WATER SECURITY GUIDANCE DOCUMENT

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PART 1 SECTION 1
DEFINING AND ASSESSING WATER SECURITY

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ABSTRACT

The section introduces the project, outlining the concept of water security, including how it is defined and the genealogy of the term. Current approaches to measuring and assessing water security are outlined, along with a guide to using this Guidance Document.

THIS SECTION IS BASED ON THE FOLLOWING JOURNAL ARTICLES AND POLICY REPORTS:

Cook, C. and Bakker K. (2011). **Water Security: Debating an emerging paradigm**. Global Environmental Change, 22(1): 94 - 102. http://dx.doi.org/10.1016/j.gloenvcha.2011.10.011

Dunn, G. and Bakker, K. (2011). **Fresh Water-Related Indicators in Canada: An Inventory and Analysis**. Canadian Water Resources Journal Vol. 36(2): 135-148.

Norman, E.S., Bakker, K and Dunn, G. (2011). **Recent developments in Canadian Water Policy: An emerging water security paradigm**. Canadian Water Resources Journal Vol. 36(1): 53-66.

Emma Norman with Karen Bakker, Christina Cook, Gemma Dunn and Diana Allen (2010). **Water Security: A Primer**. Vancouver, BC: UBC Program on Water Governance. http://www.watergovernanace.ca/wp-content/uploads/2010/04/WaterSecurityPrimer20101.pdf

Dunn, G. and Bakker, K (2009). **Canadian Approaches to Assessing Water Security: an Inventory of Indicators** (Policy Report). Vancouver, BC: UBC Program on Water Governance. http://www.watergovernance.ca/PDF/IndicatorsReprtFINAL2009.pdf

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March 2012

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BACKGROUND: KEY ISSUES AND CONTEXT

Fresh water-related issues are of growing concern throughout Canada, both in terms of quality and quantity:

- According to Environment Canada, one quarter of all Canadian communities have experienced water shortages since the mid-nineties.
- Water quality in more than one thousand rural communities is as bad as or, in some cases, worse than many developing countries. In 2007 alone, there were 1766 boil water advisories across Canada in small towns, cities and townships, some of which had been in place for more than 5 years. A further 93 were in place in First Nations communities (Eggerston 2008).
- Some ecosystems are showing signs of stress due to compromised water quality and declining water levels.
- These issues will be affected by global climate change impacts (the full scope of which is still unknown).

There are multiple stressors that result in water insecurities. Many water management approaches fail to link water quality and quantity together, both in terms of human health and aquatic ecosystem health. Furthermore, often there is inadequate consideration and assessment of risks to water. Disparate water management challenges demand a broad integrative approach that accounts for multiple stressors and cumulative effects. We suggest that the concept of water security, broadly defined, is one promising approach to sustainable water governance.

PURPOSE OF THE GUIDANCE DOCUMENT

The purpose of this Water Security Guidance Document is to:

a. Define the concept of water security, and document multiple perspectives on this concept (*Part I*)
b. Present methods for small water system managers to assess potential risks to water security (*Part II*)
c. Present possible responses to these risks, focusing on governance-based strategies (*Part III*)

INTENDED USERS

This Water Security Guidance Document has been developed for small communities to assess risk to water security in their watershed, but many of the concepts and issues are applicable at larger scales. The Water Security Guidance Document contains a broad range of information for both experts and non-experts. Intended users include, but are not limited to: community watershed groups, citizen environmental committees, water managers, municipal water policy and decision makers, aggregate mining industry officials, source water protection groups, provincial water planners and watershed groups, health authority officials and water suppliers.

FORMAT OF THE WATER SECURITY GUIDANCE DOCUMENT

The Water Security Guidance Document comprises three parts:

Part 1 – Concepts: *Part I* introduces the concept of water security, outlining multiple perspectives on water security, and current approaches used to assess water security.

Part 2 – Assessing Water Security (Measuring Risk): *Part II* comprises step-by-step guides to applying each component of the water security assessment framework including risk assessment, vulnerability scoring, current status, and groundwater quality mapping. Although these tools can be used independently, they can also be applied in combination, depending on the needs and resources of the community. It is important to note that these concepts are deeply interconnected, and together form a comprehensive assessment of overall water security. Indeed, the *Water Security Risk Assessment (Section 2)* is strongly tied to the *Water Security Status Indicators (Section 4)*. The *Vulnerability Scoring Method (Section 3)* is a component of overall *Water Security Risk Assessment (Section 2)*. Likewise, *Mapping Groundwater Contamination (Section 5)* is a component of *Water Security Status Indicators (Section 4)* illustrating methods to spatially represent data.

Part 3 – Managing Water Security (Adaptive Governance): *Part III* outlines some approaches developed during the project for water managers to manage risk to water security. It includes *Fostering Good Governance Practices (section 6)* and *Boil Water Advisories Protocol (section 7)*.

Appendix A: Gives an overview of the project including research team and project partners.

Appendix B: Lists all project-related outreach activities (including peer reviewed journal articles, policy reports, conference and workshop presentations, and advisory roles).

Table 1: The Water Security Guidance Document (2012)

Part I: Water Security (Concepts)	
	Overview of the Guidance Document
	Defining and Assessing Water Security
Part II: Assessing Water Security (Application)	
Section 2	Water Security Risk Assessment (WSRA)
Section 3	Water Security Risk Scoring Method
Section 4	Water Security Status Indicators (WSSI)
Section 5	Mapping the Likelihood of Groundwater Contamination
Part III: Managing Water Security (Governance)	
Section 6	Working Towards Water Security: Fostering Good Governance Practices Through Adaptive Management
Section 7	Boil Water Advisory Protocol

Appendices: Ancillary Material	
Appendix A	Project Overview
Appendix B	Complete List of Water Security Project Publications

DEFINING WATER SECURITY

Water security is an emerging concept, which has gained increasing attention over the past five years. For example, in 2009, the World Economic Forum described water security as "the gossamer that links together the web of food, energy, climate, economic growth and human security challenges that the world economy faces over the next two decades" (World Economic Forum 2009, 5). In this Guidance Document we define water security as "sustainable access on a watershed basis to adequate quantities of water, of acceptable quality, to ensure human and ecosystem health". This definition sets baseline requirements for water resources management in a watershed on a continuous basis; there must be access to adequate quantities of acceptable quality of water for both humans and the environment.

Water security takes a broad look at all demands placed upon a watershed, including quality, quantity (including climate change and allocation), aquatic ecosystem health, human health, risk and adaptive governance. Water security demands a greater priority for water. As such, it is a broad concept of integrated water management that balances resource protection and resource use. It is important to measure water security because this approach examines the watershed as a whole. Setting a goal of water security could enable decision-makers to effectively assess and mediate between conflicting demands for water use and minimize potentially adverse impacts from land and water management practices.

Water security-related issues have been of growing concern in Canada over the past decade. Well-publicized water contamination incidents in Walkerton (Ontario), North Battleford (Saskatchewan), and Kashechewan (Ontario) have alerted Canadians to public health issues related to water quality (Butler 2008; O'Connor 2002; Parr 2005). At the federal level, reports from the National Water Resources Institute (Environment Canada) and the Senate on increased threats to water have attracted renewed attention to water issues (Environment Canada 2001, 2004; Senate of Canada 2005).

Canada is not alone in dealing with water quality and water quantity concerns. Water, by its very nature, presents managers with three issues that are difficult to resolve: (1) competition between users of water resources; (2) vertical coordination of the multiple levels at which water is used and managed; and (3) the mismatch between geopolitical and administrative boundaries, on the one hand, and hydrological boundaries on the other.

These issues flow, in part, from the fact that water is a multi-purpose resource, with multiple sets of users operating at different scales. In turn, this creates competing uses and diverse views of stakeholders within the policy debate. For example, cities sit within watersheds, and the water within cities is often the subject of competing claims both upstream and downstream: industrial, tourism, amenity, residential, agricultural, and resource (e.g., hunting and fishing) uses. The debate over the Oak Ridges Moraine (north of Toronto) is one such example, of which there are many across the country.

CONCEPT OF WATER SECURITY: GENEALOGY OF THE TERM[1]

Despite increased concern about water-related issues, no common definition of water security exists. Indeed, use of the term water security has increased across a wide range of disciplines in the last decade. Figure 1 illustrates the trend of steadily increasing frequency of use of the term "water security" in academic, peer-reviewed journals.

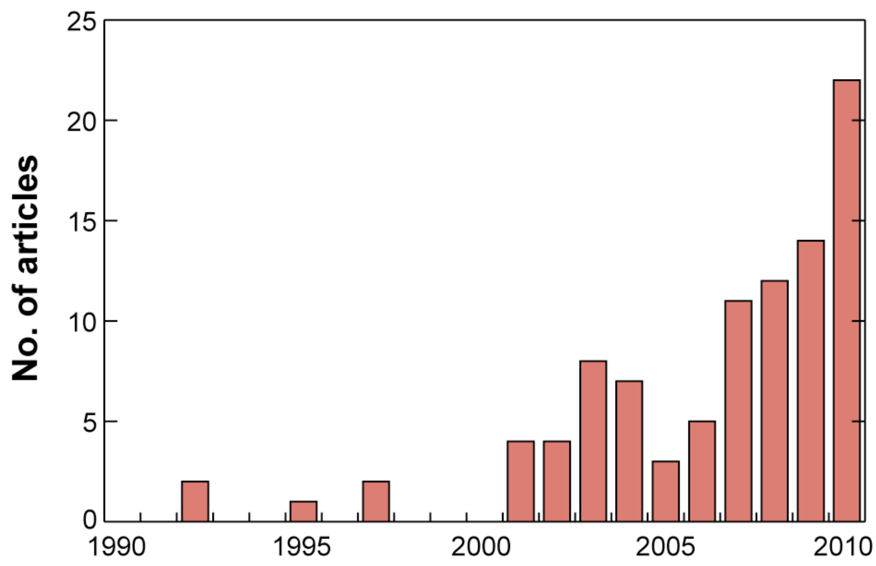

Figure 1: Articles containing the term "water security" in the academic literature (1990 – 2010). Source: Web of Science database

The analysis also illustrates the diversity of disciplinary approaches currently characterizing academic research on water security. Figure 2 indicates that a wide range of disciplines use the term "water security".

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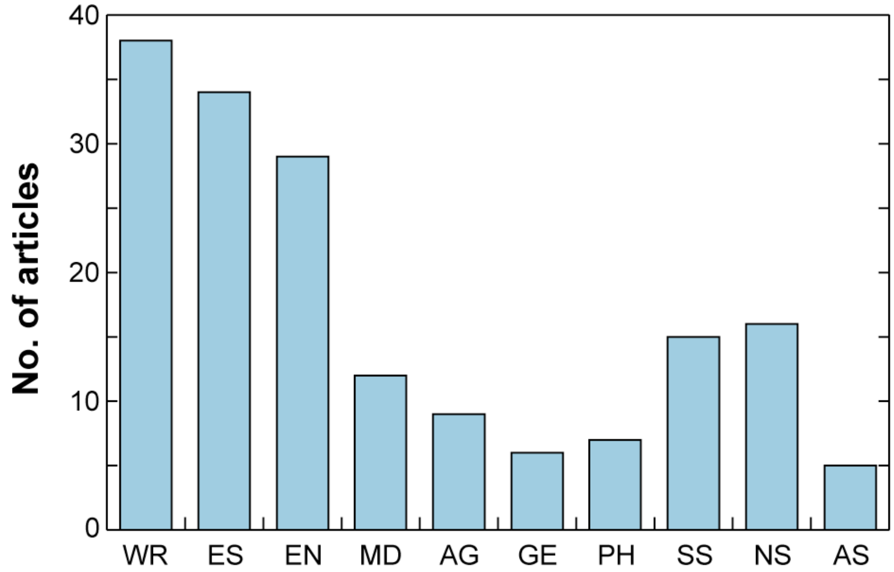
[1] The section comprises excerpts from "Water Security: Debating an emerging paradigm" by Christina Cook and Karen Bakker. Global Environmental Change (in press). Reproduced with permission from Elsevier Ltd.



WR=Water Resources;
ES=Environmental Studies, Sciences, and Ecology;
EN=Engineering (Civil, Environmental, Chemical, Multidisciplinary);
MD=Geosciences, Multidisciplinary sciences;
AG=Agriculture, Agronomy;
GE=Geography;
PH=Health (Public, Environmental, Occupational);
SS=Social Science (International Relations, Law, Planning and Development, Anthropology, Area Studies, Ethics, Economics, Operations Research and Management Science, Sociology);
NS=Natural/Physical Science (Biology, Computer Science, Fisheries, Food Science, Limnology, Biodiversity Conservation, Social Science, Tropical Medicine, Plant Science, Parasitology);
AS=Meteorology and Atmospheric Sciences

Figure 2: Disciplinary grouping of articles containing the term "water security" (1990 – 2010). Source: Web of Science database

Another salient finding of our analysis is the variability of scales at which water security is defined and measured. Scale is critical in assessing water security because of the scalar variability of hydrology, as illustrated by a recent study (Vörösmarty et al. 2010). The global focus of that study is useful for inter-country comparisons; however, the relatively coarse spatial resolution of the study hides significant variability in water security. In Canada, for example, which is classified as "water secure", decreasing water availability in the Prairie region is a growing concern, and long-term water quality issues in Aboriginal communities have been well documented (Phare 2009).

In general, the definitions of water security used in the 1990s were linked to specific human security issues, such as military security, food security and (more rarely) environmental security. Then, at the Second World Forum in 2000, the Global Water Partnership introduced an integrative definition of water security that considers access and affordability of water as well as human needs and ecological health. Since then, a variety of a scholars and policymakers have taken up the term and given it various meanings, with some developing discipline-based definitions and others advancing an integrative, interdisciplinary approach. Within this diverse literature, four interrelated themes dominate the published research on water security: water availability; human vulnerability to hazards; human needs (development-related, with an emphasis on food security); and sustainability.

Water security is an overarching conceptual framework that articulates the desirability of balancing competing land and water-use practices, much like Integrated Water Resource Management (IWRM). We argue in favour of an integrative and broad framing of water security for four reasons. First, a broad framing of water security is complementary to IWRM, as both imply the need to integrate water quantity and quality, in addition to ecosystem and human health concerns. 'Narrow' approaches to water security may move away from the integrative approach central to IWRM, which implies the need for robust governance processes to mediate the trade-offs between different stakeholders, scales, and uses of water. Second, a broad and integrative approach may be more analytically robust, because it is more comprehensive. Definitions of water security that focus solely on water quality, for example, are likely to miss water quantity-related concerns, which also affect secure access to water. Third, water security provides a means to respond to recent calls for a "clear vision or direction about a desired end state for a catchment or river basin" (Mitchell 2006, 52). In other words, water security provides a framework, which lends itself to a 'vision', which is normatively goal-oriented (insofar as security implies a particular state). We suggest this is positive because it focuses attention on the end goal (water security) rather than the process of "integrated management" (as has been the case with IWRM). Fourth, the use of the term 'security' implies thresholds (below which water is insecure)—which may be of use in situations where monitoring and enforcement have been lacking. With thresholds in place, stakeholders and regulators must ensure water meets some agreed upon minimum standard, and water security may lend (at least discursively) greater priority to doing so, as explored below.

Operational definitions of water security are also, our analysis indicates, likely to vary geographically. Specific definitions of water security have emerged in regions where particular water security concerns are acute. Our review of research on water security in Australia, China, and the Middle East and North Africa illustrates these regional specificities where disciplinary framings have taken a particular focus. In Australia, well known as the world's most arid continent, water security has been defined predominantly as a concern of water availability (quantity) to be addressed by the national and state governments through a variety of mechanisms, as detailed in A National Plan for Water Security (Government of Australia 2007, 2010). In China, the industrial and populous north is considered highly water insecure (Xia et al. 2007). Here, water security research often has a combined focus on both availability and pollution. In the Middle East and North Africa region, the focus is on sharing a scarce resource amid increasing demand in an unstable geopolitical climate. One article defines water security as having "[A]vailable and secured enough quantities of fresh water to meet normal/rationing demand under emergency situations until water production facilities are constructed or rehabilitated" (Al-Otaibi and Abdel-Jawad 2007, 301).

ASSESSING WATER SECURITY

Currently, indicators are one of the most commonly used methods for water security assessment, as they enable the synthesis of large amounts of complex information to be presented in a simplified format that can be easily understood. However, indicators are static, presenting a snapshot in time of current status; risk or future status is not included. The risk due to deterioration of quality and quantity over the longer term is an important issue. Accordingly, this Guidance Document addresses both current and future risk related to water (in)security.

ASSESSING RISKS TO WATER SECURITY

An important element of water security is the likelihood that the water source may become deteriorated in some way and have some impact on human or ecosystem health. Deterioration is viewed both in terms of quality and quantity. Risk to water quality and quantity associated with current land use practices, changes in land use, climate change, or changes in water demand, can be evaluated by considering these various stressors.

The risk assessment itself encompasses several elements. For example, within a groundwater quality context (chemical), the intrinsic susceptibility of an aquifer can be mapped using information on the soils, geology, water table depth, etc. using a variety of established methods (See Part II, Section 5). The threat of contamination (such as application of fertilizer or sudden release via a spill) or the threat due to overuse and the associated uncertainty of occurrences must be taken into account (See *Part II, Section 3*), leading to an overall vulnerability of the resource. Risk analysis, however, also requires some estimate of consequence, such as the cost to replace a water supply well, or the cost to the public health care system if people get sick. To assess water quality risk, one first needs to know the hazard the chemicals present pose, their quantities, and whether they could have an impact on human health if humans were exposed to them. Second, one needs to know the likelihood that the chemicals would be released (i.e., how are they stored?). Third, one needs to know how easily those chemicals could enter the aquifer and contaminate it – this is determined by the properties or intrinsic susceptibility of the aquifer. Fourthly, one needs to know the pathway the contaminant might take to the water source. Finally, one needs to consider the potential consequences of the hazard threat and susceptibility pose to water quality. A similar type of analysis could be done for surface water sources. The *Water Security Risk Assessment (WSRA)* method presented in this document *(Part II, Section 2)* provides spatial indicators of risk by mapping attributes of the built and natural environments.

Water quantity risk assessments are more difficult to tackle because not only is information on the current supply and demand needed, but also projections are needed about how that ratio might change in the future. Whilst projections for future use can be made, a supply assessment is difficult because of natural climate variability and climate change. In fact, climate change and variability are wild cards that can potentially impact both water quantity and quality.

ASSESSING CURRENT WATER SECURITY STATUS

Current approaches for determining whether a water source measures up to a baseline (minimum standard or threshold) are often based on indicators. Indicators play an important role, enabling us "to take complex scientific and social data to provide a simplified, quantified and communicated expression that anyone can understand" (US EPA 2008). There are many indicators of water quality, but fewer indicators of water quantity (particularly demand in relation to supply), as our indicator inventory determined (Dunn and Bakker 2009, 2011). Indicators are static in that they describe how water measures up at some instant in time. Target and baseline values play an important role in the use of indicators, as these help define changes in policy and action. As such, indicators need to be tracked over time (ideally through continuous assessment) to determine improvements, or declines against baselines or thresholds. The integration of the results from monitoring and assessment into the decision-making process could ultimately help move communities closer to water security. The Water Security Status Indicator (WSSI) assessment method (*Part II, Section 4*) is a new approach, which offers communities a process by which to assess their current water security status. The WSSI assessment method provides practitioners with a framework to select water quality and quantity indicators related to ecosystem and human health.

MANAGING RISKS TO WATER SECURITY: A GOVERNANCE-BASED APPROACH

Managing Water Security (*Part III*) presents a governance-based approach to managing water security risks. An adaptive governance approach focuses on the process by which the information from water security status and risk assessment is absorbed, decisions are made and implemented, and decision makers are held accountable in the development and management of water resources and the delivery of water services. This place-specific governance approach promotes strategies that are sensitive to feedback (both social and ecological) and are oriented toward system resilience and sustainability. In *Part III, Section 6 Fostering Good Governance* we outline and define an adaptive management approach and provide examples of steps communities can take to implement "good governance" practices with the aim of achieving water security. In *Part III, Section 7 Boil Water Advisory Protocol* we present a step-by-step guide for government regulatory officials and water suppliers involved in the decision to issue and rescind boil water advisories.

Practicing good governance is crucial for communities to achieve water security and an adaptive governance approach can facilitate this. Succinctly defined, adaptive governance is a methodological approach to resource management, whereby policies are implemented as experiments and learning is integral to resource stewardship. Adaptive governance formalizes a "learning by doing" approach that can link science and policy. It entails three overlapping activities: participation of stakeholders; policy-development; and monitoring and enforcement. Risks and changes to ecosystem health and human health are monitored and assessed over time. Policies and decision-making processes are then adapted over time, creating a closed (and hopefully virtuous) feedback cycle.

SUMMARY

Our research findings suggest the importance of a broad and integrative approach to water quality and quantity, which incorporates human health and aquatic ecosystem health. We specifically suggest that the assessment of current water security status needs to be combined with the assessment of risks, and the results incorporated into an adaptive governance framework, which formalizes a flexible “learning by doing” approach that can respond to changing conditions. In facilitating this integration the concept of water security is worthy of consideration for both research and policy strategies in support of sustainable water governance.

GLOSSARY OF TERMS

Adaptive Management, a systematic process for continually improving management policies and practices by learning from outcomes of operational programs.

Aggregate Extraction Site, (may include pit or quarry) is a land from which unconsolidated or consolidated aggregate is being or has been excavated. Aggregate materials include: gravel, sand, clay, earth, shale, stone, limestone, dolostone, sandstone, marble, granite, rock or other prescribed material.
Source: Aggregate Resources Act, R.S.O. 1990, c. A.8.

Aquifer, an aquifer is a water-bearing layer underground.

Aquitard, the layer of geological material that prevents or inhibits the transmission of water to or from a confined aquifer. Source: Ontario Drinking Water Source Protection documents: http://www.sourcewaterinfo.on.ca/content/spProject/glossary.php.

Assessment Framework, a methodology, strategy, or approach to analyzing a system.

Boil Water Advisory, public notifications of drinking water quality that are primarily used as temporary, precautionary measures to protect the public from possible waterborne illnesses.

Community, can be broadly defined. In this project we often refer to a small municipality as a 'local community'.

Confined Aquifer, an aquifer overlain by a low permeability layer (saturated and usually under (artesian) pressure).

End-user, a person or persons that would use a particular product.

Goals, often more qualitative and desire-based (for example the ability to swim or canoe in a river without it being full of algae or smelly).

Good Governance (water), the democratization of water management decision-making e.g., participatory, census-oriented, accountable, transparent, responsive, effective and efficient, equitable and inclusive, and following the rule of law (Norman et al. 2010; Bakker 2002).

Governance (water), water governance is the process by which water resources and services are organized and managed. This includes not only laws and regulations, but the entire range of political, organizational and administrative processes involved in managing the water supply: from the time when communities articulate their interests, and that input is absorbed, to the time when decisions are made and implemented, and decision makers are held accountable for the development and management of water resources and the delivery of water services (Norman et al. 2010; Bakker 2002).

Hazard, these may be quantity-related (such as contaminants) or quantity-related (such as large water extraction volumes).

Indicator, a univariate or absolute number, statistic or parameter. Tracked over time, an indicator can provide information, often related to a trend on the condition of a phenomenon and have significance extending beyond that associated with the properties of particular statistics (Dunn and Bakker 2009).

Index, a multivariate, aggregate or complex number that incorporates a number of components. An index is often comprised of a number of indicators and expressed as a numerical scale (e.g., 1-100). It is a composite reflection that can enable, for example, two cities to be compared (Dunn and Bakker 2009).

Indices, plural of index, or indicator.
Note: Despite their different meanings, the terms "indicator", "index" and "indices" are often used interchangeably. Frequently indicator is used as a catchall term that may include indices, performance measures, report cards, benchmarks and objectives. The concept of indicators is loosely inferred when monitoring status, trends and conditions. In this Guidance Document we use the term indicator as an umbrella term for both indicator and index.

Intrinsic (Aquifer) Susceptibility, a relative measure of natural susceptibility. For an aquifer it is a relative measure of the ease with which a contaminant, introduced at the surface, will move from the surface down into an aquifer.

Loss, loss is the economic, environmental or health consequence associated with the deterioration of a water resource (either in terms of its quality or quantity).

Objectives, quantitative, science-based targets often specific to a particular variable.

Orthophotograph, an aerial photograph from which distortions due to camera tilt and ground relief have been removed. An orthophoto has the same scale throughout and can be used as a map to measure true distances.
Source: adapted from ArcGIS glossary.
(http://support.esri.com/en/knowledgebase/GISDictionary/term/orthophotograph)

Participatory Governance, focuses on deepening democratic engagement of citizens in the processes of governance with the state. The idea is that citizens should play a more direct role in public decision-making or at least engage more deeply with political issues.

Raster, a raster data type is, in essence, any type of digital image represented by reducible and enlargeable grids.
(http://en.wikipedia.org/wiki/Geographic_information_system#Raster)

Risk, a function of vulnerability and loss.

Risk Assessment, the identification, assessment, and prioritization of risks.

Stakeholder, a person (or persons) with vested interest in an issue.

Unconfined Aquifer, is exposed at surface, meaning that the permeable materials comprising the aquifer are not protected by a cover of lower permeability materials that can act as a barrier to entry to contaminants introduced at surface.

Vulnerability, the potential for damage caused by various hazards (e.g., contamination, over use), offset by the natural protection provided by the physical (unaltered or altered) system.

Water Security, sustainable access on a watershed basis, to adequate quantities of water, of acceptable quality, to ensure human and ecosystem health.

Watershed, every waterway lies within a watershed. A watershed (also known as a "catchment" or "drainage basin") may be defined as a geographical area in which surface waters flow towards one destination. Surface watershed boundaries (or "divides") follow the highest ridgelines around the stream channels and meet at the lowest point of the land where water flows out of the watershed. Water flows in two different directions on either side of the divide. Ground-watersheds may not coincide with surface-watersheds. Watersheds may be small, representing a single tributary within a large system or quite large, covering thousands of kilometers. Watersheds can extend across borders, engaging multiple scales of governance.

Watershed-scale, an arbitrary scale of analysis constructed around a 'watershed'.

LIST OF ACRONYMS

ALR – Agricultural Land Reserve
AVI – Aquifer Vulnerability Index
BC MoE – British Columbia Ministry of Environment
BMP – Best Management Practices
BWA – Boil Water Advisory
CA – Conservation Authority
CCME – Canadian Council of Ministers of the Environment
CCME WQI - Canadian Council of Ministers of the Environment Water Quality Index
CDWQG – Canadian Drinking Water Quality Guidelines
DEM – Digital Elevation Model
EC – Environment Canada
Eh – Reduction Potential
EMS – Environmental Monitoring System
GIS – Geographic Information Systems
GRCA – Grand River Conservation Authority
GVWD – Greater Vancouver Water District
HC – Health Canada
HRS – Hazard Ranking System
IWRM – Integrated Water Resources Management
LA 21 – Local Agenda 21
MAL – Ministry of Agriculture and Lands
MENA – Middle East and North Africa
MHO – Medical Health Office (Ontario) or Medical Health Officer
MNR – Ministry of Natural Resources
NAICS – North American Industry Classification System
NGO – Non-Governmental Organization
PTTW – Permit To Take Water
PWN – Private Well Network
SCDM – Superfund Chemical Data Matrix
SFU – Simon Fraser University
ToL – Township of Langley
UBC – University of British Columbia
UoG – University of Guelph
US EPA – United States Environmental Protection Agency
WAI – Water Availability Index
WHO – World Health Organization
WSAF – Water Security Assessment Framework
WSRA – Water Security Risk Assessment
WSSI – Water Security Status Indicators

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