

- Collaborative planning
- Environmentally healthy watershed and lake
- Planned diverse recreation

2.3.1 Collaborative Planning

What does it mean?

It is a partnership of all stakeholders which is based on a culture of trust, sharing of knowledge, and understanding individual stakeholder needs to realize common watershed goals. Established goals align with the vision and mission of the cumulative effects management plan. Decisions will balance the needs of the Sylvan Lake watershed.

Short Term Objective(s)

a) Identify alignments and possible policy discrepancies or gaps among Municipal and Provincial and Federal governments

Medium Objective(s)

a) Build trust between stakeholders and SLMC
b) Adopt tangible planning and management tools

Long Term Objective(s)

a) Achieve collaboration of all stakeholders in planning recommendations and decisions that affect the Sylvan Lake Watershed area
b) Collectively investigate a carrying capacity of the watershed that will ensure the lakes current desirable water quality is maintained.
c) Endorse a plan to balance social, economic, and environmental needs.

2.3.2 Environmentally Healthy Watershed and Lake

What does it mean?

It means to first identify and define what a healthy environment in Sylvan Lake Watershed is through engagement of all stakeholders. Through collaboration, engagement, and knowledge it will be possible to set objectives, baselines, and indicators ensuring a clean water, healthy habitat, balanced development and recreation. This will be achieved by stakeholders being aware of the impacts of their decisions and personal actions on the watershed.

Short Term Objective(s)

a) Understand the current watershed ecological health and risks to its health
b) Improve management of watershed
c) Work to protect and enhance water quality in the watershed
d) Identify best management practices for reducing impacts to shorelines from fluctuating lake levels
e) Work with the stakeholders to empower stewardship of the lake and watershed

Medium Objective(s)

a) Improve community knowledge, attitude and actions towards watershed health
b) Improve overall watershed health

Long Term Objective(s)

a) Achieve positive cultural/social and environmental change
b) Enhanced political support for incentive based policies and enforcement of current regulations.
c) Create an effective monitoring and evaluation systems

2.3.3 Diverse Planned Recreation

What does it mean?

To allow continued and growing recreational uses on Sylvan Lake and on land within the watershed that enhances people's experiences. These uses must be based on the principles of mutual respect for the lake, wildlife, and users, as well as continued enjoyment, and diversified leisure opportunities that meet the needs of all users.

Short Term Objective(s)

a) Understand the need for additional responsible public access to the lake
b) Understand recreational capacity of the watershed and identify thresholds above which consequences are undesirable.
c) Assign responsibility for enforcing regulations

Medium Objective(s)

a) Determine the applicability and need for recreational zoning
b) Define acceptable recreational uses within the watershed that provide a balance between economic growth, watershed health and user needs

Long Term Objective(s)

a) Protect the lake and watershed through creating responsible public access
b) Identify and enable safe use of the watershed whilst participating in recreational opportunities
c) Supply collaborative enforcement through inter agency communications and cooperation
d) Diversify recreational uses on the lake, on the land, and in all seasons.

2.4 Performance Management

In order to manage the performance of the CEMS framework it requires a clear, deliberate system to evaluate progress. This evaluation mechanism is based on delineating a vision, mission and clear outcome statements.

A sound performance management includes several key elements:

- Indicator Selection – with limits and triggers for each indicator
- Management Strategies – including approaches and actions to achieve outcomes (these are also based on the indicators and the limits and triggers established)
- Monitoring – from baseline – where we currently are and where are we going
- Evaluation – assessing monitoring information, actions and strategies to gauge progress and adapt to on-going needs
- Reporting – communicating the results

This framework contains information one major element of performance management, indicator selection. The management strategies, monitoring, evaluation and reporting will be included in the Phase two documentation.

2.5 Indicators

Indicators need to be chosen that will help to gauge and measure both a current assessment of the situation and be a useful tool to analyze how the situation is changing over time. They need to exemplify if there are trends in occurrences in a clear and efficient manner. There are two major types of indicators, these include:

- **Condition indicators** - these are indicators that have quantified metrics that could be compared with provincial guidelines or scientific threshold values
- **Risk indicators**- identify potential threats to the health of the watershed as determined by the Technical Advisory Committee (TAT) Examples - Urban, Rural, Agricultural and Recreational Development, Manure Production

For each indicator there are limits and triggers. These are measuring tools and are defined as:

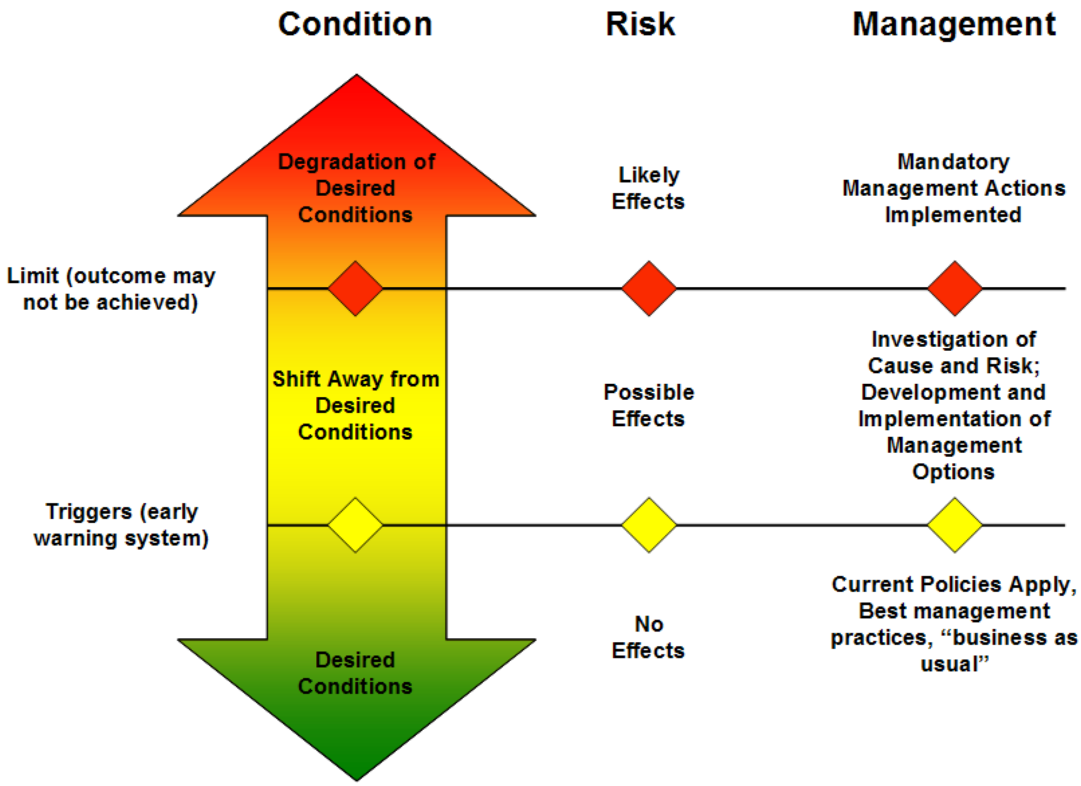
- **Triggers** – set lower than limits or in advance of limits as a warning signal that proactive management is required.
- **Limit** – represents the level at which the risk of adverse effect becomes unacceptable.

Indicators are established for each of the outcomes. A detailed description of each indicator and the outcomes can be found in section 4.

2.6 Management Zones

For each of the three outcomes there are specified management zones. These zones as shown below in figure 3 are found within the three colour bands. The green zone is the zone of desired outcomes, it is the preferred option. The yellow zone is where we first begin to see issues in the condition of the watershed and lake specific to each outcome. The transition between the green and yellow zone is where the **triggers** begin to show, this is the 'early warning system' that the condition is moving from desirable to undesirable. The red zone is where we have a degradation of desired conditions, the worst case scenario. The transition between the yellow and red zone delineates where the **limit** exists. Beyond this limit the desired outcome, for example a healthy lake and watershed will not be met.

Figure 3 – Management Zones



2.7 Monitoring and Evaluation

In order to show progress or effectiveness of action we need to know where we are starting from, which is called the "baseline". An established baseline is needed for each indicator, and then an on-going **monitoring** schedule for each indicator is required to tell us how we are doing. The monitoring will tell us where we are at that point in time, and help us to see important trends in the indicators being monitored. Trends in monitoring data that show a shift toward a less desired state will need to be assessed. **Evaluation** of the monitoring information, in conjunction with the management activities and actions being applied at the time the data was collected is required to assess the overall management strategy and adjust where necessary. When a regional trigger or limit is exceeded, a management response is required which will include:

- verifying the data;
- investigating the causes;
- determining what management action is necessary and ensuring it occurs; and
- communicating this information.

The nature of the management actions undertaken will depend on the circumstances and the kinds of approaches that will best support achievement of the outcomes and objectives. The management strategies are not discussed in this document but will be included in Phase 2.

3. CEMS Framework – Outcome Specific Indicators

As discussed in section 2 each outcome has a set of indicators associated with it. These are specifically designed to help monitor and evaluate the condition of the watershed and lake at present and to help track condition into the future. Describe below are the three outcomes including detailed indicators and management zones for each outcome.

The indicator selection was done after extensive consultation with TAT, SLMC, the community and additional members of municipalities. For more information on the results from workshops please refer to the CEMS data collection report.

3.1 Collaborative Planning

The collaborative planning outcome is divided into two separate sections to help delineate the different roles between SLMC and individual municipalities. The reason for this was to exemplify that autonomy over decision making remains with individual municipalities.

The collaborative planning outcome will be monitored through the indicators shown in the section below, as depicted in the applicable "management zones."

a) Planning

Figure 4 – Green Zone Planning

- Referrals of development applications, ASP, MDP, IDP are brought to SLMC and referred to all 8 municipalities
- Best management practices are in place and being applied
- All 8 municipalities use the SLMP to guide decisions (municipal plans incorporate key SLMP concepts into bylaws)
- Review of the SLMP happens every 5 years
- 30 m setback from lake is adhered to by all municipalities for new development
- Sensitive ecological areas are avoided in all municipal planning
- Septic fields are no longer in existence within 100 m of the shoreline
- Regional sewer line is in progress through the Commission
- Riparian areas along shoreline are protected and in good condition
- Some MR and ER are being maintained as open space
- Water levels and water quality issues are dealt with collaboratively by all 8 municipalities
- Aesthetics of development (viewscapes) are incorporated into planning decisions
- Planning is proactive
- Plans are monitored and enforced; trend analysis is compiled

Figure 5 – Yellow Zone Planning

- Referrals of development applications, ASP, MDP, IDP not brought to SLMC and only referred to adjacent municipalities – trust lacking – little collaboration
- Review of the SLMP longer than 5 years
- Best Management Practices are rarely being applied
- Only 6 municipalities use the SLMP to guide decisions (municipal plans tend not incorporate key SLMP concepts into bylaws)
- 30 m setback from lake is not adhered to by all municipalities for new development
- Sensitive ecological areas are ignored in planning
- Septic fields still in existence within 100 m of the shoreline
- Regional sewer line has been delayed
- Riparian areas along shoreline are only minimally protected and in poor condition
- Some MR and ER are being developed instead of being maintained as open space
- Water levels and water quality issues are dealt with only by some of the 8 municipalities
- Aesthetics of development are not considered (viewscapes)
- Planning is primarily reactive not proactive
- Limited monitoring of plans / minimal enforcement / no trend analysis

Figure 6 – Red Zone Planning

- Development applications, ASP, MDP, IDP are not brought to SLMC, not referred to all 8 municipalities
  (lack of trust , no collaboration)
- Best Management Practices are not being applied
- SLMP is not being used to guide decisions by the 8 municipalities (municipal plans do not incorporate key SLMP concepts into bylaws)
- No review of the SLMP
- 30 m setback from lake is not adhered to by all municipalities for new development
- Sensitive ecological areas are ignored in planning
- Septic fields still in existence within 100 m of the shoreline
- Regional sewer line is not being considered
- Riparian areas along shoreline are not protected and badly disturbed
- MR, ER developed instead of being maintained as open space
- Water levels and quality issues dealt with separately by municipalities
- Aesthetics of development are not considered (viewscapes)
- Planning is totally reactive not proactive
- No monitoring of plans / no enforcement / no trend analysis

b) SLMC

Figure 7 – Green Zone SLMC

- Meets 4 x / year or more
- Membership is 100% of municipalities

- Full technical support from municipal staff (i.e. all 8 municipalities are represented on TAT)
- Full communication and RFDs from SLMC to Councils on progress of the SLMC and other related initiatives regularly occur
- Communication Strategy has been developed and communication to the general public happens at least 4 times per year (after each SLMC meeting as a minimum)
- An education program/strategy is in place for the general public

Figure 8 – Yellow Zone SLMC

- Meets only 2 – 3 x / year
- Membership is < 100% and > 80% of municipalities
- Limited technical support from municipal staff (i.e. only ½ of municipalities are represented on TAT)
- Limited communication or RFDs from SLMC to Councils on progress of the SLMC and other related initiatives
- Limited communication to the general public (only once per year)
- Limited education program/strategy for the general public

Figure 9 – Red Zone SLMC

- Meets less than 2x / year
- Membership is < 80% of municipalities (SLMC lacks support by the 8 municipalities)
- No technical support from municipal staff (i.e. no TAT)
- No communication or RFD's from SLMC to Councils on progress of the SLMC and other related initiatives
- No communication to the general public
- No education program/strategy for the general public

3.2 Environmentally Healthy Watershed and Lake

There are three sub-sections to this outcome. They are detailed in the sections below and include:

- Water quality
- Water balance
- Bio-indicators

3.2.1 Water Quality

At the time of writing this document the work on water quality focused on the quality of lake water. This was done intentionally due to staff resources. However this does not presume or intend to prioritize the lake water quality over the quality of the groundwater and other surface water quality in the watershed. In the future both groundwater and other surface water quality will be incorporated in current and future work.

When selecting the water quality indicators there were two main assumptions that were made, these include:

- The public expects that nuisance cyanobacterial (blue-green algal) blooms in Sylvan Lake will be prevented, aesthetic values will be preserved, and biodiversity protected.
- Water quality in both the lake and watershed will be maintained or improved compared to the Sylvan Lake records in the Alberta Lake Water Quality database[1].

3.2.1.1 Water Quality Indicators

The concentrations of nitrogen (N) and phosphorus (P) plant nutrients in the lake must remain below the levels that are known to promote the growth of algae blooms. Given that the primary concern would be the shift from a meso-eutrophic lake to a eutrophic state, and the two primary contributing factors to algal blooms are we are using TP (Total Phosphorous) and TN (Total Nitrogen) as the “Indicators” around which management frameworks activities will be undertaken.

Lake experts recommend that the measured concentration of Total Nitrogen (TN) should be less than 1.0 milligram per litre (mg/L) and that of Total Phosphorus (TP) should be less than 0.035 milligrams per litre as a general rule. (Please see the appendix C for further information on indicators and water quality).

Monitoring of TP and TN will be undertaken as part of the management framework. Other parameters routinely monitored (Appendix) will be under review, but are not being used for “control” purposes at this point.

a) Nutrient Concentrations and Risk to Sylvan Lake

The purpose of the two graphs below is to illustrate the state of Sylvan Lake water quality by highlighting the important TN and TP nutrient variables. Each graph includes red, yellow and green panels that define the concentration ranges for high, medium and low risk of chronic cyanobacterial (blue-green algae) growth. Although TP is typically much lower than TN, algae growth in lakes is particularly sensitive to changes in the phosphorus level as this is typically the limiting nutrient for algal growth in lakes.

The graphs show how both TN and TP concentrations have remained relatively constant over two decades of sampling. The recommended limits for TN and TP are shown as red lines on the charts. The green lines are set at the statistically calculated concentration below which 90 percent of the variable TN and TP data points fall.

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1 http://envext02.env.gov.ab.ca/crystal/aenv/viewreport.csp?RName=Detailed%20Lake%20Water%20Quality%20Data

As shown in figure 10 below the typical TN concentrations generally fall in the Green zone, well below the recommended maximum of 1.0 mg/L. In figure 11 the typical TP concentrations are in the Yellow zone and close to the recommended maximum of 0.035 mg/L.

b) Baseline Data Collection

It is important to note that there are many sources of TP and TN, the current indicators the Sylvan Lake Cumulative Effects Management Plan has identified. These sources include atmospheric sources (not readily controllable), point source and non-point sources.
In order to understand the current situation, available monitoring data for the lake and streams within the watershed will be compiled and analyzed to establish where actions are best directed. Currently the situation shows levels in the lake itself are within management zone 1 (green), but are quickly approaching zone 2 (yellow) or zone 3 (red) for phosphorous.

To date, sampling has been conducted on various creeks within the watershed.

Figure 10 – Historical Total Nitrogen Concentration for Sylvan Lake

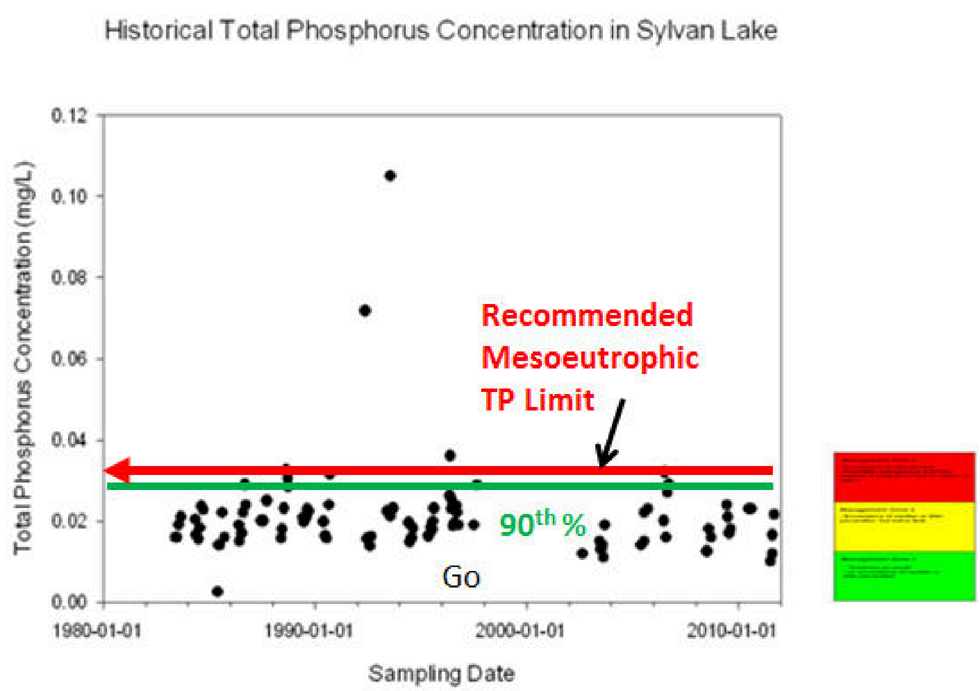
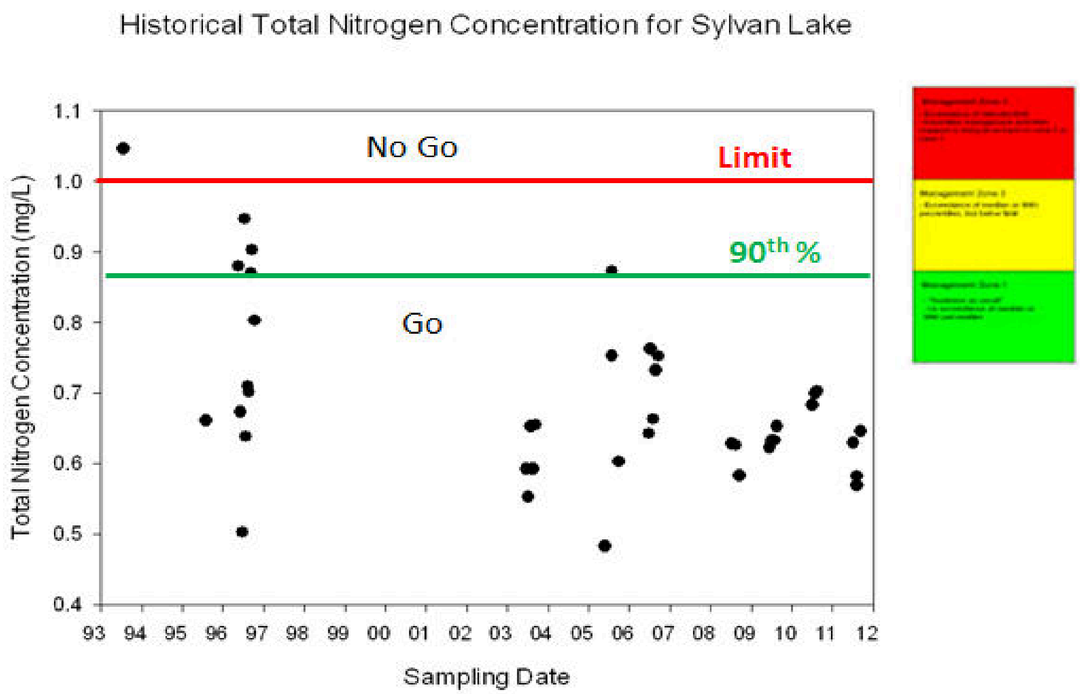


Figure 11 – Historical Total Phosphorous Concentration in Sylvan Lake Water balance



3.2.2 Water Balance

The balance among inputs and outputs of water in and out of the Sylvan Lake watershed determines the net volume of water that remains in the lake itself. If that net volume of water increases then the lake level rises. If that net volume of water decreases then the lake level drops. According to law, the Crown (Province of Alberta) owns the water in Sylvan Lake. The total water inventory is one component of the natural capital of the watershed and will be regarded as an asset of value that is essential to maintain a water supply for use by human, agriculture, forest, and terrestrial and aquatic resources that depend on it.

A water inventory that was compiled by AESRD indicates the lake volume to be approximately 420 million cubic meters[2] . This accounts for the surface wetland areas and subsurface groundwater volumes that contribute to the watershed.

The level of Sylvan Lake fluctuates mainly due to variations in climate and seasonal weather conditions that affect the quantity of water transported by dominant natural precipitation and evaporation-transpiration processes. Records of the level of Sylvan Lake have been kept for most of the last century. Surveys and anecdotal evidence show that the lake level has varied significantly from year to year with changing seasonal weather conditions. Change over longer cycles likely occurs because of the effect of climate oscillations that depend on surface temperature and currents in the Pacific Ocean. During the last two decades the lake level has

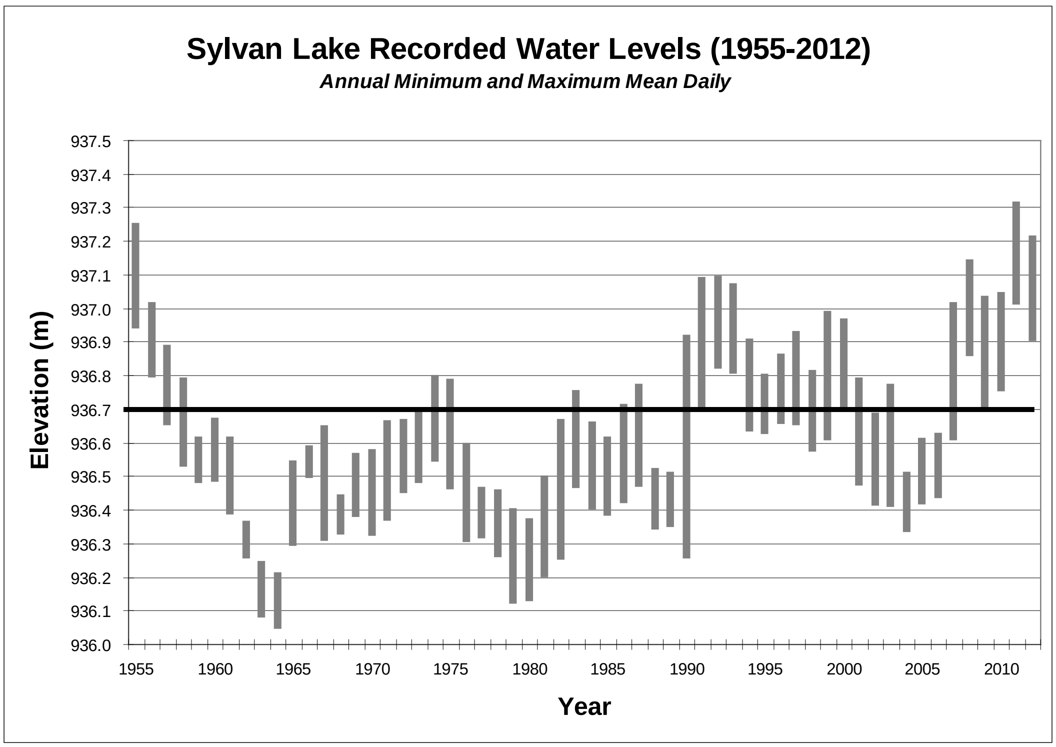
[2] Sylvan Lake Water Quality Assessment and Watershed Management Considerations (AXYS 2005)

been monitored by the federal and provincial governments. Those records are accessible online.[3]

Figure 12 below shows the annual maximum and minimum during the open water period over the last 57 years. It exemplifies that the lake level can change significantly within each open-water season.   Figure 13 presents data for 2011 to show the typical precipitation-dependent increase[4] between ice melt and peak level in mid-summer, around July 1, followed by an evaporation-dependent decrease[5] until freeze-up.

Input of precipitation onto the total Sylvan Lake watershed area of 104 square kilometers (km^2) is roughly balanced by losses from evaporation off the 42 km^2 area of the lake, and combined evaporation-transpiration off the surrounding land area of 64 km^2. The major flows are determined by natural processes and cannot be controlled by human intervention.

Figure 12 – Sylvan Lake Recorded Water Levels (1955-2012)

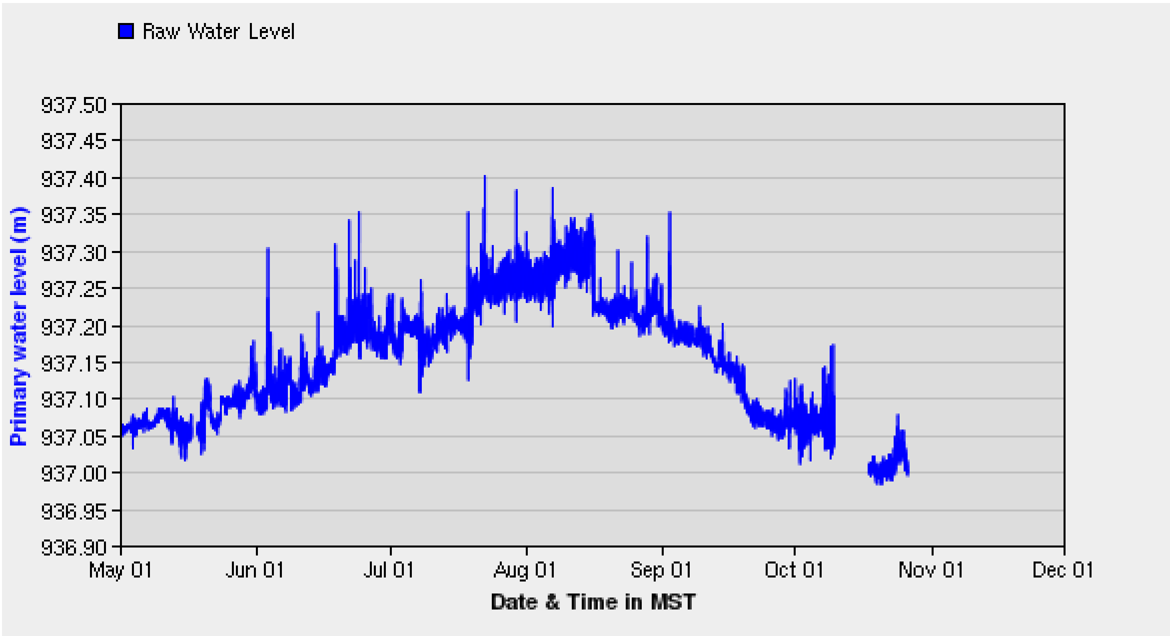


[3] Online Sylvan Lake level monitoring. http://www.environment.alberta.ca/apps/basins/DisplayData.aspx?Type=Figure&BasinID=7&DataType=3&StationID=RSYLLK

[4] http://sylvanlakewatershed.wordpress.com/2012/07/18/precipitation-record-for-the-sylvan-lake-region-over-70-years/

[5] http://sylvanlakewatershed.wordpress.com/2012/07/18/sylvan-lake-evaporation-rate/

Figure 13 – Water level 2011



If weather and climate conditions change in ways that alter the dominant natural variables of precipitation and evaporation then the level of Sylvan Lake could increase above the historic maximum, or drop below the historic minimum. No systematic trends are evident in 70 years of data so either outcome is unlikely.

The major flows are determined by natural processes and cannot be controlled by human intervention. Minor flows affected by processes that occur within municipalities are ranked in Table 2. Units are millions of cubic meters of water. The information presented in the table ranks the input and output water flows that affect the water balance and highlights those that might be controlled with engineered infrastructure. The main components of the water balance (AXYS 2005 estimates) in units of million cubic meters are ranked in magnitude. Data shown in bold font include Outlet Creek flow and population-dependent "Other Losses" that are potentially controllable with engineered infrastructure.

Table 2 - Minor flows that may be affected by human intervention

Precipitation	20.4
Evaporation	-31.2
Surface Runoff	10.8
Groundwater Inflow	4.6
Outlet Creek Flow	-2.9
Water Well Pumping (2005)	-1.5
Water Exported in Sewage	-1.5
TSL Stormwater Export	-1.0

A high population growth rate has the potential to increase all water balance flows that are sensitive to the scale of urban infrastructure for management of stormwater, domestic water supply and sewage processing.

3.2.2.1 Water Balance Objectives and Indicators

Water balance objectives and indicators have not been set for the Sylvan Lake watershed at this time. The level of Sylvan Lake continues to provide a direct practical indicator of the cumulative effects of the interaction of both natural and population-dependent variables. Data on the potentially-controllable variables shown in Table 2 are already or could be available for supplementary monitoring. No water balance triggers have yet been selected for monitoring and reporting for the purpose of water inventory control.

SLMC and ESRD are continuing to work on water balance models and engage stakeholders in appropriate monitoring and management of water within the Sylvan Lake watershed. Further information regarding on-going work will be provided as the CEMS framework evolves.

3.2.3 Bio-Indicators

Establishing Boundaries and Uses

The area to be considered within the Sylvan Lake Cumulative Effects management plan is the geographical area of the Sylvan Lake Watershed. The reason for choosing the watershed boundaries was to easily delineate a geographical area that is small enough in size to be manageable but large enough to be influential on the landscape that appears here.

Indicator Selection

A wide range of bio-indicators are available for analysis and potential selection as an indicator. The indicators that have been chosen will require prioritization before the implementation of the plan. Emergent problems and/or quick win efforts may also be undertaken in addition to the indicators proposed in this section. An example of an emergent indicator would be Zebra and Quagga mussels. Prioritization may depend on the social, economic and ecological factors each influences. The selection of indicators was based on:

1. Consultation with key stakeholders groups including Alberta Environment and Sustainable Resource Development and Department of Fisheries and Oceans.
2. A clear and equitable representation of biological factors in the watershed
3. Does a data set already exist for a particular indicator? If a database is in existence and monitoring is already established this enables the group to continue monitoring on a cost effective basis.
4. Is it economically viable to collect data on the biological indicator in the future?
5. Is there interest in the community regarding the biological indicator?
6. Biological indicators that are of identified importance at present.
7. Will realistic change occur that will affect the bio-indicators chosen?

8. Are there municipal, provincial or federal mechanisms in place that will allow the committee to influence change over land use practices in the watershed to ensure a change to the status of the bio-indicators?

As a result of numerous meeting s and discussions ten bio-indicators were chosen. These indicators cover off the flora and fauna aspects of the watershed specific to vegetation, fisheries, avian and ungulates. The indicators are below; each is explained in detail in individual sections.

- Spawning habitat for Pike
- Emergent vegetation
- Wetland health
- Forested areas
- Riparian health
- Eagle population
- Colonial water bird population structure

3.2.3.1 Spawning Habitat for Pike

This indicator recognizes the importance and for key life stages for Northern Pike. Spawning habitat consists of areas with vegetation in areas of calm, shallow water, flooded marshes, tributaries, weedy bays, and area with flooded terrestrial vegetation, provided that high water levels are maintained throughout the embryo and fry stages. If spawning occurs within tributaries adequate flows must be present and maintained for adult fish to travel in and out, for hatching, rearing, and for travel of juvenile fish back into the main lake. Otherwise, this is considered loss spawning production. The availability and quality of suitable habitat is the factor which most often limits abundance. Substantial increases to northern pike populations can be achieved by enhancing the quality and quantity of spawning habitat. The presence along with connectivity or absence of spawning habitat locations is an indicator of lake health and production capability for fish populations found in Sylvan Lake.

- All areas of emergent vegetation that are mapped and established as of the earliest air imagery on record (~1949) and all mapped areas with dense sub-emergent vegetation.
- All inlet and outlet tributary creeks allow for fish passage to remain unrestricted.

- 15% loss of emergent vegetation and sub-emergent area whether the loss is human induced or natural
- Fish passage and movement is restricted within tributaries

- Any loss greater than 20% which is human induced
- Any loss greater than 30% which is naturally induced
- Fish passage is completed restricted to tributaries

Key Considerations for this Indicator

There have been no studies documenting or quantifying northern pike spawning locations both within lake and tributaries. Recent and historical knowledge and belief has shown northern pike have used inlet and outlet tributaries as primary spawning locations. It is believed the loss and degradation of these areas has resulted in reduced abundance of pike in Sylvan Lake. One major issue has been the development in and around the inlet tributary and intermittent connectivity of the outlet creek (Sylvan Creek) in drier years.

3.2.3.2 Emergent Vegetation

This indicator recognizes and establishes the importance of vegetation for colonial water birds and for fish spawning habitat. The presence or absence of emergent vegetation is an indicator of the health of the lake and its ability to provide habitat for the fauna that is found there.

- All areas of emergent vegetation that are mapped and established as of 2012 remain intact or improve

- 15% loss of emergent vegetation whether the loss is human induced or natural

- Any loss greater than 20% which is human induced
- Any loss greater than 30% which is naturally induced

3.2.3.3 Wetland Health

This indicator will provide information on health of the watershed as a whole regarding the habitat condition. Wetlands are also important as filtration devices for water quality which will lead into the water bodies within the watershed.

Triggers and limits to be determined based on Sylvan Lake specific data. The indicators for rate of loss and the importance of wetlands are difficult to determine without a baseline.

3.2.3.4 Forested Areas

Forested lands create more aesthetically pleasing views, they provide buffers for weeds and pollutants to the lake and provide habitat. When they are strategically placed near the water's edge they may also provide the additional bonus of decreasing disturbance to emergent vegetation and providing habitat corridors to aid in the movement of fauna.

Triggers and limits are to be determined for the watershed, this information is difficult to assess without quantifying the habitat and the needs of the watershed. It is recommended that a full landscape assessment is completed on Sylvan Lake watershed to determine habitat requirements based on current and realistic conditions.

3.2.3.5 Riparian Health

Healthy riparian vegetation helps to filter, trap and absorb nutrients, sediments, and pollutants before the water reaches the lake, improving water quality. The roots of the plants help to stabilize the bank and protect it from erosion caused by boats or waves. Riparian areas help to ensure the water balance of the lake by acting as sponges to help absorb excess water and replenishing groundwater supplies.

They are important habitat features for wildlife and provide aesthetically pleasing vistas for home owners and visitors.

- Maintain or improve the 51% healthy shoreline as of 2007
- Any increase of moderately impaired shoreline from 7% to 12% of 2007 levels
- Any increase in highly impaired shoreline from 42% as of 2007 data

3.2.3.6 Eagle population

The presence of the Eagle helps to indicate healthy fish and waterfowl populations. It is also a useful indicator for aesthetic reasons and community engagement.

- Presence of Bald Eagle in watershed and the eagle is successfully reproducing
- Presence of Bald Eagle in watershed and but the eagle is not successfully reproducing
- The Bald Eagle no longer presides in the watershed

3.2.3.7 Colonial water bird population structure

These are important indicators of health as they are the fauna that naturally preside in the area. Their presence/absence and population structure are key to healthy populations. There is no current data regarding baseline of health or population numbers for colonial water birds including Black Tern, Foresters Tern, Eared Grebe, Horned Grebe, Western Grebe, Red-neck Grebe, and Marsh Wren. One major issue for Western Grebe nests is wave action from boats since their nests are floating masses of vegetation. The Western Grebe is quickly disappearing from Alberta and may result in the bird becoming listed as Threatened soon.

- Maintain the established population based upon a determined baseline.
- No breeding colonies are left
- Nests are being abandoned
- Population is declining
- Colonial water birds are absent or in very low numbers on Sylvan Lake.

3.3 Diverse Recreation

Due to the fact that diverse recreation is subjective in nature and value-based it will require on -going public consultation to help determine the indicators more concisely. There are five sub-categories in the diverse recreation outcome. Each of the sub-categories are discussed in greater detail below with each weighted equally.

- Sport fishery

- Lake use
- Open/public space
- Access
- Natural spaces

3.3.1 *Sport Fishery Indicators*

3.3.1.1 Walleye Population Structure

This indicator recognizes the importance and relevance of one of Alberta's most sought-after sport fish species. As a top predator walleye are a keystone species in the ecology of Alberta's lakes having effects on the animal community structures with the lake, and trickle down effects on plankton, algae, and water quality. The loss or maintaining a walleye population can have considerable consequences relating directly to aquatic ecosystems, social affects with all lake user groups, and even local economics. Walleye populations are monitored by Fisheries Management Branch using the Fall Walleye Index Netting (FWIN) protocol.

- Maintain or exceed an overall Walleye catch per unit effort (CUE) of 30 to 40 walleye/net that consists of a wide and stable age class distribution. High angler catch rates averaging >1.5 walleye/hr.

- An overall Walleye catch per unit effort (CUE) of 10 to 30 walleye/net that consists of a narrow and unstable age class distribution.
- Signs of recruitment failure, truncation of size distribution, and/or weak year classes present. Moderate angler catch rates averaging <1 walleye/hr.

- An overall Walleye catch per unit effort (CUE) of <10 walleye/net.
- Obvious signs of recruitment failure, consecutive missing year classes, truncation of size distribution. Low angler catch rates<0.1 walleye/hr.

3.3.2 Lake Use

- Safety of users is controlled with few if any accidents occurring on the lake and shoreline
- Boat density > to be determined
- <5 complaints are received regarding conflict between lake users
- User experience is positive
- Enforcement of lake use is done on a regular basis and bylaws are being in place to protect/deal with riparian areas, wake disturbance, noise pollution
- Little if any, damage to public property by recreational users
- Thresholds in place for all user types
- Zones are in place to minimize user conflict
- Mandatory registration is in place; or alternatively voluntary registration of ice fishing huts is > 75% and no huts left on the lake at the end of the season
- Fishing success is high
- Non-motorized boats (canoes, sailboats, etc.) are sharing the lake with motorized boats in a compatible way

- Safety of users is somewhat controlled however accidents are occurring on the lake and shoreline
- Boat density > to be determined
- 5-10 (?) complaints are received regarding conflict between lake users
- User experience is neutral
- Enforcement of lake use is done periodically and bylaws are being introduced (protection of riparian areas, wake disturbance, noise pollution)
- Minimal damage to public property by recreational users
- Thresholds in place for some types of users
- Limited zones in place to minimize user conflict
- Limited (<50%) voluntary registration of ice fishing huts and greater than 1 hut left on the lake at the end of the season
- Fishing success is decreasing
- Decline of non-motorized boats (canoes, sailboats, etc) due to excessive wakes and use by motorized boats

- Safety of users is uncontrolled and accidents are occurring on the lake and shoreline
- Boat density > To Be Determined
- \> 10 complaints are received regarding conflict between lake users
- Poor user experience
- No enforcement of lake use and established bylaws (protection of riparian areas, wake disturbance, noise pollution)
- Recreation damaging public property
- No thresholds in place for different types of users
- No zones in place to minimize user conflict
- No voluntary registration of ice fishing huts and greater than 2 huts left on the lake at the end of the season
- Fishing is no longer viable
- Almost no non-motorized boats (canoes, sailboats, etc.) in use due to excessive wakes and noise by motorized boats

3.3.3 Open/Public Space

- Beaches are available at several sites along the south end of lake (Town of Sylvan Lake, Petro Beach)
- 1 – 2 towel spaces (36 sq. ft.) per $9.3m^2$ (100 sq. ft.) within Sylvan Lake Provincial Day Use
- Formal walking trails have been established between areas of open space

- Limited (sandy) beach or constructed beach at south end of lake (Town of Sylvan Lake, Petro Beach)
- Greater than 2 towel spaces (36 sq. ft.) per $9.3m^2$ (100 sq. ft.) within Sylvan Lake Provincial Day Use
- Limited formal walking trails established between areas of open space

- No (sandy) beach or constructed beach at south end of lake (Town of Sylvan Lake, Petro Beach)

- Greater than 3 towel spaces (54 sq. ft.) per 9.3m^2 (100 sq. ft.) within Sylvan Lake Provincial Day Use
- No formal walking trails established between areas of open space
- Sylvan Lake Provincial Day Use no longer in existence
- Jarvis Bay Provincial Park no longer in existence

3.3.4 Access

- More than 3 formal boat access points with parking
- Formal access points have been developed alleviating frustration and safety issues
- Use of MR/ER to foot access to the lake
- Established areas for dog access to the lake

- Fewer than 3 formal boat access points with parking
- Congested access points causing frustration and safety issues
- Restricted use of MR/ER to foot access to the lake
- Few areas for dog access to the lake

- Fewer than 2 formal boat access points with parking
- Congested access points causing frustration and safety issues
- MR/ER are not allowed for foot access to the lake
- No area for dog access to the lake

3.3.5 Natural Space

- Natural areas minimally impacted
- Minimal loss of vegetation
- Planning has maintained biodiversity
- < 30% of riparian areas rated as poor

- Natural areas severely impacted
- Excessive loss of vegetation
- Development has impacted biodiversity
- >30% of riparian areas rated as poor

- Loss of natural areas
- Excessive loss of vegetation
- Development has severely impacted biodiversity
- 50% of riparian areas rated as poor

Appendix A

Definitions

Action – the work that needs to be done to correct or monitor a situation

Adaptive Management - A systematic, rigorous approach for deliberately learning from management actions with the intent to improve subsequent management policy or practice.

BMP– Best management practices - Methods or techniques found to be the most effective and practical to achieving an objective (such as preventing or minimizing pollution) while making the optimum use of resources.

Cumulative Effects - are changes to the environment that are caused by an action in combination with other past, present and future human actions.

Indicator – something that helps us to understand where we are, where we are going and how far we are from the goal. It must be a clue, a symptom, a pointer to something that is changing. Parts of information that summarize the characteristics of systems or highlight what is happening in a system. http://hostings.diplomacy.edu/baldi/malta2001/statint/Statistics_Int_Affairs-27.htm

Condition indicators - have quantified metrics that could be compared with provincial guidelines or scientific threshold values. Examples TN. TP. Wetland Loss, Bacteria

Risk indicators- identify potential threats to the health of the watershed as determined by the Technical Advisory Committee (TAC) for the SOW. Examples - Urban, Rural, Agricultural and Recreational Development, Manure Production

Objective - something that one's efforts or actions are intended to attain or accomplish

Limits – meant to define the boundary beyond which we do not want to go. In surface water quality, it is a level or condition beyond which the most sensitive use may not be protected.

Ambient limit: a level or condition beyond which the most sensitive use may not be protected

Metrics – the measuring tool used for each indicator to ensure we are achieving our objectives

Shared Governance - A collaborative, goal-setting, and problem-solving process built on trust and communication where both government and stakeholders share responsibility for setting and achieving shared outcomes.

Triggers – A condition, which if exceeded, results in some action being taken (eg intensified monitoring, risk assessment, point source management).

VEC – Valued ecosystem components - are parts of the natural and human world that are considered valuable by participants in a public review process.

Water Quality Objective "WQO" - a numerical concentration or narrative statement which has been established for specified waters, at a specific site, and which has an action and/or management commitment."

References for definitions:

Guidance for Deriving Site Specific Water Quality Objectives for Rivers
http://environment.gov.ab.ca/info/library/8565.pdf

Internet and the use of data for International Affairs
http://hostings.diplomacy.edu/baldi/malta2001/statint/Statistics_Int_Affairs-27.htm

Appendix B

Sylvan Lake Management Committee Cumulative Effects Terms of Reference

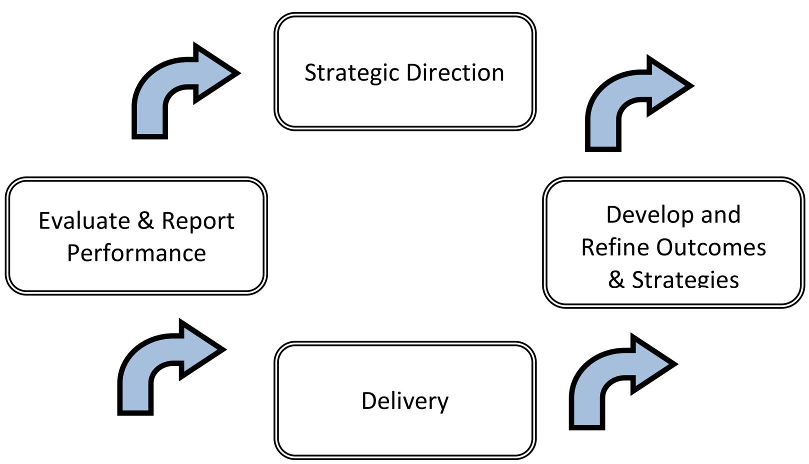
1. Introduction

Cumulative effects are the combined impacts that occur over time from a series of individual impacts from previous, current, and reasonably foreseeable future actions. The practice of looking at applications on a project-by-project basis has been, and continues to be, the generally used approach to assessing impacts. This approach has allowed approval processes to understand individual impacts. With increased economic and population growth pressures, the project-by-project approach does not describe the combined effects of the cumulative impacts.

The concept of assessing cumulative effects is not new and has been practiced in varying forms for years. However, the approaches have not been done in a structured or formal manner.

The Cumulative Effects Management System (CEMS) is being put forward as a more formal approach proposed by the Government of Alberta to address cumulative effects. The CEMS model is a structured adaptive management approach (i.e. a systematic process for continually improving management policies and practices) to address cumulative effects. The fundamental components of CEMS are shown below.

Cumulative Effects Management System



The principles of CEMS include:

Outcomes Based – there are clearly defined outcomes. Outcomes are a narrative description of the desired end state that is defined for the area;

Place Based – geographically specific areas at different scales within the province or region;

Collaborative – culture of shared stewardship using a shared knowledge base;

Adaptive – responsive to change based on performance and applying lessons learned;

Comprehensive Tools – regulatory and non-regulatory approaches are used to address cumulative effects;

Shared governance is also considered a fundamental concept where provincial, municipal and other stakeholders share responsibility for the development and delivery of policy, planning, programs, and initiatives.
It is proposed to apply this CEMS approach in the Sylvan Lake watershed area. This will enable better decision making, opportunities for stewardship identified, and a strategy to implement the initiatives to achieve the desired outcomes.

2. Relationship to Regional Plans

The Land-Use Framework is a planning approach to achieve Alberta's long-term economic, environmental, and social goals. Regional plans are legal documents and form public policy for the region. The plans are enforceable with the requirement that all provincial and municipal decisions made in alignment with the regional plan. Cumulative effects management is a critical component of the regional planning.

Sylvan Lake is within the Red Deer Region where the planning process (RDRP) has not yet commenced. No assurance can be made on what specific outcomes or objectives will be included into the RDRP. To minimize misalignment with the regional planning process and regional outcomes, it is important that the processes used for the Sylvan Lake CEMS is done in a manner consistent with the regional planning processes.

3. Key Tasks, Deliverables and Timeframe

The scope of the proposed CEMS work is to be done over two phases. The initial phase is to develop or refine the CEMS process to be specifically relevant to the Sylvan Lake watershed. As part of this, it is intended to utilize the existing studies and report recommendations that have been previously completed for the Sylvan Lake area. Please note: this does not exclude the possibility of additional research or collecting of additional information if this is critical to the planning process.
The second phase of the proposed CEMS work is to apply the CEMS process. The "work plan" for Phase II will be the Phase I deliverables. Although the scope of this document is to describe the work plan for Phase I activities, it is anticipated that the SLMPC will follow through with the implementation.
The proposed work plan has the following components:

1. ***Refine CEMS Process*** – an initial key activity is to refine the CEMS process specific to the needs of Sylvan Lake. The figure above illustrates the four fundamental components of CEMS. This task of the proposed work plan is to provide greater mapping of the processes for each of the main components. To undertake this work, it is proposed to strike a subcommittee of the SLMPC supported by Alberta Environment staff.
2. ***Identify Outcomes & Strategies*** – outcomes specific for Sylvan Lake need to be prioritized. Existing work and reports provide a good starting point to identify and prioritize the possible outcomes that the SLMPC would like to see for Sylvan Lake. The prioritized outcomes will focus the development and implementation of strategies to achieve the outcomes. Strategies have a broad range of options including specific

stewardship activities, proposed policy and bylaw change considerations, education and awareness, etc.

3. ***Select Triggers and Limits*** – Triggers and limits provide an early response trigger indicating when outcomes are being threatened. Greater oversight and management is triggered when the trigger or limit have been exceeded. It is important to include these components as part of the CEMS process along with appropriate indicator parameters. It should be noted that this fundamental component of CEMS is consistent with the regional planning process.
4. ***Amend Sylvan Lake Management Plan*** – the existing SLMP is proposed to be amended to include the specific Sylvan Lake CEMS process, the strategies and initiatives that will be undertaken to achieve the outcomes, who is responsible to undertake those strategies and initiatives, performance measures, and role of SLMPC to monitor and report on the plan implementation.
5. ***Implement Strategies and Initiatives*** – this represents Phase II of the work plan to implement the strategies and initiatives identified in Phase I of the work plan. This may also include consideration for short term initiatives that can be implemented concurrently with the Phase I work although it is recognized that it is usually most desirable to implement strategies and initiatives after completion of the plan. It is a suggested role of the SLMPC to monitor the performance of Phase I plan implementation.

Key principles promoted within this work plan are as follows:

- It is encouraged that consensus is used as the basis for all decisions;
- the SLMPC subcommittee will be responsible to execute the work plan with support and advice from Government of Alberta staff;
- Alberta Environment will provide specific CEMS advice with the intention of developing the CEMS consistent with but not necessarily the same as the regional planning processes;
- The work plan will use existing studies and reports in the Phase I work;
- This document focuses on Phase I activities (i.e. developing the CEMS approach specific for Sylvan Lake) recognizing that Phase II work logically follows; and
- Monitoring and reporting of outcome indicators is considered a component of Phase I work.

The following table summarizes the work plan details. The SLMPC subcommittee, along with Alberta Environment support and guidance, is responsible for obtaining the deliverables within the proposed timeframe.

Work Plan Element	***Deliverables***	***Timeframe to Complete***
Refine CEMS Processes	- CEMS process specific to Sylvan Lake;	Late Summer Early Fall 2011
Identify Outcomes & Strategies	- Outcomes prioritized & strategies identified; - Short term and long term strategies identified;	Late Fall 2011 Short Term: Summer 2011 Long Term: Winter 2012

Set Triggers and Limits	- Indicator parameters selected; - Triggers and limits set;	Late Fall 2011 Late Fall 2011
Amend SLMP	- SLMP updated;	Late Winter 2012
Implement Strategies & Initiatives	- CEMS acted upon;	Ongoing…

Appendix C

Water Quality Technical Components

1. How Water Quality Objectives Are Developed

Water quality objectives (WQOs) have been developed for several Alberta rivers but rarely for Alberta lakes. The principle behind developing WQOs for lakes is the same for rivers, although somewhat simplified since flow conditions and, in general, seasonality effects do not need to be accounted for as predominant water quality issues occur during the open water season only (e.g. nuisance algal blooms).

Recent increased incidences of nuisance cyanobacterial (blue-green algal) blooms on Alberta lakes have heightened public awareness surrounding the issues of lake health and public safety. Development of WQOs for lakes in general helps us to establish triggers and limits to apply in the project's cumulative effects management plan.

Required physical and chemical properties of lake water are selected from the master menu of variables that are summarized in the Table 1 below. The first section of the table includes a set of analyses that characterize the nutrients and related variables like suspended algae. The second section lists several ions that are dissolved when precipitation flows as surface or groundwater and contacts minerals. Each line of data is important to answer different questions about water quality.

In the Sylvan Lake watershed the top priority is to avoid algae blooms in the lake water during the late summer when sunlight and temperature combine with nutrients to promote growth. For that reason Total Nitrogen and Total Phosphorus analyses are the most important water quality variables.

When establishing WQOs, the protected uses are given priority. That ranking helps to filter guidelines and establish limits. In general, there are six common uses for which protective guidelines exist:

- aquatic life
- drinking water
- recreational
- livestock watering
- irrigation
- industrial

It is important to note that the Cumulative Effects Management Plan will reflect all protective guidelines as past, present and future use must be considered.

2. Selection of Water Quality Indicators

Several water quality parameters are available for analysis and application as indicators. To qualify as an indicator, these questions were asked:

1. Does the parameter affect the proposed goal? In the case of Sylvan Lake, the goal is to maintain or improve water quality thus preventing nuisance algal blooms. Therefore, parameters which do not affect algal growth were eliminated.

2. Is the selected parameter easy and cost effective to measure? If an indicator is complex to measure, potentially prone to accidental contamination, or expensive to measure it reduces its suitability for use as a routine indicator.
3. Is the parameter sensitive to change? To be useful, indicators must reflect both positive and negative changes in the lake environment. If a parameter does not detect changes in cyanobacteria populations as a result of significant disturbances, its usefulness as an indicator is diminished.
4. Can we influence the selected parameter? We cannot control some natural parameters, such as temperature and light, so those are not considered. It is important to select indicators that are both measureable and manageable.

As a result of the screening process, total phosphorus and total nitrogen were selected as indicators. Both parameters influence the growth of algae in Sylvan Lake, are relatively easy and cost effective to sample and analyze, do reflect changes in the watershed and can be managed through human and municipal government actions. Other parameters were evaluated using the review process and may be monitored if the goals of the Sylvan Lake Management Committee change or expand.

3. Quality Control of Water Quality Data

Data for water quality parameters in Sylvan Lake was obtained from Alberta Environment and Sustainable Resource Development's Water Database System (WDS). This includes both government and non-government collected data (primarily from the U of A, Alberta Lake Management Society Lakewatch program, and the Sylvan Lake Watershed Stewardship Society). The period of record for Sylvan Lake extended as far back as 1969 for some parameters and included data until the end of 2011. Data underwent a number of screening processes before the development of WQOs. These included:

1. Data for the open-water period only were used, i.e., the period between May 1 and October 31 in any given year. Chemistry changes due to seasonality effects so it was important to limit the data set to the open-water period of highest concern. Under-ice data were collected much less frequently, and elimination of this data did not result in a significant loss of information.

2. Parameters were critically reviewed and combined when appropriate. Some parameters had slightly varying methodologies over the years or different reporting values (e.g., reporting in units of micrograms per litre vs milligrams per litre). These were checked and where appropriate, converted and combined to ensure a continuous record.

3. Lab and field measurements were checked and averaged. For some parameters, such as pH, both lab and field measurements were collected for the same sample. These were checked to ensure they were similar and then averaged.

4. If parameters that had values below the instrumental detection limit, one-half the detection limit was assumed and substituted to permit further statistical assessment.

5. Total nitrogen calculation. Total nitrogen is not directly measured in the lab, but rather is calculated as the sum of organic and inorganic nitrogen components. The standard method to obtain Total Nitrogen is to add Total Kjeldahl Nitrogen (TKN, organic fraction) and Nitrate/Nitrite nitrogen (inorganic fraction) concentrations.

6. Deep Sample or Profile data were removed. Only the composite or grab samples were retained for this analysis. As water chemistry can change with depth and may not be representative of the active growing zone for algae, the deeper profile data were removed. This did not represent the elimination of a significant amount of data as much of the historical work on Sylvan Lake has focused on composite and grab samples.

7. For replicates, average values were calculated and used.

Further data screening was conducted for total phosphorus and total nitrogen. As part of the development of WQOs, the screened dataset needs to be examined for trends in the data. If concentrations of a parameter are increasing or decreasing, it can be indicative of human activities and needs to be accounted for. The approach utilized by the RDRWA for dealing with trends in the data was to retain the lowest 10 year continuous record or the most recent 10 year record to use to establish triggers and limits (Anderson and Dolan 2012).

In the case of Sylvan Lake, screening of the total phosphorus data showed significantly higher concentrations in the 1970s relative to all other years sampled (Figure 1). This was the result of lab inaccuracies at the time, more recent data being much more reflective of actual concentrations in Sylvan Lake. Hence, total phosphorus data from this period of record was removed.

Both total phosphorus and total nitrogen did not show apparent trends over the period of record (Figures 2 and 3). Thus, for the purposes of developing WQOs for these two indicators, the entire period of record was utilized.

4. Water Quality Threshold Values for TN and TP

The judgment of freshwater lake experts, based on their observations and analysis of many cases, has concluded that a TP concentration of 0.035 mg/L is the maximum acceptable value to protect the meso-eutrophic condition of Sylvan Lake. That is a reduction of 0.015 mg/L below the previous TP maximum of 0.050 mg/L that was the standard for several years under the Alberta Surface Water Quality Guidelines[6].

[6] Alberta Surface Water Quality Guidelines: http://environment.gov.ab.ca/info/library/5713.pdf

Table 1. List of Water Quality Physical and Chemical Properties for laboratory Analysis

(a) Group 1. Nutrient Indicators

	Symbol	Units
Total Nitrogen	TN	mg/L
Total Kjeldahl Nitrogen	TKN	mg/L
Ammonia	NH3-N	mg/L
Nitrate+Nitrite	NO3+NO2-N	mg/L
Nitrate	NO3-N	mg/L
Nitrite	NO2-N	mg/L
Total Phosphorus	TP	mg/L
Phosphorus Total Dissolved	TDP	mg/L
TN:TP Ratio		
Secchi Disk Transparency		m
Chlorophyll-a		µg/L

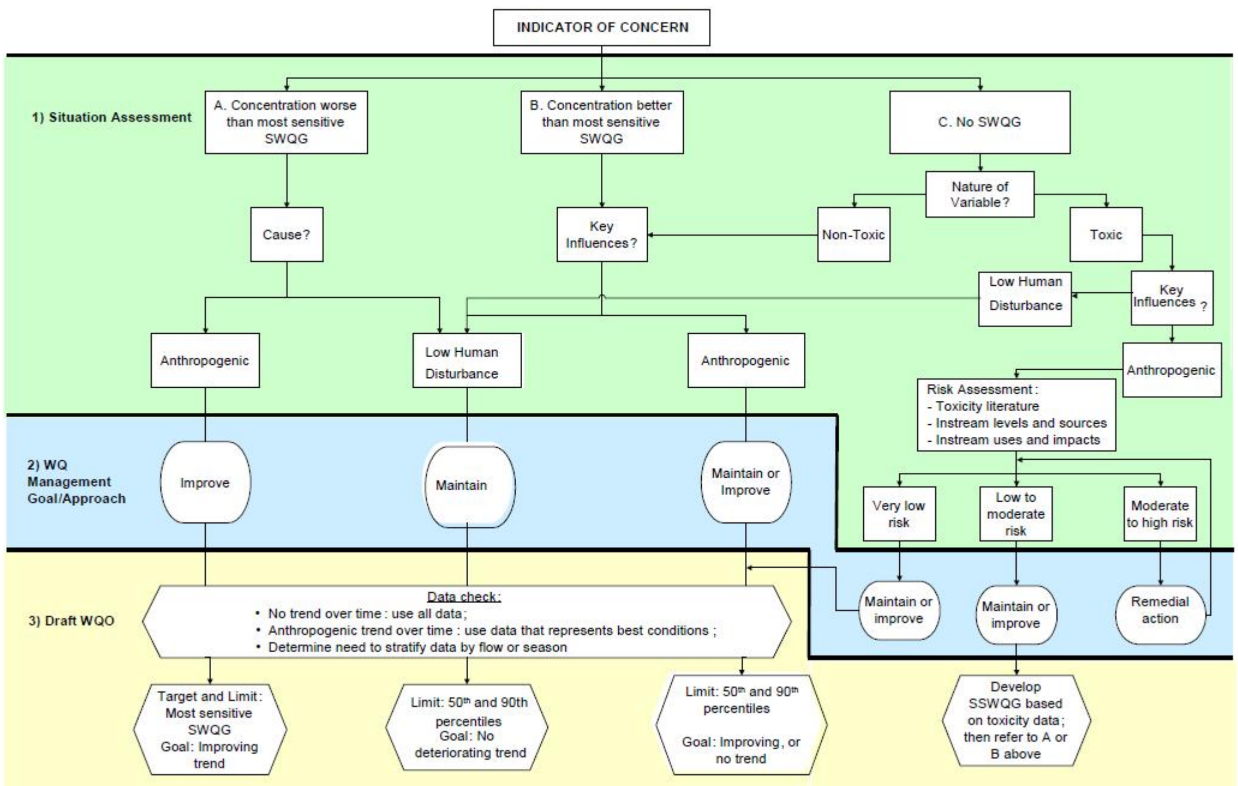
(b) Group 2. Other Indicators

Sodium Dissolved	Na	mg/L
Potassium Dissolved	K	mg/L
Magnesium Dissolved	Mg	mg/L
Calcium Dissolved	Ca	mg/L
Bicarbonate (HCO3)	HCO3	mg/L
Carbonate	CO3	mg/L
Fluoride Dissolved	F	mg/L
Chloride Dissolved	Cl	mg/L
Sulphate Dissolved	SO4	mg/L
Total Dissolved Solids	TDS	mg/L
Dissolved Organic Carbon	DOC	mg/L
pH (Lab)		
Specific Conductance (Lab)		µS/cm
Filterable Residue	FR	mg/L
Non-filterable Residue	NFR	mg/L
Total Alkalinity		mg/L
Phenolphthalein Alkalinity		mg/L
Total Hardness		mg/L

5. Application of Water Quality Data for Cumulative Effects Management

The development of WQOs followed the flowchart presented in Figure 3. When determining what guideline to use for an indicator in establishing limits, all of the applicable uses and relevant guidelines are documented. If multiple relevant guidelines for an indicator are available, the most protective guideline is chosen to ensure protection of all uses. For both total phosphorus and total nitrogen, the only relevant guidelines available are for the protection of aquatic life. It is worth noting that these guidelines are currently under revision and nutrients may fall under a management strategy approach. However, for the purposes of this exercise, the guidelines were considered applicable and useful for the protection of Sylvan Lake.

Figure 3. Water Quality Objective Flowchart[7]



The 50th (median) and 90th percentiles were calculated for total phosphorus and total nitrogen. The 50th percentile or median represents the long-term value we want to maintain in Sylvan Lake. This is assessed in the future through long-term trend analysis conducted intermittently. If the long-term trend

[7] Anderson, A-M. and A. Dolan. 2012. Draft Site-Specific Water Quality Objectives for the Red Deer River Basin with Emphasis on the Mainstream. Prepared for the Red Deer River Watershed Alliance. 58pp.

indicates an increase in the median value, this may be attributed to human activities and management actions to reduce this number would need to be implemented.

The 90th percentile represents the value below which 90 percent of all data collected fall below. Individual samples that are collected and exceed the 90th percentile should be investigated to determine their cause and, if necessary, management actions implemented to remedy the situation.

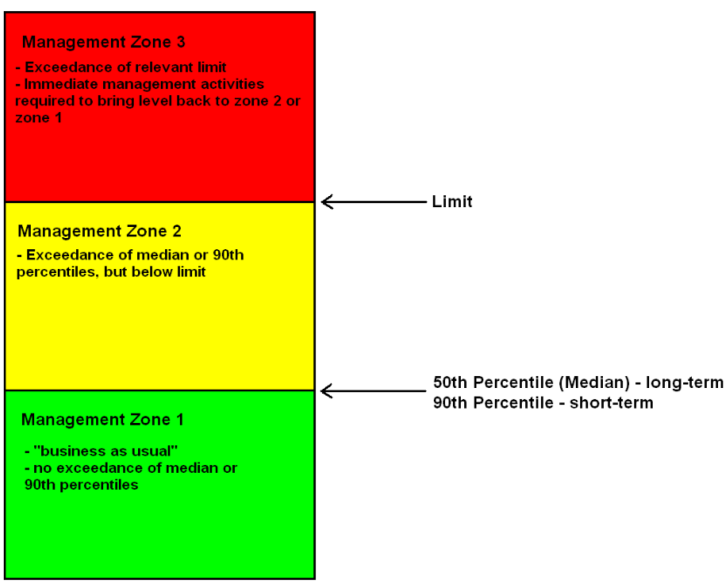
Table 2 presents the calculated 50th and 90th percentiles for total phosphorus and total nitrogen in Sylvan Lake as well as limits as determined by applicable PAL guidelines.

Table 2 – Total Phosphorus and Total Nitrogen percentile values and guideline limits for Sylvan Lake

	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
Trigger at 50th percentile (median)	0.019	0.65
Trigger at 90th percentile	0.028	0.87
Guideline/Limit	0.035 (to maintain meso-eutrophic)	1

The values presented in Table 2 can be broken down into concepts of management zones. Management zone 1 (GREEN) would include values below the long-term median or 90th percentile. This zone could be described as "business as usual" where current management strategies are applied including ongoing monitoring, education and awareness and continuous improvement activities for minimizing nutrient delivery to Sylvan Lake. Specific management activities are detailed in the management framework section.

Figure 4. Three Management Zones



Management zone 2 (YELLOW) would include values between the long-term median or 90th percentile and the guideline/limit value. Values in this zone would represent an increase in the indicator which may be the result of human activity. In this zone, the management response could include further investigation of cause and potentially increasing activities with the intent of reducing nutrient concentrations back to management zone 1 levels (e.g. restricting fertilizer use). Specific management activities are detailed in the management framework section.

If the long-term median or 90th percentiles exceed the guideline/limit value, this would be indicative of changes which could lead to significant issues in Sylvan Lake such as presence of nuisance blue-green blooms. Please note that in order to maintain the current meso-eutrophic state, and avoid a eutrophic state, the limit has been set at 0.035.

Under the CCME framework (see attached pdf), the cutoff values are as follows (from Table 1):

- Ultra-oligotrophic <0.004
- Oligotrophic 0.004 - 0.01
- Mesotrophic 0.01 - 0.02
- Meso-eutrophic 0.02 - 0.035
- Eutrophic 0.035 - 0.1
- Hyper-eutrophic >0.1

This zone, known as Management Zone 3 (RED), would require even more drastic management actions to reduce nutrient concentrations, such as halting further development, significant upgrades in wastewater and stormwater infrastructure, and enhanced land management practices to prevent nutrient delivery to Sylvan Lake.

Overall, the goal is to maintain or improve water quality in Sylvan Lake. In other words, the long-term goal should be to keep within Management Zone 1 where management activities are minimal in terms of financial and human resource costs. To continuously achieve this in a developing watershed like Sylvan Lake will require offsets to accommodate new activities while also ensuring new developments have minimal impact to the water quality of Sylvan Lake.

6. Creek Monitoring Summary

Birchcliff Creek (data from 2001 to 2008)
Golf Course Creek (data from 2001 to 2008)
Honeymoon Creek (data from 2001 to 2008)
Jarvis Bay Creek (data from 2006 & 2007?8)
Lambe Creek (data from 2001 to 2008)
Northwest Creek (data from 2001 to 2008)

Sampling included :

Physical parameters

- Includes pH (how acidic or alkaline water is), conductivity (dissolved salts), oxygen, temperature, turbidity, odor and flow rate
- Aquatic life has specific range which they can tolerate, too high or too low or too rapid of changes can harm them
- Physical parameters also affect toxicity of other parameters (e.g., ammonia)

Nutrients

- Required for growth of plants, including algae and aquatic weeds (macrophytes)
- Too many nutrients, or in the wrong proportion can lead to excessive growth
- Nutrients can have human and animal health implications (e.g., "blue baby" syndrome from high nitrate concentrations)

Coliforms

Coliforms Fecal Cfu/100 Ml
Coliforms Fecal No/100 Ml
Coliforms Total Cfu/100 Ml
Colour (Visual) At Site N/A
Escherichia, Coli Cfu/100 Ml
Escherichia, Coli No/100 Ml
Alkalinity Total Caco3 Mg/L
Ammonia (Nh3) Mg/L
Ammonia Dissolved Mg/L
Bicarbonate (Calcd_) Mg/L
Calcium Dissolved/Filtered Mg/L
Carbonate (Calcd_) Mg/L
Chloride Dissolved Mg/L
Fluoride Dissolved Mg/L
Hardness Total (Calcd_) Caco3 Mg/L
Hydroxide (Calcd_) Mg/L
Ionic Balance %
Iron Dissolved Mg/L
Magnesium Dissolved/Filtered Mg/L
Manganese Dissolved Mg/L
Nitrogen Dissolved Nitrate Mg/L
Nitrogen Dissolved Nitrite Mg/L
Nitrogen Dissolved No3 & No2 Mg/L
Nitrogen Total Kjeldahl (Tkn) Mg/L
Oxygen Dissolved (Field Meter) Mg/L
Phosphorus Total (P) Mg/L
Phosphorus Total Dissolved Mg/L
Potassium Dissolved/Filtered Mg/L
Silica Dissolved Mg/L
Sodium Dissolved/Filtered Mg/L
Sulphate Dissolved Mg/L
Total Dissolved Solids (Calcd_) Mg/