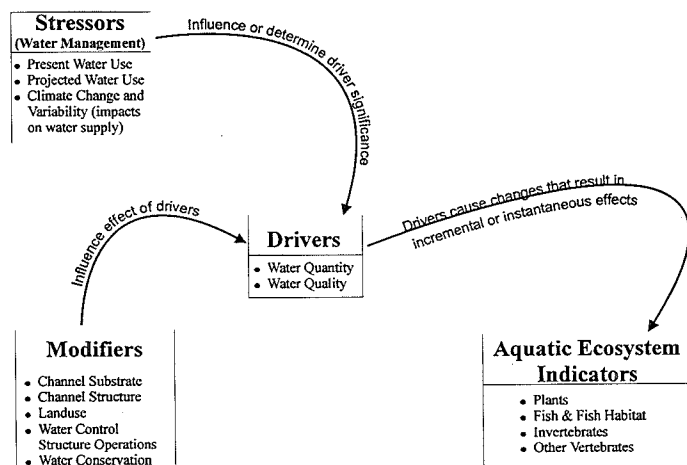


Ecological Consideration for Water Takings (Proposed Framework)

The following is a 7 step framework for asking questions relating to a water taking. This framework is based on results of an Ecological Indicators Workshop held in April, 2001 in support of the Canada/Ontario Water Use and Supply Project. The framework addresses the various indicators identified at that workshop. The workshop laid out 4 study parameters for indicators 1) Stressors, 2) Drivers, 3) Aquatic Ecosystem Indicators and 4) Modifiers.

Relationship between Study Parameters

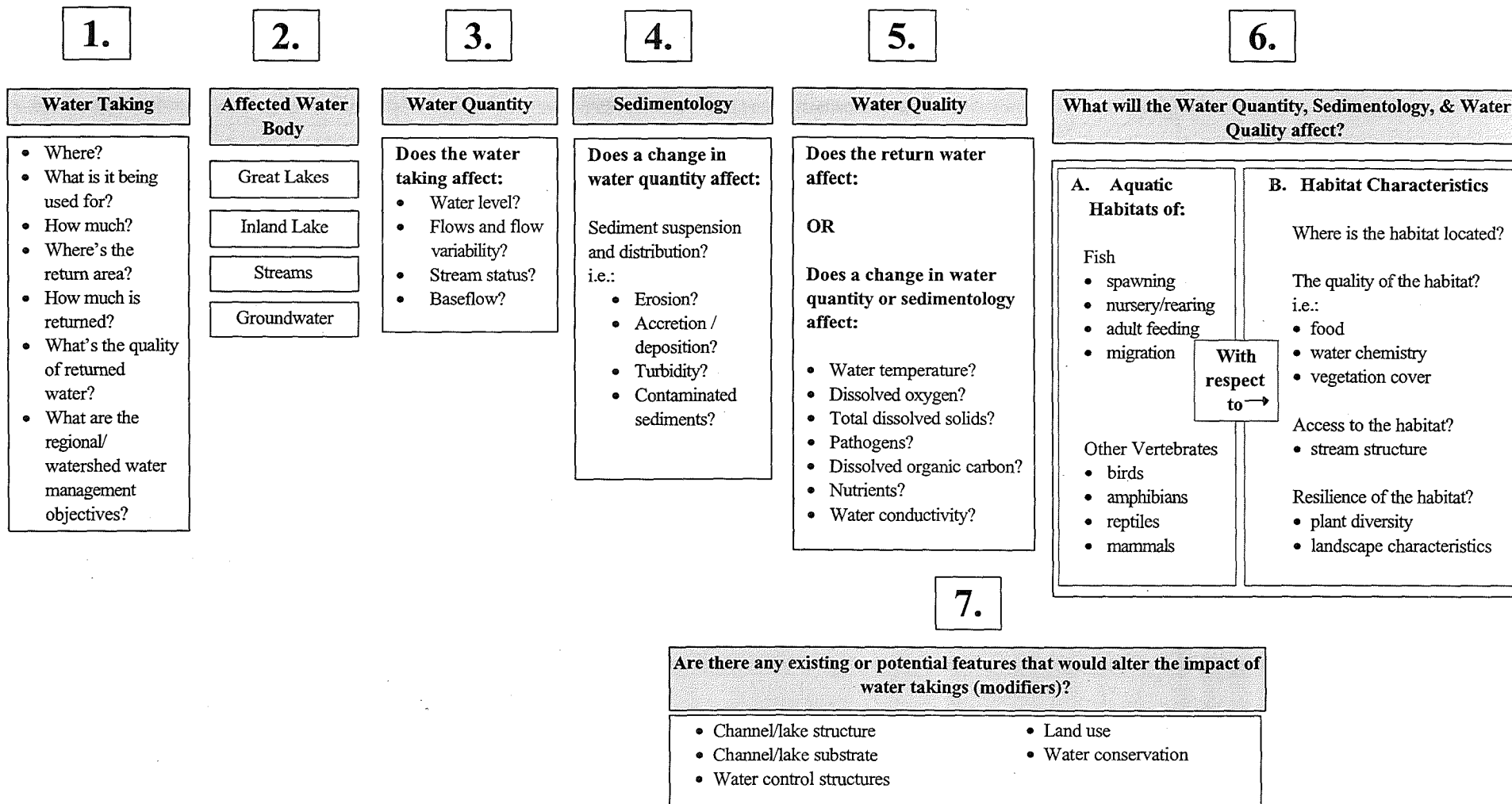


Some modifications have been made to the original workshop indicators based primarily on comments received during the review process. Most notably, it was stressed that it makes more sense to focus on habitats of fish and other vertebrates rather than the species themselves. The primary reason for this is that it is easier to relate changes in water resources to the habitat than to a species population which may be under the influence of numerous stressors. Sedimentology which is listed below was not specifically dealt with at the indicators workshop, but has been added since it was inferred in a number of discussions.

The framework begins with asking questions directly related to the water taking itself and then follows through the various parameters. One important step at the beginning of the process is to identify any existing regional/watershed water management objectives. This will help to focus the questions required in the decision making process. A description of each of the indicators identified is provided as is an example scenario. For more details on the results of the Ecological Indicators Workshop, please refer to the workshop summary.

Ecological Considerations for Water Takings

Proposed Framework (Steps 1 - 7)



Definition of Indicators used in the Proposed Ecological Considerations for Water Takings Framework

NOTE: Each of the numbered headings below correspond with a numbered section in the attached diagram entitled Ecological Considerations for Water Takings.

3. Water Quantity:

Water Level/Flow:

Water levels and flows assist in determining the degree to which shorelines and nearshore features will be exposed to hydraulic/hydrologic and/or weathering processes. Depending on shoreline and nearshore geomorphology, alterations of levels and flows have the potential to transform the sedimentary cycle, mobilize contaminated sediments, and change the structure of nearshore/shoreline habitats (e.g., wetlands). By closely monitoring or predicting water levels and flows in comparison to water takings, we will be better able to determine features (e.g., habitats) potentially sensitive to these changes.

Baseflow:

Baseflow is defined as the groundwater contribution to streamflow (Singh, 1992). During the winter, surface runoff decreases due to the colder temperatures and as a result, streamflow may be wholly supplied by groundwater. The drilling and depletion of aquifers is becoming increasingly common in the Great Lakes Basin as a result of changing land uses and increased development. The replenishment of groundwater aquifers has yet to be fully understood. The groundwater-flow and discharge relationship is spatially and temporally variable and its impact on the health of aquatic ecosystems is significant. By analysis and monitoring of baseflow/groundwater, negative ecological impacts might be discernible and preventable. Groundwater levels may be monitored through gauged stations.

Flow Variability:

The variability of flow has a significant impact on the health of an ecosystem. Species richness can be dependent upon the variability of flow: some life cycles require periods of minimum or maximum flow in order to be completed. Other aquatic environments such as wetlands are highly sensitive to flow variability. The variability of flow, whether observed on a daily, weekly, monthly or annual basis, affects different species and ecosystems in a variety of manners. The rates of increase, or ramping, of flow may also be significant. Accelerated rates of increase may have damaging effects on an ecosystem, and may be used as an indicator. Data availability is widespread across the basin, and as such, ranks flow characteristics as the most important measure of water quantity monitoring.

Stream Status:

As an indirect result of water quantity, intermittent and permanent streams are an indicator of water quantity, and will subsequently affect the health of aquatic communities. The use of monitoring permanent and intermittent stream lengths, periodicities and rates of change will enable water managers to highlight areas prone to intermittent water flow. The problems associated with flow irregularity will only be exacerbated if future water supplies are threatened as forecasted.

4. Sedimentology Definitions

The transformation of the landscape occurs through the movement of sediments, typically through the medium of water. Soil or sediment is eroded from the land, transported by water and deposited. This deposition can occur on land, or in rivers, streams or lakes. Sediment movement within the Great Lakes Basin is a significant component of landscape and coastal evolution.

Erosion:

The process of erosion occurs when soil or rock particles are weathered and subsequently removed by the action of rain, snowmelt, groundwater, wind and waves, channel flow, plant and animal activities. Human activities include nearshore development, urbanization, forestry, agricultural development and can greatly affect the rate of erosion.

Turbidity:

A measure of the amount of particles carried in water is turbidity. These particles are fine-grained and can include silt, clay, organic matter and other microscopic organisms. High turbidity reduces the clarity of the water, which directly impacts the amount of photosynthesis that can take place, resulting in potential impacts on fish and other biological communities through the reduction of plant productivity.

Turbid water can also the operation and maintenance of domestic, industrial and agricultural water use.

Suspended sediment can affect the amount of light that penetrates the water, hence stressing fish and vegetation populations by decreasing photosynthesis and by increasing water temperature. High amounts of suspended sediment can also cause physiological damage to fish and other aquatic organisms. Vegetation can become choked or dislodged by an abundance of sediment, as well as damaging benthic vertebrate and invertebrate communities.

Deposition:

The carrying capacity of water will determine the size and weight of suspended particles, or load. When the water can no longer suspend a certain size or weight of particle (due to a deceleration in the speed of the moving water), the particles are deposited. This deposition of sediment is largely responsible for the fluvial, beachfront, nearshore and offshore sedimentary features we see within the Great Lakes basin. Re-working and re-distribution of beach material is significant on the Great Lakes. Important fluvial features include cutbanks, pointbars, floodplains, channel bars, and deltas.

Contaminated Sediments:

Sediments also aid in the transport and settling of pollutants and contaminated sediments. Sediments particles can absorb and carry agricultural and industrial chemical compounds. If these toxins are released into aquatic habitats, they can damage food sources or cause abnormalities or death in the fish or other aquatic organisms.

5. Water Quality:

Water Temperature:

Water temperature is largely responsible for the types of biota found in an aquatic environment, and is typically controlled by the amount of water entering the groundwater system (influent streams) or the amount of colder groundwater entering the stream (effluent stream). The detection of change in water temperature regimes is extremely important in those aquatic environments which include water temperature-sensitive species. Although site robustness will vary, the sites that have water temperature-sensitive species should be frequently monitored.

Water temperature is also important in lakes where thermal stratification occurs. If a shift in water temperature occurs, so too will the process of thermocline formation, and subsequently could affect ecosystem health in the lake.

Water temperature data are available extensively in the south, but has limited distribution in the northern portion of Ontario.

Dissolved Oxygen:

Some aquatic ecosystems are extremely sensitive to the level of dissolved oxygen (DO) in the water. Although fluctuations of DO occur on all time scales, monitoring programs of DO typically do not take into account daily variability in DO levels. This is particularly important at sites where nighttime DO levels decrease rapidly due to higher air temperatures, which threatens the health and survival of various aquatic lifeforms. Unfortunately, there are concerns about data logger accuracy and spatial availability of DO data (particularly for streams). DO data are available extensively for lakes.

Total Dissolved Solids:

The amount of suspended solid content (total dissolved solids or TDS) in rivers and lakes can alter the water's physical and chemical properties. The TDS concentrations are the combined total amounts of minerals, salts, heavy metals, cations and anions present in the water (McNeely et. al., 1979). TDS concentrations consist of input through industrial, agricultural, and domestic activities and through natural processes. The environmental effects of TDS concentrations range from mild (increase in water hardness) to levels of life-endangering toxicity. Common dissolved solids such as carbonates, sodium, potassium, sulfates, nitrates and silica are all present under natural conditions. However, changes in other water parameters (such as temperature or flow) may lead to changes in TDS concentrations to the point that ecosystem health is threatened.

Turbidity:

Turbidity is the measure of suspended fine-grain particles. These include silt, clay, organic matter and other microscopic organisms. The turbidity of a stream, river or lake can result from natural processes such as erosion, runoff and algal blooms. Anthropogenic impacts on these natural processes will in turn effect the turbidity, which ultimately may effect the health and productivity of the aquatic ecosystem. High turbidity reduces the clarity of the water, which directly impacts the amount of photosynthesis that can take place, resulting in negative impacts on fish and other biological communities through the reduction of plant productivity, siltation of spawning beds and fouling of gills. Water temperature will also increase more rapidly and to higher levels in turbid waters.

TDS and turbidity data, despite their effectiveness in monitoring water quality, are limited spatially and temporally across the basin. Selected sites for monitoring may be used and therefore should be included for use as ecological indicators.

Pathogens:

Pathogens are any disease causing organism such as bacteria, viruses and parasites (e.g. *E. Coli*). Pathogens usually enter a water system through surface runoff with the potential to reduce water quality. Pathogens often enter water courses through livestock wastes carried in surface runoff.

Dissolved organic carbon:

Dissolved organic carbon (DOC) is directly related to oxygen supplies and demands in an aquatic environment. Due to this, DOC concentrations are also related to turbidity and temperature conditions. The majority of DOC is comprised of humic compounds, partly degraded plant material and animal by-products. It is resistant to microbial degradation and is largely a by-product of photosynthesis. However, anthropogenic activities, particularly at water treatment facilities, may increase the amount of DOC in a system. Excessive amounts may reduce levels of dissolved oxygen, which can have a negative impact on an aquatic ecosystem. DOC data are available for lakes in Northern Ontario, but are lacking in the south.

Nutrients:

Organic and inorganic nutrients enhance the fertilization of aquatic plant life. Too much nutrient concentration can cause the proliferation of undesirable algae and other plant life. This proliferation can place too much demand on limited amounts of oxygen in the water. Phosphorus, nitrogen and trace metals are all examples of nutrients. Nutrient enrichment is most commonly a result of runoff from surrounding farmland carrying fertilizers and pesticides to water bodies and/or from inadequately treated effluent from sewage treatment plants. Nutrients are important for identifying cause and effect at specific study sites. The response of nutrients is captured by dissolved oxygen and algae growth. Nutrients are typically measured at provincial water quality sites.

Water Conductivity:

The use of measuring conductivity in streams and lakes has emerged as an effective means of qualifying water chemistry. Conductivity measures the amount of ions present in the water, and can provide insight into the water contributed by groundwater to a lake or stream. It can also provide an indication of the amount of pollution, if the pollution is associated with an increase in the concentration of dissolved ions. Conductivity measurements can be made quickly, but do not offer comparative quantifiable data. The data can also be highly variable between and within sites. Due to the data variability, it will be difficult to rely on this indicator to determine trends. Data are available spatially across the basin, but are limited temporally.

While considering the criteria for indicator selection, the previous four water quality parameters were suggested to have the highest feasibility and greatest impact as indicators in determining areas of ecosystem sensitivity. These water quality parameters are being suggested for the ecological information they may provide, despite the identified drawbacks when compared to the criteria for indicator selection.