

## **Water – A Precious Resource**

**Canadian Petroleum Products Institute**

**February 2010**

## Water – A Precious Resource Canadian Petroleum Products Institute

Section	Topic	Pages
I	<b>CPPI Water Management Framework</b>	(see separate power point presentation)
II	<b>How is Fresh Water used in Petroleum Refining?</b>	3 - 5
III	<b>Petroleum Refining and Water</b> <ul style="list-style-type: none"> <li>• A History of Continuous Improvement</li> </ul>	6
IV	<b>Examples of Recent Actions and Current Plans by CPPI Refiners to:</b> <ul style="list-style-type: none"> <li>• Further Reduce the quantity of water used</li> <li>• Further Protect the quality of returned water</li> </ul>	7 - 8
V	<b>Quantity of Water Used and Consumed by CPPI Member Refineries</b>	9 - 10

### Canada's Water Resources

Relative to other countries, overall Canada is blessed with an abundance of high quality fresh water and large water ecosystems that support a large and diverse array of plant and animal wildlife.

In some areas of Canada though, that resource is under severe stress – both the available quantity due to increasing demand from all sectors and the quality of the water ecosystem.

Governments are actively engaged in developing sound policies to dramatically improve the management and protection of Canada's water resources.

The petroleum refining industry has been a leader in responsibly managing its use of water and supports the broad policy undertakings currently underway by Canadian governments.

This paper describes the role of water in today's petroleum refining industry in Canada against a backdrop of a history of Canadian leadership by the industry in managing its use of water responsibly over the past century.

## **Section II**

### **How is Fresh Water used in Petroleum Refining?**

Section II is about fresh water and its importance to petroleum refining. It is intended to provide a background level of understanding to readers unfamiliar with the petroleum refining industry and the key role that water plays in the operation of an oil refinery. It also focuses on the path ahead and what CPPI refiners are doing to improve the quality of their water effluents and minimize their consumption of water.

Water is used in the refinery in many different ways. In many cases, the water withdrawn from the ecosystem is used, treated and returned. Only a portion of the water withdrawn is consumed as a chemical feedstock or lost to evaporation in a cooling tower. In fact, in some areas of the country, the amount of water collected and treated at the site from crude and rainwater actually exceeds the refinery water consumption. At these sites, the refinery returns more water to the ecosystem than it removes! In more arid regions of the country, where there is a shortage of large water bodies and cooling towers are more prevalent, the water use is lower and the water consumption is higher.

The members of the Canadian Petroleum Products Institute currently operate seventeen refineries across Canada. The average water intake is 3,700 m<sup>3</sup> per 1,000 m<sup>3</sup> of crude oil processed, however the average water consumption is much lower, at 400 m<sup>3</sup> per 1,000 m<sup>3</sup> of crude oil processed.

#### **Water used to remove salt from crude oil**

All conventional crude oils (except synthetic or bitumen) have about 60 -100 kilograms (kg) of salt per 1,000 cubic meters (m<sup>3</sup>). This salt must be removed from the crude oil prior to fractionating and subsequently processing the crude oil. This processing step occurs in a desalter where crude and fresh water are intimately mixed at about 105 degrees Celsius (C). The salt dissolves in the water phase and the brine is removed from the crude. Typically treatment rate is 7% by volume fresh water, however it may be less. Based on 7%, for a 16,000 m<sup>3</sup>/day refinery, this would require about of 1,100 m<sup>3</sup>/day of water. Brine is either treated or disposed into deep underground wells.

#### **Water used as a process fluid** **In the form of steam**

There are many refining process units where water in the form of steam is required to come into contact with hydrocarbons to facilitate distillation and separation of hydrocarbon components. Steam stripping (fractionation by injecting steam into the process) is an example, as is injection steam for catalytic crackers to keep the catalyst bed fluidized. Depending on the number of process units and their size, stripping steam for a nominal 16,000 m<sup>3</sup>/day cracking refinery (with a cat cracker of ~ 5,000 m<sup>3</sup>/day) could require 25- 50 tonnes per hour or 600 - 1,200 m<sup>3</sup>/day of water as a process fluid. All the water is recovered and either reused, or returned after treatment to the water ecosystem source of the water, or disposed into deep underground wells. Refinery units needing process steam include: crude units; vacuum distillation; cat crackers; cokers; light ends fractionators; hydrogen desulphurization unit; and lube plants.

#### **In the form of condensate**

Wash water is used in the reactor effluent heat exchange train or in tower overhead systems, primarily for corrosion control.

## Section II

### How is Fresh Water used in Petroleum Refining?

#### Water used as a heating fluid

All refineries need water in the form of steam for heating purposes. For this use, the steam does not come in direct contact with the hydrocarbon. Typically, a 16,000 m<sup>3</sup>/day high intensity (coking refinery) in Canada will require between 360 tonnes per hour (summer) and 700 tonnes per hour (winter) steam load, which translates to 8,500 – 17,000 m<sup>3</sup>/day water. Most refineries will use the pressure energy in the steam to drive the motors of rotating equipment (pumps, compressors, air blowers) instead of using electricity, prior to then using the steam as a heating medium. Most of the steam (60 – 90% ) will be recovered as hot liquid condensate (hot water) and recycled for reuse. In addition to the steam plant, all refineries recover waste heat from refinery furnace and boiler stacks to boil water and convert to steam for use as a heating medium. Heating can range from high temperature level heat transfer in a steam/hydrocarbon heat exchanger, to low level heat exchange – keeping insulated pipes warm via outside the pipe steam tracing (low pressure steam in small tubing outside the wall of the pipe).

#### Water used as chemical feedstock

Most refineries use treated fresh water as a chemical feedstock for the synthesis of hydrogen – which is needed in the refinery to remove sulphur from fuel products and to upgrade heavy oil to transportation fuels. Water is chemically reacted with a hydrocarbon stream (most commonly, methane) and the reaction products are carbon dioxide and hydrogen.

#### Water used as a cooling fluid

The largest single use of water is as a fluid to cool most hydrocarbon streams to storage tankage (rundown) temperatures, which is about 5 to 10 degrees C above ambient temperatures. All refineries are heavily heat integrated with heat exchangers to transfer heat from hot hydrocarbon streams to cooler ones. Water cooling represents typically the last cooling step to return the hydrocarbon close to ambient temperature (except for heavy fractions such as lubricating oils and marine bunker oils where storage tank temperatures must be in the 95 – 140 degree C range). None of the cooling water comes into contact with the hydrocarbon and after use is either recycled or returned to the receiving body of fresh water.

There are 2 primary types of refining cooling water systems:

**Once Through Cooling Water (OTCW)** – These systems take water from the ecosystem and use it once only for cooling and then return the heated water to the water ecosystem typically at a temperature that is 5 – 10 degrees C warmer. A typical OTCW system for a nominal 16,000 m<sup>3</sup> per day cracking refinery would be 360,000 m<sup>3</sup> per day. All the water is returned to the water ecosystem without any change in water quality except slightly warmer.

## Section II

### How is Fresh Water used in Petroleum Refining?

**Cooling Water Systems (CWS) (Recirculating)** - These systems recover and reuse cooling water many times over. The heat picked up by the cooling water is released to atmosphere by flowing the warm water across wood slats of a 15 - 25 meter high structure called a cooling tower. About 10% of the water is lost to atmosphere as water vapour (to cool the rest of the water). These systems build up contaminant levels and therefore, require purge rates of 2 to 5% of total flow. The purged water is routed to the water effluent treating system to keep these contaminants from being discharged into the environment. Makeup rates therefore are ~ 15% of total flow. These systems therefore use about 80 to 85% less water than OTCW systems. To prevent growth of algae such systems need to be treated with algaecides.

Air Fin Coolers: Some refineries have moved away from water as the cooling medium to ambient air as the cooling medium. This requires much larger "air fin" (with forced air circulation) heat exchangers. The cooled hydrocarbon streams must still be cooled with water exchangers (called trim coolers) as in summer most air fins cannot meet the low final temperature requirements for the hydrocarbon streams. However, a refinery constructed with air fin coolers will typically require about 60 - 70% less cooling water than a refinery without air fin coolers.

Typically, a cracking refinery with a 30% OTCW system and a 70% CWS and with about 50% of exchangers on air cooling will use about 2,500 - 3,500 m<sup>3</sup> of cooling water per 1,000 m<sup>3</sup> of crude oil processed.

#### **Fire Water**

All refineries need access to reliable and instant access to large amounts of water in the event of a refinery fire. The water is required to cool the fire and prevent the spread of the fire to other process units and petroleum storage tanks in the refinery. When water is put on a fire, it acts to exclude air (oxygen), which helps extinguish the fire.

## Section III

### Petroleum Refining and Water – A History of Continuous Improvement

Access to fresh clean water has always been a prerequisite for petroleum refining. In Canada, the industry recognized the importance of water and its management – with an on-going track record of continuous improvement.

**1950s** – Application of Biological Oxidation Process for treatment of refinery waste water effluents. This technology was an adaptation of living organisms used in municipal waste water treatment plants to virtually eliminate the traces of dissolved hydrocarbons and other contaminants (ammonia, nitrates, sulphides) in refinery waste water. The enzymes were tailored specifically to deliberately convert petroleum refinery water effluent contaminants to harmless by-products (water, carbon dioxide and nitrogen). This process is now used universally in every refinery in the world – with effluent quality, that in most cases, exceeds drinking water standards. It was the first and still remains one of the unique examples of the use of a living biological process to treat industrial waste water effluents.

**1960's** – Several Canadian refineries worked in concert with the federal government (PACE - Petroleum Association for Conservation of the Environment) to study the behaviour of live fish in treated refinery effluents. This was the first sector in Canada (and the world) to use and research the behaviour of live fish living in treated refinery effluents (prior to the discharge of the effluent back into the water ecosystem). Over the next 15 years, coarse fish (perch, carp) were replaced with more sensitive species (rainbow trout). Since the fish thrived and with no fish kills nor impairment, refiners worked cooperatively with the federal government to send live fish (after one month exposure to effluent) to determine uptake of residual contaminants in fish flesh (called tainting). Refineries were essentially living laboratories to research and development on Canadian fish species in regards to exposure to some classes of trace industrial contaminants.

**1970's** – Water conservation efforts lead to the construction of more recycled cooling water systems for 60 to 80 percent reduction in water intake. In some cases, refineries also began a gradual process of displacing water cooling exchangers with air cooling exchangers.

**1980's** – Ontario refineries working with the Ontario government embarked on research into the most sensitive aquatic species (water fleas – *Daphnia Pulex* and *Daphnia Magna*) to test mortality, morbidity and ability to reproduce. This work led to the development of stringent water regulations, which was fully met by the petroleum refining sector.

**1990's+** - Canadian refineries typically perform with water effluents at about 7-12 percent of maximum allowed concentration limits for trace contaminants, and usually return the water used back to the water ecosystem cleaner than the water intake from the water ecosystem to the refinery.

**2000** – Some refineries are now using activated carbon filters to further lower contaminant levels.

## **Section IV – Examples of Current Continuous Improvement**

**There are several types of water actions that CPPI members are taking or planning. These kinds of improvements fall into a few groupings:**

- **Further Reduce the quantity of water used**
- **Further Protect the quality of returned water**
- **Provide education and involvement in working to address water challenges**

### **Suncor - Strathcona, Alberta Refinery**

A recycled water line from the City of Edmonton's Gold Bar Wastewater Treatment plant reduces the amount of water drawn directly from the North Saskatchewan River and provides water for Suncor's Strathcona County refinery. The 5.5-kilometre pipeline, the first of its kind in Canada, sets a new standard for environmental best practices. The award-winning project meets Suncor's water needs for new processes and provides surplus water for other users along the river valley, including the Sunridge and Nordic ski clubs for snowmaking and the parks system for irrigation and pond recharging. The public-private partnership between the City of Edmonton, Suncor and Strathcona County was funded by Suncor for approximately \$25 million.

The membrane-treated water is cleaner than the wastewater formerly returned to the river at Gold Bar. The recycled water will help Suncor meet new federal standards in the manufacture of fuels to reduce vehicle emissions. Suncor will use the water to produce hydrogen, and for general refining purposes, such as steam production and cooling. Under the water line arrangement, Strathcona County will purchase the recycled water, operate and maintain the pipeline on behalf of Suncor, and deliver the water to the refinery. About 30% of the water used for refining processes will be returned to the river through the Alberta Capital Region Wastewater Treatment Plant.

The Recycled Water Line project has been singled out by the Alberta Government for going beyond expectations in protecting water resources and exemplifying the province's Water for Life strategy.

### **Suncor**

In 2009, with an investment of nearly \$2 million, Suncor is launching three new water partnerships created jointly with Canadian Parks and Wilderness Society, Centre for Affordable Water and Sanitation Technology and Alberta Ecotrust Foundation. The programs created through these partnerships will educate and empower youth to make socially responsible decisions when it comes to water and to be role models for others in their water stewardship. Protecting water and water-related ecosystems is important to Suncor, which is why the company is focusing its Community Partnerships environmental funding in these areas. These new partnerships support the corporate-wide water principals that guide business operations around the world and help consistently manage the water footprint.

## **Imperial Oil - Sarnia Site**

Upgraded cooling water treatment means less freshwater use. Improvements to plant operations, is a continuous focus at Imperial Oil. In 2006 Imperial upgraded one of the cooling water systems at the Sarnia Site. Cooling water is now able to be recycled for longer periods of time, which resulted in 66% less water being used (from 318 m<sup>3</sup> per day to 95 m<sup>3</sup> per day). In addition, the reduced water stream from the cooling tower directionally improved the effectiveness of the water treatment facility and hence clean-up of the water stream before it was returned to the river.

## **Imperial Oil - Youth Education on Water Management In 2008**

The Society for Environment and Energy Studies Development (SEEDS) introduced the Water Systems and Habitats educational module to Grade 7 to 12 students across Canada. The module instructs students in making informed decisions about the responsible allocation of water. It presents a case study based on a real-life development project outside Calgary. In this case study, there is not enough available water in the immediate area to support the project and to make it work would require negotiation of water rights from surrounding regions.

Students assume the point of view of one of 12 stakeholders, playing roles such as the developer, mayor, environmental activist, rancher, or farmer. They then work through water allocation issues by looking at the project's rationale and options. In the end, each decides, based on what they've learned, their perspective and their own thought processes, whether they would give the project the green light or not. Their results are presented in a final statement to their classmates and teacher. This module is part of the SEEDS Habitat in the Balance series which Imperial Oil is funding with \$500,000 over five years.

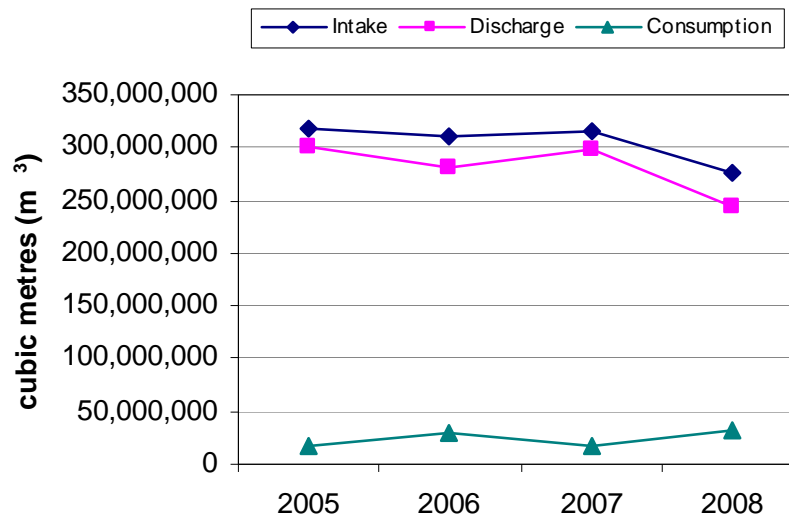
## Section V Quantity of Intake Water and Discharged Water for CPPI Member Refineries

### 2008 Industrial Water Survey Summary

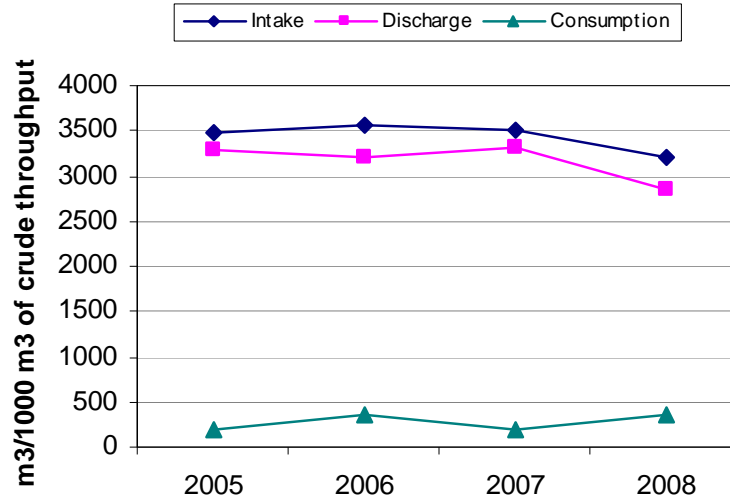
The 2008 water usage data was reviewed and the following is a brief summary of observations:

- In 2008, CPPI members Intake water totaled approximately 276,681,721 m<sup>3</sup>, while discharge water was approximately 244,770,151 m<sup>3</sup>. Both are lower than 2007 total intake and discharge of 315,959,134 m<sup>3</sup> and 298,932,486 m<sup>3</sup>, respectively.
- When normalized by throughput, total average water intake and discharge have decreased since 2007.
- Approximately 79% of the Intake water was identified as being from a “fresh” source.

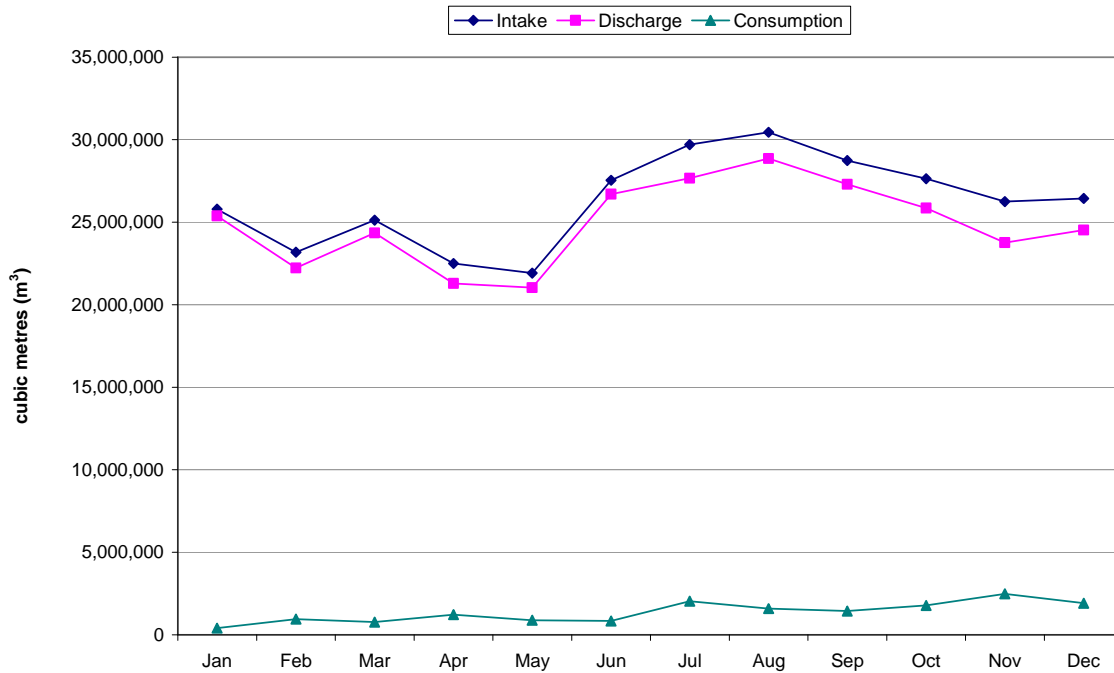
### CPPI Refinery Water Use and Consumption



## CPPI Refinery Water Use and Consumption (Normalized)



## 2007 CPPI Refinery Water Use and Consumption Seasonal Variation Impacts



Note: Update available only every two years (corresponding to the years that members report to Statistics Canada)