eQ Insights

Volume 5/August 2012

Water Use and Treatment in the Pulp and Paper Industry

The purpose of this brief is to provide our customers and stakeholders with an overview and update on water management in the pulp and paper industry. Paper buyers can use this information to make informed decisions regarding suppliers and claims about their environmental performance. They may also choose to use the systems and tools discussed below for achieving company-specific goals related to responsible water management.

The information provided herein is based on Sappi's knowledge and expertise and is supported by many of the studies included in the reference section.

Table of Contents

1

Overview

As large industrial users of water, the pulp and paper industry has long managed water in the context of a regulatory environment. In other words, all mills in North America must use and treat water in accordance with environmental permits. However, the industry is now collectively moving beyond water quality to better understand quantity and the environmental impacts of water use. Sappi and other industry participants are committed to better understanding our impacts and we have identified the evaluation of water footprinting tools and water disclosure as a key initiative. While access to water is an issue of global concern it is critical to recognize local, site-specific resources. Herein we provide an overview on water usage in the pulp and paper industry and offer reflections on the driving forces for and barriers to change.

2

The Global Water Issue

Water issues have been identified as the most serious sustainability challenges facing the planet, partly due to the impacts of climate change (1, 2). Less than 1% of the world's water is easily accessible fresh water and increasing population, urbanization, per capita demand, and pollution damage to supplies will put even greater pressure on these limited resources (3). Today, roughly 20% of the world's population (1.2 billion people) live in

sappi Sappi Fine Paper North America
255 State Street, Boston MA 02109

areas of physical water scarcity, while nearly another 25% live in areas where governments lack the technical capacity, funding, or infrastructure to meet basic human and environmental water needs (4). Freshwater availability in different areas of the globe has been mapped by the WBCSD[a] (3) and shows the following general pattern:

- Overall, North and South America, Europe and Russia are identified as areas with little or no water scarcity[b].
- Areas of physical water scarcity[c] include a portion of the U.S. southwest and south-central areas, the border of Northern Africa, large portions of Asia and southeast Australia.
- Most of central Africa is affected by economic water scarcity[d].

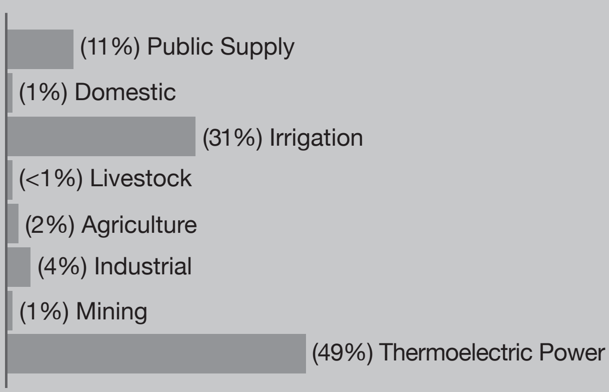
3

The Status of Water in North America

A 2010 study on the effects of global warming on water supply and demand in the contiguous United States (5) has found that more than 1,100 counties — one-third of all counties in the lower 48 — will face higher risks of water shortages by 2050 as a result of global warming. These areas include parts of Arizona, Arkansas, California, Colorado, Florida, Idaho, Kansas, Mississippi, Montana, Nebraska, Nevada, New Mexico, Oklahoma, and Texas. Water sustainability in the Great Plains and Southwest United States is at extreme risk. The study points out that the three categories of water use with the greatest demand are agricultural use, power plant cooling, and public supply. In the United States, industrial[e] water use makes up 4% of total water withdrawals (Figure 1). Thermoelectric power (49%), irrigation (31%) and public supply (11%) make up a total of 91% of the water withdrawals in the U.S. (6).

Sappi's U.S. manufacturing operations are located in regions of little or no water scarcity (Maine and Minnesota).

Summary of Estimated Water Use in the United States Figure 1



4

An Overview of Water Initiatives

Water initiatives can be broadly classified into the following three categories (7):

1. Water footprinting — as promoted by the Water Footprint Network (8). Water footprinting is a process that looks at the direct and indirect water use of any system a user wants to examine. Examples include individual product footprints, corporate, community, and even national water footprints.

2. Water Sustainability and Stewardship — as demonstrated by the Alliance for Water Stewardship (9) and the Global Water Roundtable (10). Initiating international cooperation for development of a water stewardship standard and regional and local initiatives to enable stakeholders to achieve their facility or watershed level targets.

3. Disclosure and Risk Management — as demonstrated by the Water Disclosure initiative launched by the Carbon Disclosure Project (11). Driving increased awareness and understanding of the environmental and business impacts of water use by providing a consistent vehicle for widespread reporting of water usage and associated risks.

Water footprinting is increasingly referenced in literature and the marketplace. Simply stated, a water footprint is the amount of water needed for a product, service or business, including supply chain needs. Much like when documenting carbon footprints, there is a need to define scope and boundaries of these types of measurements to help clarify results. A recent study on the water footprint of paper manufactured at a non-integrated fine paper mill in Germany (13) concluded that about 99% of the water footprint originated from the raw material supply chain and the remaining 1% from the paper mill production processes.

A summary of the key water stewardship initiatives since 2006 was compiled by the World Business Council for Sustainable Development and the International Union for Conservation of Nature (12). While the guide is not an exhaustive overview, it can help businesses identify which initiatives might best suit their needs. Several publications are available on the business risks of water scarcity and the tools available to identify and minimize risks (11,14,15,16).

a. World Business Council on Sustainable Development.

b. Abundant water resources relative to use. Less than 25% of water from rivers withdrawn for human purposes.

c. Water resources development is approaching or has exceeded sustainable limits. More than 75% of river flows are withdrawn for agriculture, industry and domestic purposes (accounting for recycling of return flows).

d. Human, institutional and financial capital limit access to water even though water in nature is locally available to meet human demands. Water resources are abundant relative to water use, with less than 25% of water from rivers withdrawn for human purposes, but malnutrition exists.

e. Includes water used in manufacturing and producing commodities, such as food, paper, chemicals, refined petroleum, wood products, and primary metals.

5

Water Use in the Pulp and Paper Industry

Pulp and paper operations are highly dependent on the use and responsible management of water resources. Water is used in all major process stages, including raw materials preparation (e.g., wood chip washing), pulp washing and screening, and paper machines (e.g., pulp slurry dilution and fabric showers). Water is also used, for process cooling, materials transport, equipment cleaning, general facilities operations, and to generate steam for use in processes and on-site power generation (13). There are important definitions to note regarding the use and fate of water at pulp and paper mills (see Figure 2).

Figure 3 illustrates in general terms the ways in which water enters and leaves a manufacturing operation.

The U.S. forest products industry withdraws the majority of its water from surface water sources and 14% from groundwater sources (19). Although the industry is a large user of freshwater, it consumes a small amount of the water that it uses. A study by NCASI[f] on the water profile of the U.S. forest products industry concluded that 88% of the water used is returned directly to surface waters following treatment; about 11% is converted to water vapor and emitted during the manufacturing process; and 1% is imparted to products or solid residuals (19,20). In addition, there have been significant industry performance improvements which have resulted in a 69% reduction in the average treated effluent flow volume at U.S. pulp and paper mills since 1959 (21). Over the past three decades, the quality of effluents has improved dramatically through in-process measures and ongoing refinement of wastewater treatment operations (22). As a result, several

Some Key Definitions

Figure 2

The following terms are commonly used to describe the pulp and paper industry's usage of freshwater (18):

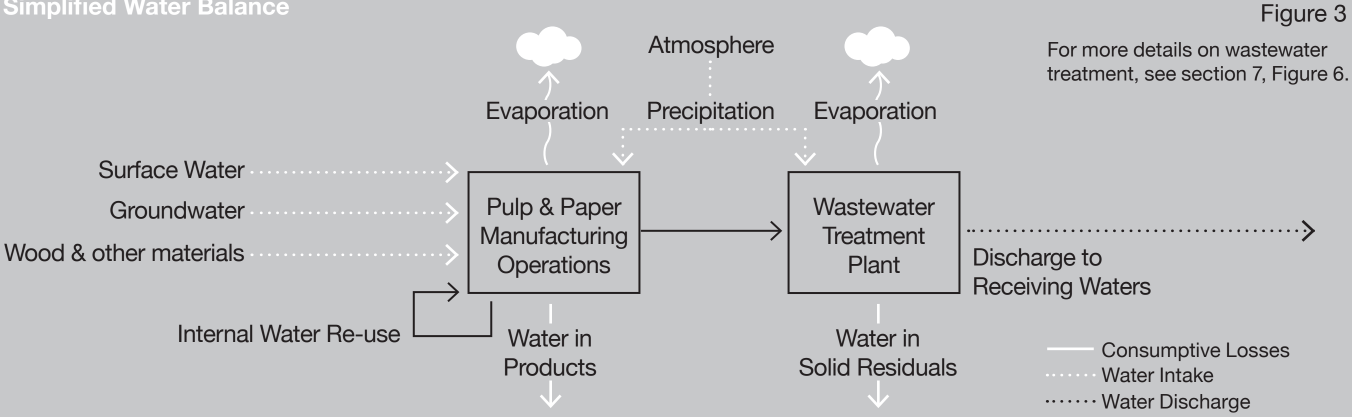
- **Groundwater**: Water held underground in the soil or in pores and crevices in rock.
- **Surface water**: Water that is on the earth's surface, such as streams, rivers, lakes or reservoirs.
- **Water use**: The total amount of water used by a facility for process and cooling needs (generally equivalent to water intake).
- **Water consumption**: The portion of water that is removed from a water source that is not immediately returned to the water source (ex: water loss due to evaporation and water leaving with product and solid residuals).
- **Effluent** (sometimes also called "wastewater"): The water discharged from a facility, often subcategorized into treated process effluent and non-contact cooling water effluent.
- **Treated process effluent**: Water that has come into contact with process materials, and thus has a certain degree of contamination from process materials. Process effluent is usually treated mechanically and biologically to remove organic material.
- **Non-contact cooling water effluent**: Water that is used for cooling duty that does not come into direct contact with process water but is usually of a higher temperature than the water entering a mill.
- **Evaporative losses**: Water that evaporates to the atmosphere, and eventually returns to the earth as rain.

When discussing water, the type of water use should be clearly defined. For example: intake, discharge, evaporation, consumption.

Simplified Water Balance

Figure 3

For more details on wastewater treatment, see section 7, Figure 6.



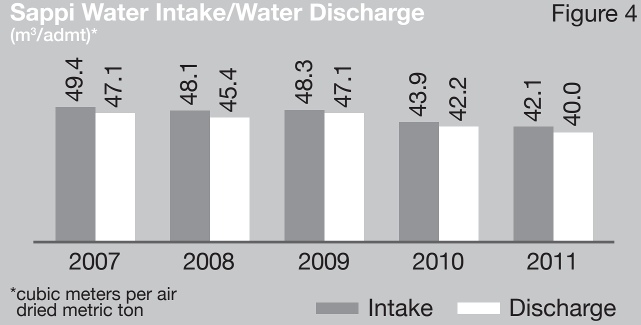
f. National Council for Air and Stream Improvement.

extensive studies on treated effluents show that there are few or no concerns regarding the compatibility of these effluents with healthy aquatic systems (19).

Between 2007 and 2011, Sappi reduced its specific water intake by nearly 15% and our performance data indicates that over 95% of our water intake is discharged back to the receiving environment (Figure 4).

The bulk of the consumed water is presumed to be lost to the atmosphere through evaporation. Both the water intake and discharge numbers include non-contact cooling water.

Sappi Water Intake/Water Discharge Figure 4



6

The Importance of Our Forests

Forests act to process precipitation into high quality surface waters (20). The NCASI water profile study reports that 67% of freshwater in the U.S. originates from forests (54% from timberland) and therefore society and industry have a shared interest in maintaining forests and the water resource benefits of forested land. Forest management can help minimize impacts to surface and groundwater by the use of Best Management Practices, including forest regrowth. Water inputs for the manufacture of forest products equal about 0.4% of the surface and groundwater yield from timberland in the U.S. and forest management generally has small and short-term impacts on water resources (19).

7

Water Treatment

Water used in the pulp and paper-making process requires treatment prior to discharge to any receiving waters. Effluent treatment is typically needed to meet environmental regulations and minimize environmental impacts to aquatic ecosystems. Some of the historical impacts of pulp and paper mill effluents have included oxygen depletion of receiving waters, solids settling on the bottom of lakes, rivers or marine areas, bioaccumulation of persistent organic chemicals in the aquatic food web, and eutrophication (increased algal growth) due to effluent loading of phosphorus and nitrogen (24). The characteristics of the untreated process effluent depend largely on the type of pulp and paper products manufactured at the mill site (25, 26), for example:

- Bleached and unbleached kraft pulp
- Pulp using the CTMP process (integrated or non-integrated mills)
- Integrated mechanical pulp and paper mills
- Recycled fiber paper mills (with and without de-inking, or tissue mills)

In the U.S., the final treated mill effluent must meet state and federal regulations (27, 28, 29) which include limits on water intake and effluent quality parameters. Water and effluent testing is conducted routinely by laboratories at mill sites, as well as by specialized private laboratories. Figure 5 below lists some

Common Parameters Figure 5

- **5-day biochemical oxygen demand (BOD5)**: The amount of dissolved oxygen consumed in five days by biological processes breaking down organic matter. The test is used to infer the general degree of organic loading of the effluent.
- **Total suspended solids (TSS)**: TSS is a measure of the settleable and non-settleable solids in wastewater.
- **Chemical oxygen demand (COD)**: A measurement of the overall pollutant load in terms of chemically oxidizable (degradable) solids. Unlike BOD, COD measurements are taken by chemical oxidation in controlled standardized conditions.
- **Chlorinated organics**: This includes several classes of chemicals such as chlorinated phenolic compounds, dioxins and furans, to name a few. AOX (adsorbable organic halogens) is a common measurement which regroups many of the chlorinated organic compounds contained in effluent produced during the bleaching of pulp. Certain chlorinated organics, such as polychlorinated dibenzo dioxins and polychlorinated dibenzo furans (PCDFs) are a concern due to their toxicity, persistence and bio-accumulative properties.
- **Flow**: This is typically the volume of treated effluent discharged to a receiving environment. In many cases mills also measure the volume of water intake and cooling water.
- **Temperature and pH**: These are standard measurements. pH is an indication of the acidity or alkalinity of an effluent.
- **Metals (ex: copper, zinc, nickel, cadmium, chromium, lead, mercury)**: Heavy metals are often measured in effluents depending on applicable regulations. Metals can cause toxicity to aquatic organisms and some, like mercury, can bio-accumulate in the food chain.
- **Phosphorus and nitrogen**: Phosphorus and nitrogen are both naturally occurring elements, but they are also key elements found in fertilizer. An increase of these elements in the aquatic environment can lead to nuisance growth of aquatic plants and oxygen depletion of receiving waters (i.e., eutrophication).

common parameters measured in pulp and paper mill effluents. Pulp and paper effluent treatment methods depend largely on the limits imposed by environmental regulations and can vary by location. In North America, mills typically operate primary and secondary (or biological) treatment systems, and, in some cases, tertiary treatment to achieve desirable levels of effluent quality.

Pulp and paper mill effluent treatment typically includes the following components (Figure 6):

- **Primary effluent treatment**. This may consist of neutralization, screening, sedimentation, and flotation/hydro-cycloning to remove suspended solids. Many mills operate primary clarifiers that can remove up to 95% of settleable solids in the process effluent.
- **Biological/secondary treatment**. This stage significantly reduces the organic content and toxicity of the effluent due to active biodegradation by microorganisms (i.e., bacteria, protozoans) living in the treatment plant and using the effluent as a source of food (carbon). The most commonly used biological treatment systems in the pulp and paper industry are Aerated Stabilization Basins (ASB) and Activated Sludge Treatment (AST). A key feature of these systems is aeration by surface or submerged aerators, and the addition of nutrients (nitrogen, phosphorus) to maintain a healthy population of microorganisms. ASB and AST systems typically reduce BOD5 by over 80% and COD by 50% to 90%.
- **Tertiary treatment**. This involves chemical precipitation to remove certain chemicals, reduce toxicity, suspended solids, and color.

Solids collected in the various treatment stages are typically dewatered and used as a fuel for energy production, and in some cases fibers and coating materials may be re-used or recycled back into the mill process.

Depending on local regulations, cooling water can either be discharged without treatment, or may require some form of treatment and/or monitoring (ex: flow and temperature) prior to discharge. Storm water (i.e., from roofs, parking lots, yards) and sanitary effluent from mill sites make up a relatively small portion of water used and are typically collected and treated to meet environmental regulations prior to being returned to receiving waters.

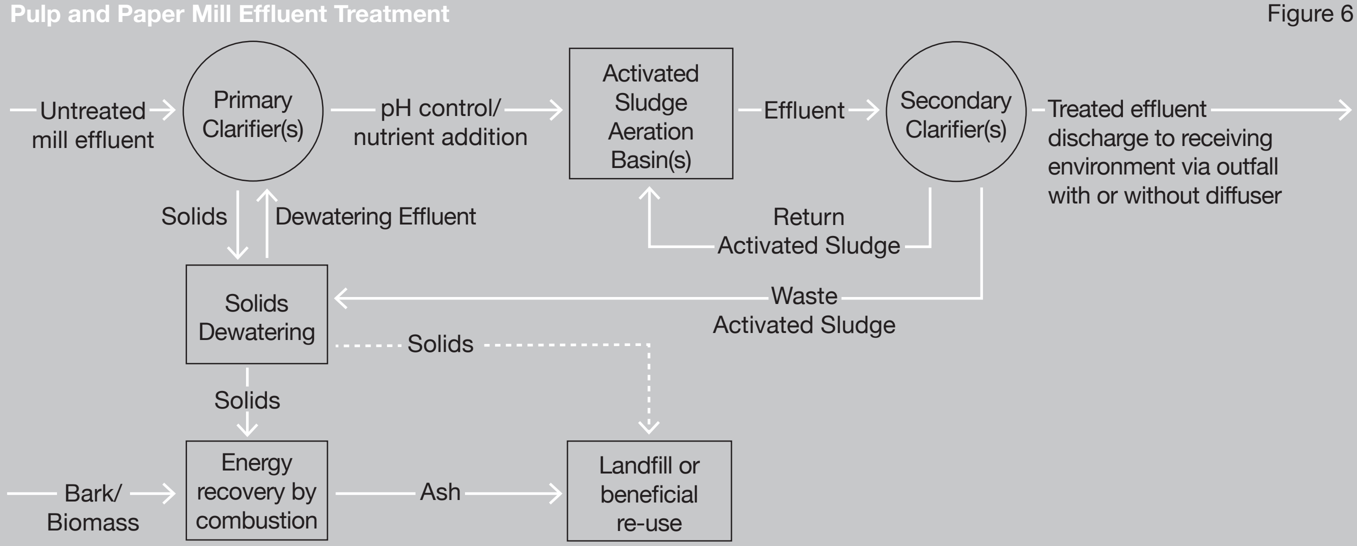
7.1 Best Practices

The benefits of reducing water use at pulp and paper mill sites include less overall chemical and energy use, lower fuel costs, reduced wastewater discharges, reduced water treatment costs and a cleaner effluent discharge, sometimes due to higher retention time in the effluent treatment plant. Water efficiency measures are usually grouped into two major categories: 1) general and facilities water management (i.e., goals, targets, audits, good housekeeping), and 2) process strategies (i.e., upgrading equipment, optimizing water re-use, reducing losses) (17).

Energy savings are closely linked to water reduction given that pulp and paper mills heat water to produce hot water and steam for cooking wood chips, pulp washing, transporting pulp, drying paper and other applications. The key production and control practices that will lead to water reduction, improved effluent quality, energy savings and regulatory compliance at pulp and paper mills include the following (17, 25, 26, 30):

- Dry (instead of wet) debarking processes.
- Recycling and re-use of certain process streams and cooling water, including optimizing shower water use and improving white water quality.
- Minimizing solids losses for coated paper production (including use of coating recovery systems).
- Water conservation measures in the mill (e.g., vacuum pump seal water)
- Preventing and controlling spills of black liquor in the manufacture of kraft pulp.
- Using elemental chlorine-free bleaching systems.
- Reducing the use of bleaching chemicals (and energy) by extended cooking and oxygen delignification.

Pulp and Paper Mill Effluent Treatment — Figure 6



Some of the preceeding practices can result in water and/or energy savings of hundreds of thousands to millions of dollars per year per mill site (17). The age of installed equipment has a significant influence on the water efficiency of a mill. Mills that have newer or recently upgraded equipment are generally the most water efficient, while mills with older, more water intensive equipment are typically the least water efficient (31). Additional references are available on water reduction within the pulp and paper industry (17,30).

One of the key challenges for pulp and paper mills is the fact that recycling of process water (instead of freshwater use) is limited by the accumulation of dissolved matter from wood and other raw materials entering the process. Some of the problems associated with contaminant accumulation are deposition and scaling, foaming, corrosion, stream dead load, and degradation of the end product quality parameters. While strategies for controlling these contaminants can be developed, the degree to which further water reduction can be achieved becomes a site-specific challenge (21).

8

Drivers and Barriers to Change

The main drivers for responsible water management are regulations, the marketplace and drought (7). In addition to effluent regulations, water use regulations are now emerging such as the EPA cooling water intake structures rule (Clean Water Act Section 316b) and the Great Lakes — St. Lawrence River Basin Water Resources Compact (7).

Marketplace drivers include systems and tools used by companies for improving water management and reporting performance. The following are examples of some well-known initiatives:

- Alliance for Water Stewardship (9)
- Carbon Disclosure Project — Water Disclosure (11)
- Ceres Aqua Gauge (32)
- Global Water Roundtable (10)
- Global Water Tool (WBCSD) (33)
- UN CEO Water Mandate (34)
- Water Footprint Network (8)

Drought is a third driver for change and can have serious implications on industrial sites and their receiving environments, including mill shutdowns for periods of days (7).

The barriers for change related to water management are economic, social and technical, such as new capital investments needed, regulatory uncertainties, the risks associated with new methods and a lack of breakthrough innovations, to name a few (35).

9

Summary

Water scarcity is a rapidly growing global concern that will influence water resource management in most regions of the world, including parts of North America. Access to water resources is becoming more controlled, especially for industrial water users. Best practices and tools in the realm of water footprinting and disclosure are developing and now being used by an increasing number of companies to identify and manage business risks related to water.

The North American pulp and paper industry is highly regulated with respect to water use and effluent quality. Environmental regulations establish a minimum baseline that companies must meet in order to prevent negative environmental impacts. The age of the technology in use at mill sites is a key factor influencing environmental performance, water and energy use. Implementation of best practices cuts water use and improves effluent quality through cleaner production processes and pollution prevention measures, which can yield both economic and environmental benefits. Improved water management is often directly linked to reduced energy use and lower greenhouse gas emissions.

Although the manufacture of pulp and paper is water-use intensive relative to most other industries, the amount of water consumed (i.e., evaporated or exported with products or residuals) represents a small fraction of the overall water used. Approximately 88% of the water used by the U.S. forest products industry is returned to surface waters following treatment. There have been significant improvements in both water use and effluent quality in the U.S. pulp and paper industry. While environmental effects of treated effluents are sometimes observed, aquatic communities are usually not altered by well-treated mill effluents. In North America, most surface waters are derived from forested areas. Forest management can affect water quality and the use of forestry best management practices greatly minimizes harmful effects (19, 20).

10

References

All Web links validated as of July 31, 2012.

1. United Nations Global Compact. 2011. Fresh Water Resources and Related Services. IV UN Conference on the Least Developed Countries, Private Sector Track. http://www.unglobalcompact.org/docs/issues_doc/Environment/LDC_Water_Final.pdf

2. Bates, B.C., Z.W. Kundzewicz, S. Wu, and J.P. Palutikof, Eds., 2008. Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva.

3. WBCSD. 2009. Facts and Trends — Water, Version 2. World Business Council for Sustainable Development.

4. Comprehensive Assessment of Water Management in Agriculture. 2007. *Water for food, Water for life: A Comprehensive Assessment of Water Management in Agriculture*. London: Earthscan and Colombo: International Water Management Institute.

5. NRDC. 2010. Climate Change, Water, and Risk: Current Water Demands Are Not Sustainable. Natural Resources Defense Council. http://www.nrdc.org/globalwarming/watersustainability/files/WaterRisk.pdf

6. Kenny, Joan F., et al. 2009. Estimated Use of Water in the United States in 2005. U.S. Dept. of the Interior, U.S. Geological Survey Circular 1344. http://pubs.usgs.gov/circ/1344/pdf/c1344.pdf

7. Schwartz, J. 2011. External Pressures and Drivers. Presentation given at Water Sustainability in the Pulp and Paper Industry (AIChE & TAPPI), Nov. 10-11, 2011, Providence, RI.

8. The Water Footprint Network. http://www.waterfootprint.org/?page=files/home

9. The Alliance for Water Stewardship. http://www.allianceforwater stewardship.org/

10. The Global Water Roundtable. http://www.allianceforwater stewardship.org/what-we-do.html#water-roundtable

11. Irbaris for CDP. 2009. CDP Water Disclosure — The Case for Water Disclosure. Carbon Disclosure Project. London, November 2009.

12. WBCSD and IUCN. 2010. Water for Business — Initiatives Guiding Sustainable Water Management in the Private Sector, Version 2. World Business Council for Sustainable Development and International Union for Conservation of Nature. March 2010.

13. UPM-Kymmene. 2011. From Forest to Paper, the story of our water footprint. August 2011. http://www.waterfootprint.org/Reports/UPM-2011.pdf

14. Pacific Institute for Ceres. 2009. Water Scarcity & Climate Change: Growing Risks for Businesses & Investors. Ceres Boston, MA, February 2009.

15. J.P. Morgan. 2008. Watching water — A guide to evaluating corporate risks in a thirsty world. JP Morgan Global Equity Research, March 2008.

16. Pegasys Consulting for WWF. 2009. Investigating Shared Risk in Water: Corporate Engagement with the Public Policy Process. World Wildlife Fund. March 2009.

17. Kramer, K., et al. 2009. Energy Efficiency Improvement and Cost Saving Opportunities for the Pulp and Paper Industry (Report No. LBNL-2268E), Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, CA. October 2009. http://www.energystar.gov/ia/business/industry/downloads/Pulp_and_Paper_Energy_Guide.pdf

18. Malmberg, B., et al. 2010. Water Profile of the Canadian Forest Products Industry. NCASI Technical Bulletin No. 975, National Council for Air and Stream Improvement, Inc., Research Triangle Park, NC.

19. Flinders, C. 2009. Water Profile of the United States Forest Products Industry. NCASI Technical Bulletin No. 960, National Council for Air and Stream Improvement, Inc., Research Triangle Park, NC.

20. Wiegand, P. S. et al. 2011. Water Profiles of the Forest Products Industry and Their Utility in Sustainability Assessment. *TAPPI Journal*: July 2011, p. 19-27.

21. NCASI, Environmental Footprint Comparison Tool. http://www.paperenvironment.org/water.html

22. American Forest & Paper Association (AF&PA). 2008. AF&PA Environmental, Health & Safety Verification Program, Biennial Report 2008. AF&PA, Washington, DC, USA.

23. Sappi Fine Paper North America. 2011. 2011 Sustainability Report. Sappi Fine Paper North America, Boston, MA.

24. Riebel, P.N. and D. Borton. 2000. Bioassessment of the Aquatic System. *Industrial Environmental Control — Pulp and Paper Industry*, 3rd edition, p. 29-64, Allan M. Springer, Ed., TAPPI Press, Atlanta, GA.

25. European Commission. 2001. Integrated Pollution Prevention and Control (IPPC) — Reference Document on Best Available Techniques in the Pulp and Paper Industry. December 2001.

26. WBG, UN Environment Programme and the UN Industrial Development Organization. 1999. Pollution Prevention and Abatement Handbook 1999 — Toward Cleaner Production. Industry Sector Guidelines, Pulp and Paper Mills. Pp. 395-400. World Bank Group, Washington, DC.

27. U.S. EPA, Summary of the Clean Water Act, United States Environmental Protection Agency. http://www.epa.gov/lawsregs/laws/cwa.html

28. U.S. EPA, National Pollutant Discharge Elimination System (NPDES) Title 40 Protection of the Environment, Part 430 — The Pulp, Paper and Paperboard Point Source Category. http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&tpl=ecfrbrowse/Title40/40cfr430_main_02.tpl

29. Maine DEP, Maine Water Quality Laws. http://www.maine.gov/dep/water/index.html

30. U.S. EPA, Office of Air and Radiation. 2010. Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from the Pulp and Paper Manufacturing Industry. Prepared by the Sector Policies and Programs Division, Office of Air Quality Planning and Standards, U.S. EPA, Research Triangle Park, N.C., October 2010.

31. Bryant, P.S, E.W. Malcolm and C.P. Woitkovich. 1995. Pulp and Paper Mill Water Use in North America. IPST Technical Paper Series Number 601, Institute of Paper Science and Technology, Georgia Institute of Technology, Atlanta, Georgia.

32. Ceres. 2011. The Ceres Aqua Gauge: A Framework for 21st Century Water Risk Management. Ceres, WBCSD, Irbaris, and IRRC Institute. http://www.ceres.org/issues/water/aqua-gauge/aqua-gauge

33. World Business Council for Sustainable Development. Global Water Tool 2011. http://www.wbcsd.org/work-program/sector-projects/water/global-water-tool.aspx

34. United Nations Global Compact. United Nations CEO Water Mandate. http://www.unglobalcompact.org/Issues/Environment/CEO_Water_Mandate/

35. Brown, R. 2011. Challenges in Reducing Water Use. Presentation given at Water Sustainability for the Pulp and Paper Industry, (AIChE & TAPPI) Nov. 10-11, 2011, Providence, RI.

We invite you to share your thoughts so that we can all benefit from innovative thinking and best practices. For questions and comments on this document, please email us at eQ@sappi.com.