Natural Resources Canada
Ressources naturelles Canada

Water use by the natural resources sectors

FACTS

March 2009

Canada

Water use by the natural resources sectors – Facts

Contents

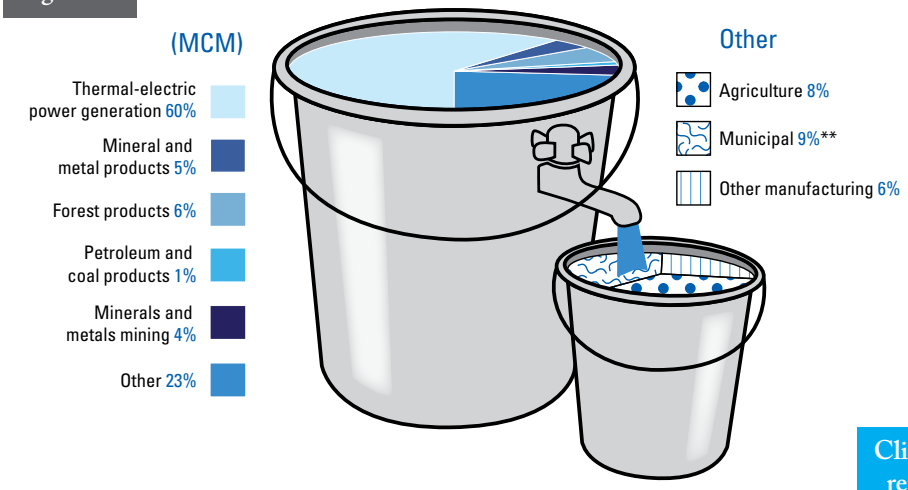
Overview of water use by the natural resources sectors

- The natural resources sectors comprise companies operating in the energy, forest, and minerals and metals sectors. Unless otherwise indicated, figures for the energy sector include only thermal-electric power generation facilities (e.g. nuclear and fossil fuel generation). Hydroelectric power generation and oil and gas development are treated separately.
- Although the natural resources sectors accounted for nearly 80 percent of Canada's water use in 2005, most of that use is non-consumptive (water is returned to its source after use).

*Gross water use by major Canadian water-using sectors, 2005**

Total: 60 436.2 million cubic metres (MCM)

Figure 1a



Note: Most figures and graphics in this report are derived from Industrial Water Use, 2005 produced by Statistics Canada.

Sources: Environment Canada and Statistics Canada water use surveys

Click here to see an alternate representation of this graph

**Numbers may not sum to 100 due to rounding.*

***Municipal includes rural.*

- As with other large water withdrawals, high-volume water use by natural resources companies can contribute to regional pressures on water availability. Many natural resources companies have taken steps to manage the impact of their operations on regional water supplies.
- In 2005, the natural resources sectors accounted for approximately 22 percent of water consumption in Canada. By comparison, irrigation activities accounted for almost 60 percent of Canadian consumption.

*Water consumption by major Canadian water-using sectors, 2005**

Figure 1b

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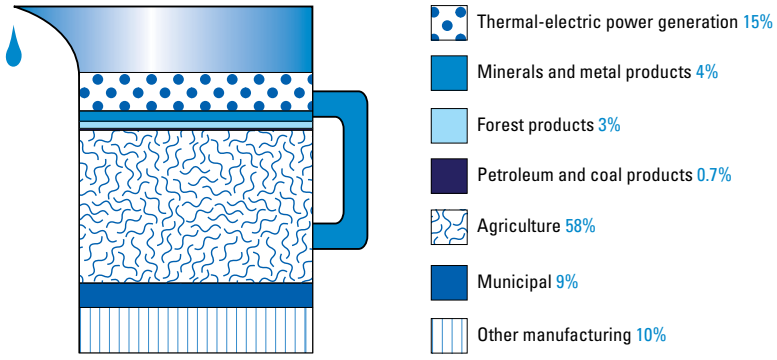

Sources: Environment Canada *and* Statistics Canada *water use sruveys*

**Numbers may not sum to 100 due to rounding.*

- Most water used by the natural resources sectors is for cooling (e.g. to cool equipment), which is why consumption rates are so low. (Water is generally not incorporated into natural resources products, as it is in some other industries.) The use of water for cooling has a negligible impact on water quality, other than a slightly heated discharge.
- Freshwater may also be used in a variety of ways as part of production processes or to wash equipment. These uses often result in contaminated wastewater that must be treated before being released into the environment.
- The natural resources sectors accounted for approximately 18 percent of the pollutant releases to water reported to the National Pollutant Release Inventory (NPRI) in 2003. Effluent flows from the natural resources sectors are carefully monitored and regulated, and extensive treatment methods prevent contamination of aquatic ecosystems.

*Sources of pollutant releases to water, as reported to the NPRI, 2003**

Figure 2

**Numbers may not sum to 100 due to rounding.*

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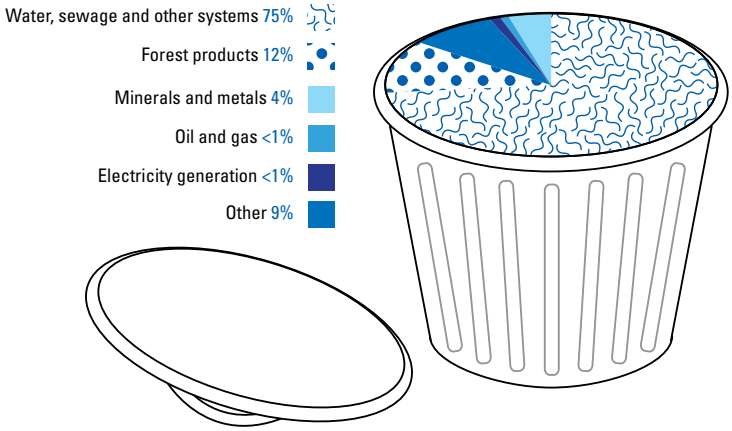


Source: Canada's National Pollutant Release Inventory

- Total water costs incurred by the natural resources sectors (excluding oil and gas production and hydroelectric power generation) were $1.29 billion in 2005. This amount reflects costs paid by natural resources companies to acquire (e.g. paying for water from public utilities and operating and maintaining water-related equipment), recycle and treat freshwater. The relative importance of these cost components is different for each sector.
- Provincial and territorial licensing fees generally account for less than 1 percent of the total water costs paid by natural resources companies. The low cost of licensing fees reflects the fact that, on a per-unit basis, water charges in Canada are among the lowest in the world.

Energy sector

- The energy sector includes the thermal power generation industry, the upstream (extraction) and downstream (processing/upgrading) oil and gas industries, and the hydroelectric power generation industry.
- The sector as a whole was responsible for less than 2 percent of reported pollutant releases to water in 2003.
- The main water issues facing the thermal-electric power generation industry relate to its high withdrawal volumes, which can stress regions with low water availability. However, most of the water withdrawn is quickly returned to its source, so consumption rates in the industry are low.
- Unlike the thermal-electric power generation industry, nearly all water use for oil and gas production could be considered to be consumptive, i.e. it is either injected into oil reservoirs or, in the case of the oil sands, held for years in tailings ponds. In addition, the oil and gas industry must carefully manage wastewater discharges to avoid contamination of aquatic ecosystems.
- All of the water used by the hydroelectric power generation industry flows through the hydroelectric installations; none is consumed.
- Water use intensity (per unit of energy generation) is highest for hydroelectric installations, followed by nuclear and fossil fuel-fired plants.

Thermal-electric power generation

- Thermal-electric power generation used 36 345 MCM of water in 2005, or 60 percent of the Canadian total. Almost all of this use is for cooling and is non-consumptive. Gross water use in the thermal-electric power generation industry has increased moderately since 1991, and the industry has the highest gross water use by far in the natural resources sectors.
- In addition to their impact on local water availability, the large surface-water withdrawals of the thermal-electric power generation industry can kill organisms that are trapped against intake structures (impinged) or swept up (entrained) with water intake. This impact on aquatic organisms is an important concern for the industry from both environmental and economic perspectives. Aquatic organisms

can clog cooling-water intakes and cost companies millions of dollars per year in maintenance and lost power generation.

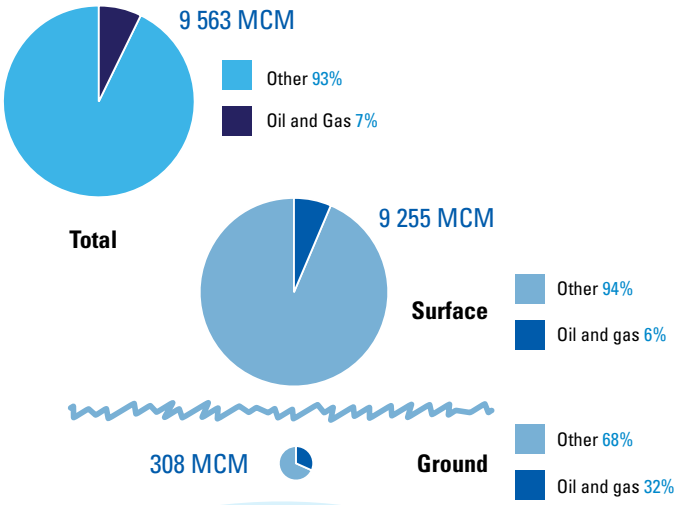
- Water consumption by Canada's thermal-electric power generation industry is low due to the high use of open-loop cooling systems. Wide-scale adoption of closed-loop systems would yield major reductions in water withdrawals with slight increases to consumption (mostly to evaporative losses). This has been the result in the United States, where closed-loop systems are more common.
- The thermal-electric power generation industry spent $99.2 million on water in 2005, equivalent to an average of $0.003 per cubic metre ($m^3$) gross water use. The majority of these costs were for the construction, operation and maintenance of water withdrawal, circulation, treatment and discharge machinery. A small percentage was paid to provinces, territories and municipalities in the form of user fees or licensing fees.

Oil and gas

- Water allocation to the oil and gas industry in Alberta grew by 54 percent from 2001 to 2005 and accounted for approximately 7 percent (694 MCM) of Alberta's total water allocations in 2005. In many cases, however, oil and gas companies use much less than the amount they are allocated.

Quantity of surface water and groundwater licensed for use in Alberta, 2005

Figure 3



Source: **Alberta Environment. 2007.** Current and Future Water Use in Alberta

Click here to see an alternate representation of this graph

- Surface-mining oil sands production uses 3.0 to 4.5 barrels of water (net) per barrel of bitumen produced. In-situ oil sands production, however, uses about one barrel of water (net) per barrel of bitumen produced. In some in-situ operations, saline groundwater replaces some or all of the freshwater requirements for extraction. Thus, for freshwater only, the average net value is 0.6 to 0.9 barrels of water per barrel of bitumen produced via in-situ extraction. Some in-situ projects in the oil sands recirculate as much as 90 percent of their water.

- Natural Resources Canada scientists at CanmetENERGY (formerly CANMET Energy Technology Centre) in Devon, Alberta, are working with oil sands mining companies to develop technology that may reduce the water consumed by tailings ponds. The goal is to decrease the net water use in mining operations to two barrels of water per barrel of bitumen produced. This decrease would result in dry tailings, eliminating the need for extensive tailings ponds and their associated environmental risk.
- Oil sands production is projected to increase two-fold by 2015. Associated increases in water consumption are expected to put pressure on water availability in the Athabasca River basin. Recognizing this, some companies have committed to improving their water-use efficiency so they can expand their operations without increased water allocations.
- In addition to water availability concerns, oil sands projects affect water quality. Water recovered from oil sands surface-mine tailings has a high salt content and is toxic, due to naphthenic acids dissolved from the oil sands. Tailings ponds in Alberta now cover more than 70 square kilometres.
- Oil sands mining operations operate under a zero-discharge policy, meaning that they contain all wastewater and runoff on-site. Any water released from mining sites is treated and monitored to avoid negative impacts to aquatic ecosystems.
- The downstream oil and gas industry manufactures petroleum and coal products for the marketplace. Like other manufacturing industries, it uses water primarily for cooling, condensing and steam, with a relatively small amount consumed. In 2005, the petroleum- and coal-products manufacturing industry used 869 MCM of water, the majority (58 percent) of it in the form of recycled water.
- The downstream oil and gas industry requires high-quality water for use in its production processes. To meet this need, 41 percent of its total water costs in 2005 were devoted to the treatment of intake water. Overall, the industry spent $210 million on water in 2005.
- Several downstream oil and gas companies have developed innovative practices to recycle water and decrease their impact on freshwater quantity and quality.
- Effluent quality for the oil and gas industry as a whole is very good. Oil and gas companies were responsible for less than 1 percent of pollutant releases to water, as reported to the NPRI in 2003.

Hydroelectric power generation

- Canada's share of energy from hydroelectric power generation is greater than that in any other country. Large-scale hydro generates almost 60 percent of Canada's electricity. Canada has also diverted more water by damming rivers for hydro than any other country.
- The construction of dams can significantly alter local ecosystems, but ongoing impacts are limited.
- While a few sites are being developed for new large-scale hydroelectric production projects, small-scale dams and run-of-river projects are receiving increased

Note: Data concerning water use by Alberta's oil and gas industry are derived from Current and Future Water Use in Alberta, *produced by Alberta Environment.*

attention. Small-scale projects can have less of the environmental and social impacts associated with large dams. It has been estimated that 5500 sites in Canada are technically feasible for small-scale hydroelectric production.

Forest sector

- The forest sector comprises forest management activities (such as tree planting; forest protection from fire, disease and insects; and harvesting) and forest products manufacturing industries (including paper and wood products manufacturing). In Canada, managers of these activities are obliged to consider the protection of ecosystem conditions, including those for water.

Forest management

- Forest management activities use little water. Nevertheless, some forest management activities, such as the construction of forest access roads and tree harvesting, may affect aquatic ecosystems. These effects can be positive if the activity is done responsibly, but they can be negative if forest managers do not adhere to guidelines and regulations. Recognizing this, forest managers have improved forestry practices to minimize the negative impacts of forest management activities on the ecosystem and to enhance the positive impacts that forest management can have on ecosystems.
- The structure of the forest cover has an important effect on characteristics of the associated water ecosystem. Forests are living systems and are constantly changing. As a result, they will have different interactions with aquatic ecosystems over time.
- Forest structure is changed by natural disturbances caused by pest or disease outbreaks and forest fires. These disturbances could result in negative impacts to the aquatic ecosystem (these impacts tend to be temporary). Where possible, forest managers use various techniques to minimize the negative impacts associated with these natural occurrences. For example, creating forests on non-forested areas by tree planting can create positive impacts on water ecosystems.
- Forest managers use pesticides to control insect infestations and for vegetation management to enhance the survival and growth of planted trees. Strict guidelines and regulations control the type, concentration and distance to water bodies of pesticides applied in forest management.
- Tree harvesting, while creating significant economic benefits for Canada, also changes the structure of the forest. An important consideration in all forest harvesting is its potential effects on water quality, and the activity is restricted where it could create negative effects on the water ecosystem. Tree harvesting and the associated need for access-road construction on crown land are planned and carried out to ensure that negative impacts to aquatic ecosystems are avoided or minimized.
- Among all forest management activities, forest access roads have the most potential to create negative impacts on forest water ecosystems – through the interruption of groundwater flow patterns, soil erosion and stream sedimentation. Therefore, planning the location, construction and maintenance of forest access

roads is one of the most important priorities among water management issues in forest management.

- Innovative practices and policies that minimize the impact of forest access roads have been developed. In addition, strict regulations at the provincial and territorial levels mitigate many of the negative impacts of road construction and maintenance.
- The negative impacts on water ecosystems from forest access roads, however, are overshadowed by those from other land-use changes, such as other industrial developments and urbanization.

Forest products manufacturing

- The manufacturing industries of the forest sector accounted for 6 percent of gross water use in Canada in 2005. This water is used in processing activities that have low overall consumption.
- Gross water use, water use intensity (water use per unit of production) and water withdrawals by forest products manufacturing have declined substantially since the 1980s.

Sources: Environment Canada *and* Statistics Canada *water use surveys*

*Water use trends in the forest sector, 1986–2005**

**Numbers may not sum to 100 due to rounding.*

Figure 4

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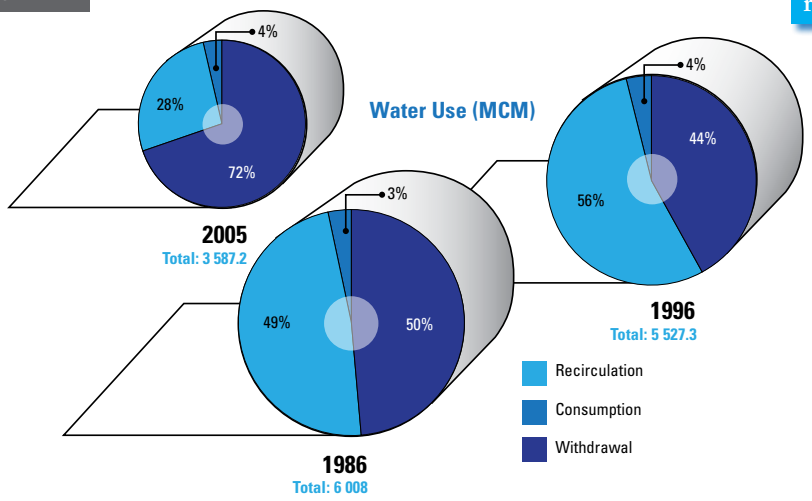


- Some of the main concerns about wastewater from forest products manufacturing operations include chronic toxicity to aquatic organisms and eutrophication (see sidebar). The industry has invested a significant amount of effort to prevent effluent from negatively impacting aquatic ecosystems and to ensure that strategies are tailored to local environments.
- Today, the Canadian pulp and paper industry has established itself as a world leader in elemental chlorine-free pulping. This process minimizes the release of dangerous organochlorine chemicals into the environment.

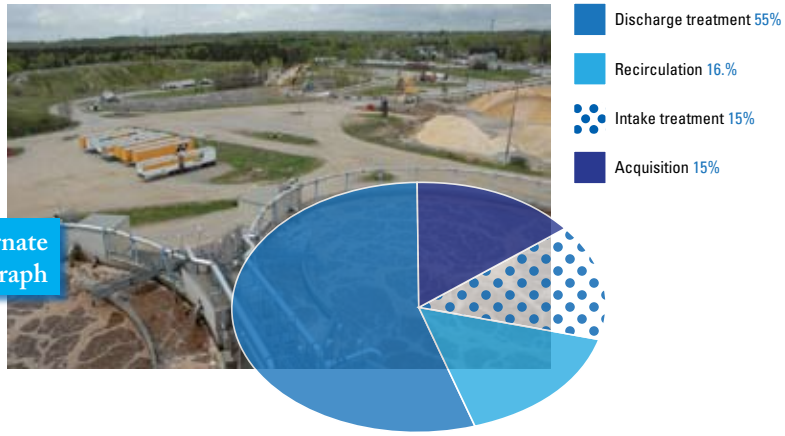
Eutrophication *is a natural process that, over geological time, can turn a lake into a bog and eventually into land. But today, in many places, this process is accelerated by high concentrations of phosphorus and nitrogen that enrich the water with nutrients, causing aquatic plants to grow quickly. As the plant growth explodes, it chokes off the oxygen supply normally shared with other organisms living in the water. When the plants die, their de-composition uses up even more oxygen. As a result, fish die and bacterial activity decreases.*

- Forest sector manufacturers accounted for 12 percent of industrial contaminant releases to Canadian waters in 2003. However, those releases take ecosystem capacity into account and are monitored and regulated to minimize negative effects.
- Canada's Pulp and Paper Effluent Regulations have significantly improved effluent quality over the past 36 years. The Regulations are continually reviewed and updated to keep pace with emerging science and technology innovations.
- The forest products manufacturing industries spent $508 million on freshwater withdrawal, recirculation and treatment in 2005 (a major increase since 1996), or $0.142 per cubic metre of gross water use (approximately double the rate paid in 1996).
- In response to the challenges associated with effluent discharges, more than half of water-related spending in 2005 was devoted to water treatment technologies and processes that decrease the industry's impact on water quality.

Forest products manufacturing total water costs, 2005

Total: $508 million

Figure 5



Click here to see an alternate representation of this graph

Source: **Statistics Canada, 2008.** Industrial Water Use, 2005.

- There have also been concerted efforts to decrease the industry's water use per unit of production. As one example, scientists at CanmetENERGY in Varennes, Quebec, have demonstrated that even efficient pulp and paper mills can significantly reduce their energy and water use by optimizing production processes. The cost savings associated with these efficiencies can often pay for the required technology investments in a relatively short period.

Minerals and metals sector

- The minerals and metals sector is not a large water user. In 2005, mining companies withdrew 459 MCM of freshwater, a moderate decrease from 1996.
- Key water management issues relate to mine dewatering (see sidebar), acid rock drainage, metal leaching, salt accumulation and wastewater treatment. Though

mining impacts on water quality and aquatic ecosystems tend to be localized, they can extend over long periods. The release of contaminants from some orphaned and abandoned mine sites has been a significant problem across Canada.

- There are 700 million tonnes of waste rock that could generate acid and 1.8 billion tonnes of potentially acidic tailings in Canada.
- Overall, the sector discharged almost 2000 MCM of treated wastewater in 2005.
- The Mine Environment Neutral Drainage (MEND) Program has developed technologies and practices to prevent or mitigate acid drainage and metals contamination. MEND technologies have been in widespread use by the industry at active mines. They are also used by the industry and by provinces and territories to address the problem of orphaned and abandoned mine sites in Canada.
- Monitoring data collected as part of the Metal Mining Effluent Regulations, considered one of the world's leading standards for mine effluent quality, indicate effluent quality from active mines is very good.
- Wastewater management and treatment methods have progressed considerably in recent decades, with improved effluent quality and reduced impacts on ecosystems as the result.
- Total water-related spending by the sector amounted to $480 million in 2005. In the mining industry, this amount was equivalent to $0.068 per cubic metre of gross water use. Compared with other natural resources industries, mining companies devoted a higher proportion of their water-related costs to recirculation, likely due to high dewatering volumes.
- Spending on discharge treatment accounted for approximately one quarter of the water costs for the minerals and metals sector. This amount is less than that spent by the forest products manufacturing industry because much of the water released by mining companies is directly from mine dewatering. Dewatering discharge does not usually require treatment because it is generally not used in processing.

Mine dewatering *refers to the activity of pumping water out of a mine site. To prevent water in aquifiers, rivers or lakes from flooding a mine, many establishments must often run their pumps continually. Some of this water may be used in processing activities, but most is disposed of off-site. As a result of dewatering, mining establishments often have zero consumption; they may even in fact be net producers of water.*

Glossary

Total water intake = water withdrawals

- The total amount of water extracted for use in an establishment or industry. The water may come from natural systems (lakes, rivers, groundwater) or from municipal or other sources.

Recirculated water = water recirculation or recycling

- Water that is used more than once, often for different processes. Recirculated water can also refer to water that leaves a particular process and then re-enters that same process, including water that is discharged to a cooling pond and is later re-used. Most water recycled by Canadian industries is for cooling and processing activities.
- Water recirculation and total water intake form the gross water use of an establishment.

Evapotranspiration *is the loss of water from a land area through evaporation from the soil and through plant transpiration.*

Transpiration *is the process by which water, absorbed by plants (usually through the roots), is evaporated into the atmosphere from the plant's surface (usually through the leaves).*

Gross water use = water use

- The total amount of water used by an industrial establishment. It is the sum of total water intake and water recirculation.

Water consumption

- The water lost in the production process. In other words, consumed water is not returned to its original source.
- Water is consumed via evaporation (escaped steam in industry or evapotranspiration [see sidebar] in agriculture) or when it is incorporated into a product (e.g. in the production of soft drinks).

Water discharge = wastewater, effluent

- The water returned to the environment in liquid form, usually close to the point of use. Discharged water may be treated or untreated.
- An establishment's total water intake is equal to the sum of its consumption and discharge.

MCM

- An abbreviation for million cubic metres.

Definitions used by Statistics Canada

Total water intake (water withdrawal) refers to the total amount of water added to the water system of the establishment to replace water discharged or consumed during production. It may be broken down into the amounts withdrawn from various sources (e.g. surface water, groundwater) and the amounts used for various purposes, or end uses. The latter refers to the initial use of water in these purposes – cooling, processing, condensing, steam generation, and sanitary and other purposes. Cooling and condensing water refers to water used for the production of steam or the dissipation of waste heat. Processing water refers to water that comes in contact with an intermediate or final product of the manufacturing operation. Sanitary water use serves basic human sanitary requirements at industrial establishments.

Recirculated water (recirculation or recycling) refers to water used more than once in an industrial establishment and in Canada applies mainly to cooling and processing activities. Recirculation does not refer to water used a number of times within a particular process subsystem of an establishment, but only to water that leaves a particular process subsystem and re-enters it or is used in another process. Recirculation and water intake combine to form the gross water use of an establishment.

Gross water use refers to the total amount of water used in the production of a product. It is the sum of total water intake and water recirculation.

Water consumption refers to water that is lost in the production process. In other words, consumed water is not returned to its original source. The two major portions of consumed water are escaped steam and the incorporation of water into a product,

as for example in the production of soft drinks. Water consumption is a strictly "local" concept for the purposes of this report and refers to water not returned to the source of abstraction in the vicinity of the establishment in question. Therefore, "consumption" is used in Industrial Water Use, 2005 as an accounting concept to describe the water balances at single establishments only. In the broader context, because of the earth's water cycle, water is never really "consumed" (evaporated water will fall back to the earth in the form of precipitation, so is not "lost" to the environment as a whole).

Wastewater (effluent) discharge refers to water that is returned to the environment in liquid form, usually close to the establishment. Discharged water may be treated or untreated. The sum of water discharge and water consumption is approximately equal to the total water intake of the establishment.

Appendix of Diagrams

Figure 1a **Total water use by major Canadian sectors**

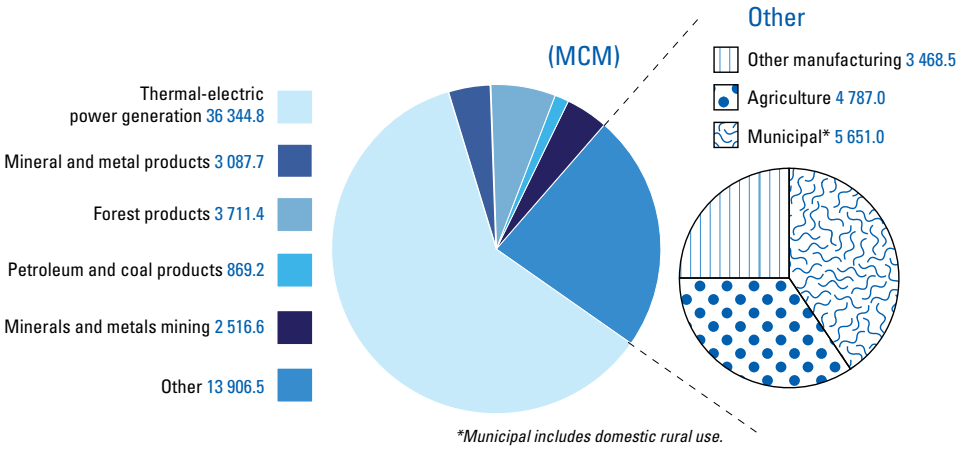


Figure 1b **Water consumption by major Canadian sectors**

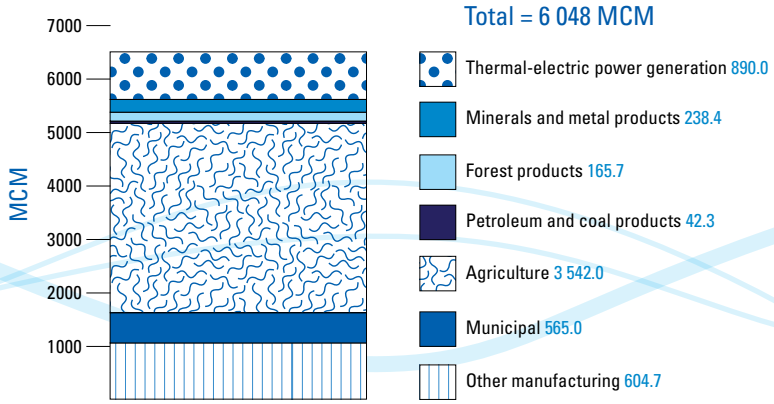


Figure 2 Sources of NPRI-reported pollutant releases to water, 2003

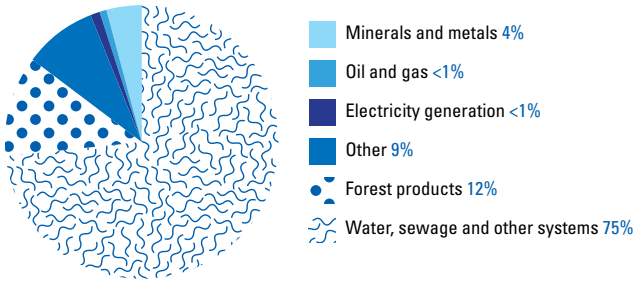
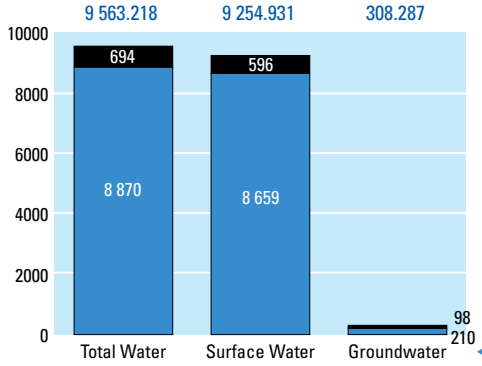


Figure 3 Quantity of surface water and groundwater licensed for use in Alberta, 2005



Canadian Association of Petroleum Producers. 2006. Water Use by Alberta's Upstream Oil and Gas Industry. Available at: www.capp.ca

Figure 4 Paper products manufacturing water use trends 1986–2005

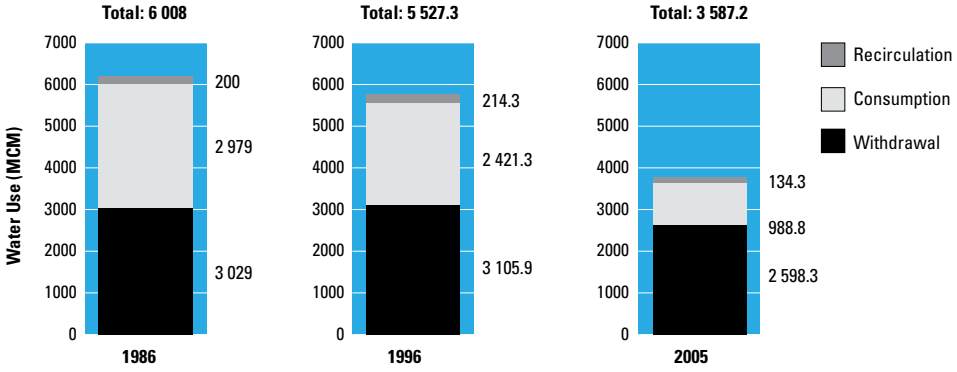


Figure 5 Forest products manufacturing total water costs, 2005 - $508 million