# WATERFUND/IBM

## The True Cost of Water

**Prepared for the American Society of Civil Engineers (ASCE)**
**International Conference on Sustainable Infrastructure (ICSI) 2014**

**Dr. Peter Williams**,
CTO, IBM "Big Green Innovations", and IBM Distinguished Engineer
**Scott Rickards**, Founder & CEO, Waterfund

*"The things which have the greatest value in use have frequently little or no value in exchange; on the contrary, those which have the greatest value in exchange have frequently little or no value in use. Nothing is more useful than water: but it will purchase scarce anything; scarce anything can be had in exchange for it. A diamond, on the contrary, has scarce any use-value; but a very great quantity of other goods may frequently be had in exchange for it"*

**- Adam Smith,**
**"An Enquiry into the Nature and Causes of the Wealth of Nations", 1776**

## BACKGROUND – A FAILURE OF SUPPLY TO MEET NEED

Water has been perceived to be underpriced for many hundreds of years, as Adam Smith's famous "Diamond-Water Paradox" shows. Smith was not the first to note this: Copernicus and Locke had mused on the subject even before Smith. For as long as water did not attract a valuation that matched its use, there was little direct financial return to be had from investing in water systems, meaning that the impetus to invest had to come from some other motive, such as civic duty or general economic development.

As a result of the lack of a compelling financial case, the capital investment backlog in water infrastructures globally is now estimated in the $billions and sometimes $trillions. The well-known "Report Card" grade of D+ given the USA from the American Society of Civil Engineers (ASCE) underscores the long-term investment failure of both the private and public sectors. Of course, this American failure pales with the "infrastructure gap" globally where an estimated 780 million people today have never had the benefit of a piped water infrastructure that delivered drinkable (or, often, any other) water in the first place.

Unfortunately, civic duty and general economic development funds no longer provide sufficient funding for the water industry. As long as water does not attract a price reflecting its true value, there will be no direct financial return and little incentive for investment in the water sector. The underfunding of the water industry has created significant drought risk in many parts of the world. Given the risks to industry, food production, health, and ultimately life, the importance of attracting the necessary capital to build water infrastructures that can provide reliable, consistent, and long-term supplies of freshwater is critical.

Under pressure from climate change, growing populations and economic activity, the finite nature of water resources is now in many parts of the world becoming apparent. In addition, ancient infrastructures in some areas imperil economic activity, and increasingly affluent and informed populations are demanding better services. The water sector is therefore becoming ever more aware that it has to balance needs to address the investment backlog and close the infrastructure gap. This will require very large capital inflows that the sector has not historically been able to attract. Also, while rising costs will over time make a financial return from investing in water easier to demonstrate, gauging risk remains problematic. The Water Cost Index (WCI) is designed to address these needs.

Under pressure from climate change, growing populations and economic activity, the finite nature of water resources is now in many parts of the world becoming apparent. In addition, ancient infrastructures in some areas imperil economic activity, and increasingly affluent and informed populations are demanding better services. The water sector is therefore becoming ever more aware that it has to balance needs to address the investment backlog and close the infrastructure gap.

This will require very large capital inflows that the sector has not historically been able to attract. Also, while rising costs will over time make a financial return from investing in water easier to demonstrate, gauging risk remains problematic. The Water Cost Index (WCI) is designed to address these needs.

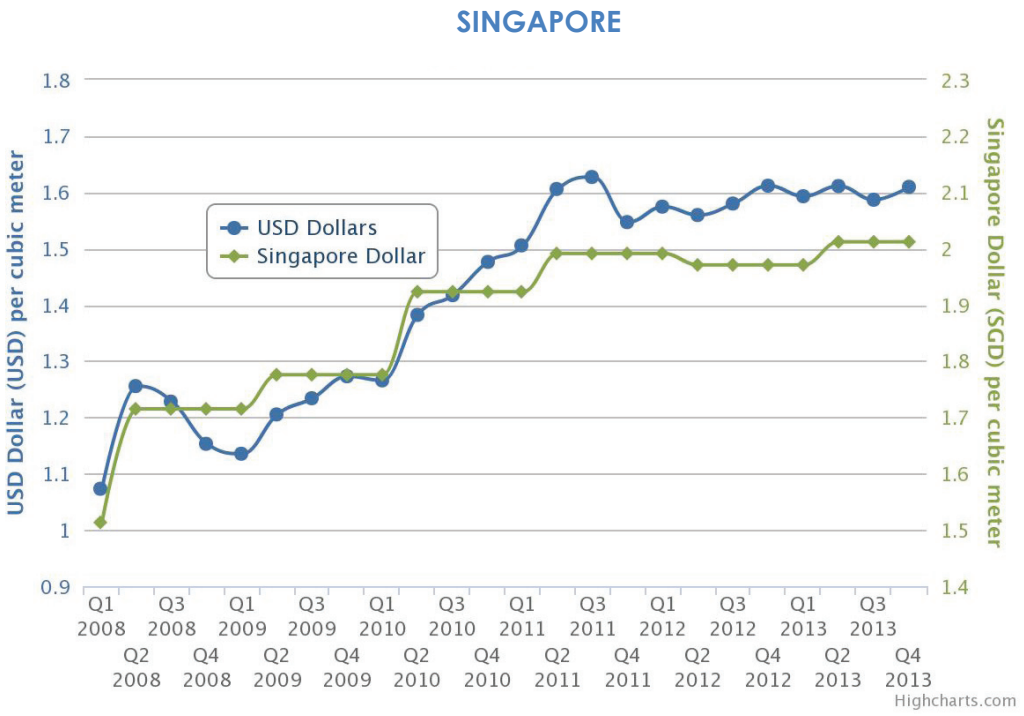
Finding equilibrium between supply and demand of water infrastructure capital relies on answering a fundamental economic question: at what cost is it economical for the world's largest cities to bring additional water supply online? The oil industry typically uses $80-100/barrel oil as the value which capital allocation can earn a return. Given its critical importance in our lives, why does the water industry not have a similar simple answer to the question? To what extent is the "global water crisis" in fact a capital crisis, as opposed to the resource crisis that it is usually assumed to be?

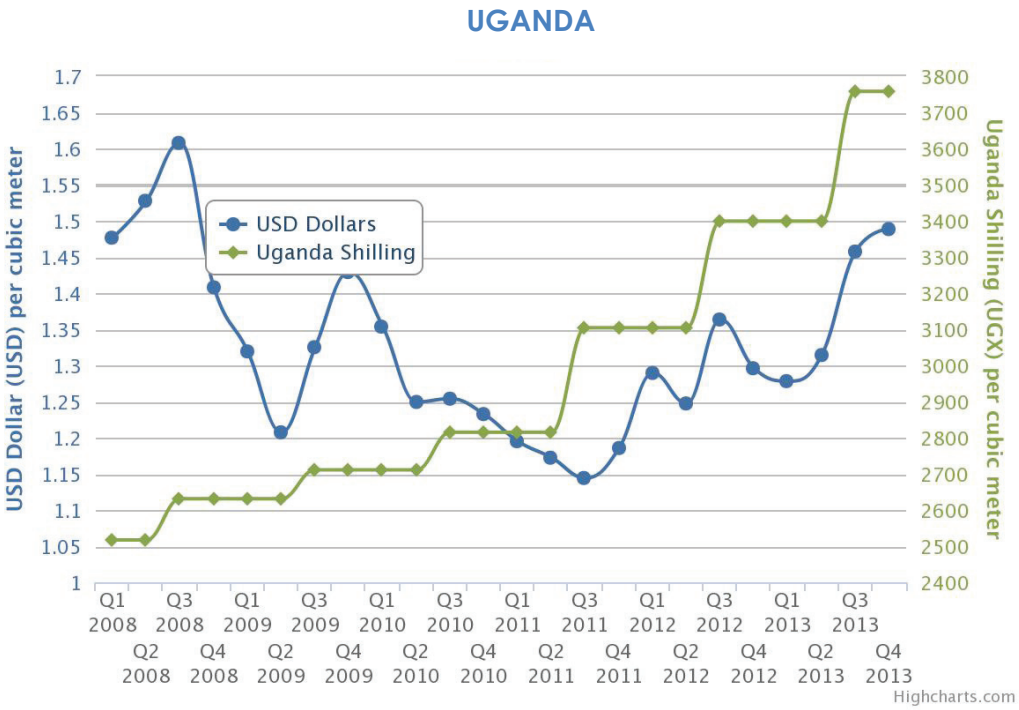
Precisely because of its critical importance, the water industry has given a pass on cost transparency by everyone from politicians, to Wall Street, to economists due to the unimaginable consequences of not having an abundant supply of fresh water. As a result, the subject of water production costs remains largely unexplored and water has taken a back seat to virtually every other resource in the battle for private investment dollars. Perhaps the water industry's "social protection" has done more harm than good. Indeed, the consequences are already clear: the global water business is riddled with underinvestment and lack of financial reporting standards.

To be clear, the subject of water scarcity has not been ignored. Indeed, there are a number of benchmarks and even exchanges which value the scarcity of physical supply. Chile has an electronic water exchange as does Australia and several other important water-short regions. Others have attempted indices which measure the scarcity value of physical water supply; some have attempted to quantify the financial impact of water pollution in creating trading schemes designed to cap that pollution.

What's missing in these marketplaces and valuation metrics is an accounting of the massive capital spending required between the raw resource and the production of "finished water" at your tap. Uganda is endowed with widespread and plentiful natural water resources, yet 93 percent of the country does not have access to piped water in their home. What's worse, the 93 percent that remain unconnected to the water network pay far higher prices that Americans and Europeans. Facts such as these lead one to believe that the "global water crisis" is in fact, to a significant degree, also a market failure. Again, finding equilibrium between supply and demand will depend on properly valuing the production cost of water.

## FIGURE 1. CURRENT WATER COST INDICES (WCI) IN USD AND LOCAL CURRENCY

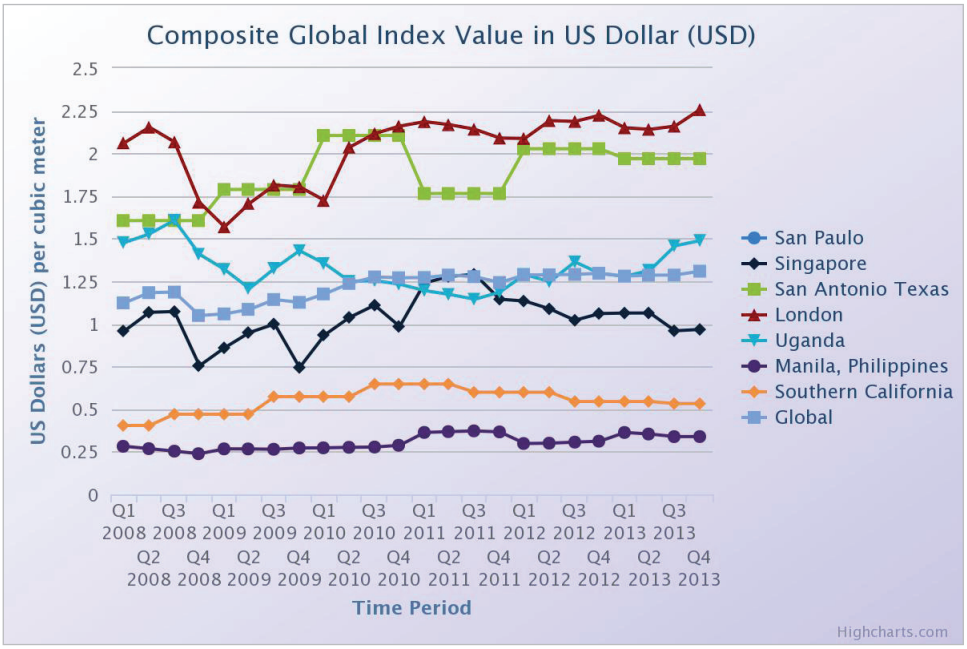



The technology and engineering capabilities to dramatically improve and solve water infrastructure issues exist today. Modern technology reduces water loss, improves energy efficiency and decreases wear and tear on infrastructures. Water banking and reservoir expansion can dramatically increase storage capacity to help dry regions get through long periods of drought. Water systems can be built connecting areas with an abundance of water to areas that experience drought. Desalination plants can turn brackish and salt water into healthy potable water much more efficiently with solar and other new technologies. And modern metering systems can provide feedback to consumers to advise them of consumption levels with (often in conjunction with tiered pricing levels) proven results in prompting the reduction of that consumption.

Large scale projects like these require overcoming legal (i.e., water rights) and political hurdles. They also demand significant capital investment. The private sector can provide vast amounts of additional capital, if it is properly incentivized. Imagine if 20% of the amount of capital that is invested in the energy sector, invested in the water sector. The water infrastructure would be significantly improved.

The good thing about a crisis is that it can be a catalyst for change. Water awareness grew considerably in California and Texas as they recently experienced severe droughts. Most critically, retail-level awareness prompted the political will to upgrade water infrastructures and begin to undertake major water projects. Increasingly affluent and informed populations in developing countries are even more demanding of their governments for better services as they realize outdated water infrastructures

imperil economic activity. The water sector is therefore becoming ever more aware that it has to address the water project backlog. Specifically, the water sector needs to find ways to attract additional capital investment. Reducing risk and enhancing return on investment (ROI) are the primary solutions for increasing investment activity. Waterfund's Water Cost Index (WCI) is designed to help mitigate investment risk while improving ROI.

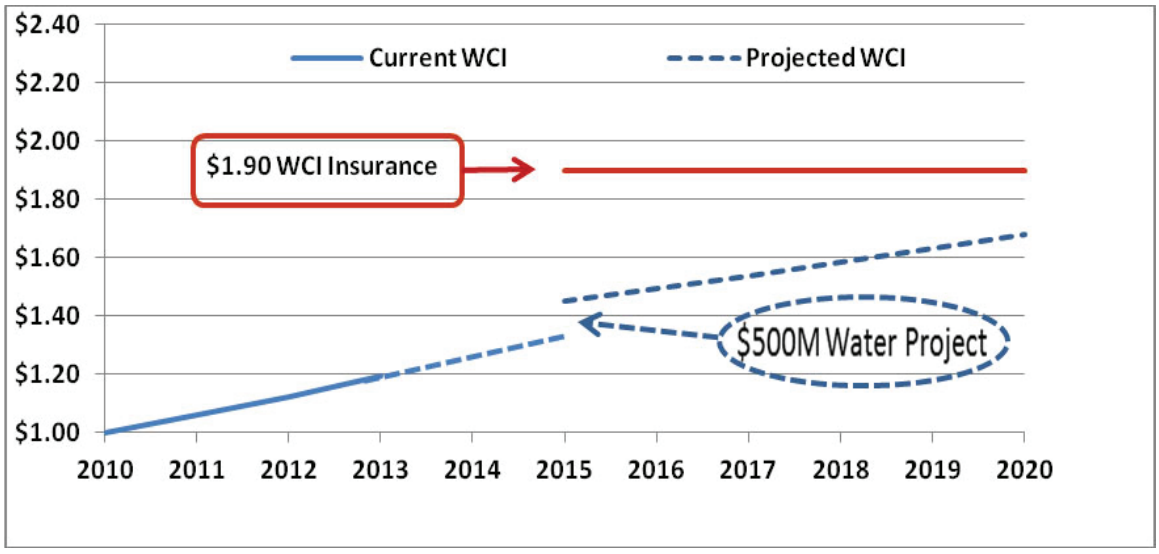



## WATER COST INDICES REDUCE FINANCIAL RISK

The Water Cost Index being developed by IBM and Waterfund seeks to shed light on what it costs the world's major cities to produce and deliver a unit of "finished water". The Water Cost Index will enable the creation of water cost benchmarks that can be used to trigger insurance payments, adjust water rates, set water tariffs, and perform financial analysis. For example, suppose the business case for a water recycling and transmission project is dependent on the eventual value of the water produced. The project's owners could reduce the risk that this represents to investors by taking out a hedging product that pays out when the Water Cost Index fails to rise over a certain level, or when the index displays volatility above a certain threshold. This risk reduction will make investment in the project more appealing.

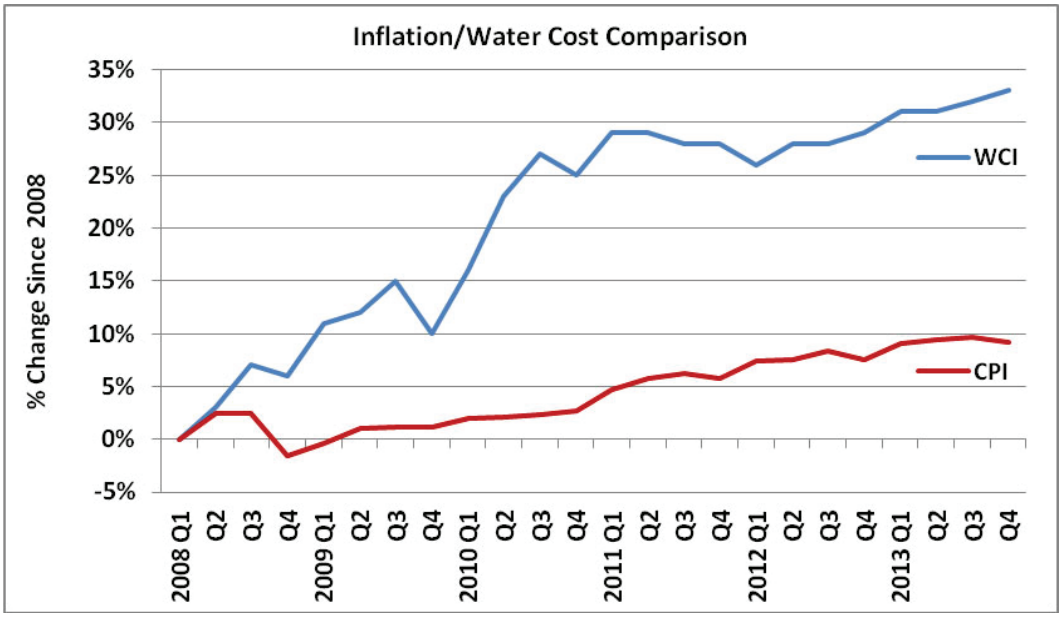
The same principle might apply to investments designed to reduce non-revenue water, whose return on investment (ROI) is dependent on the value of water saved. The Index could be used to underwrite the value of saved water, thereby de-risking the investment and enabling it to proceed. At the same time, the WCI would also be a tremendous metric to measure the improved efficiency created by reducing non-revenue wate

**FIGURE 3. WCI HEDGING EXAMPLE**




It may be asked why water agencies could not use "inflation indices" such as the CPI to hedge risk – why a separate index is needed. In practice, the CPI and other inflation benchmarks have an extremely low correlation with water costs: Waterfund's aggregate WCI increased over 30% over the past five years while the CPI grew less than 10%.

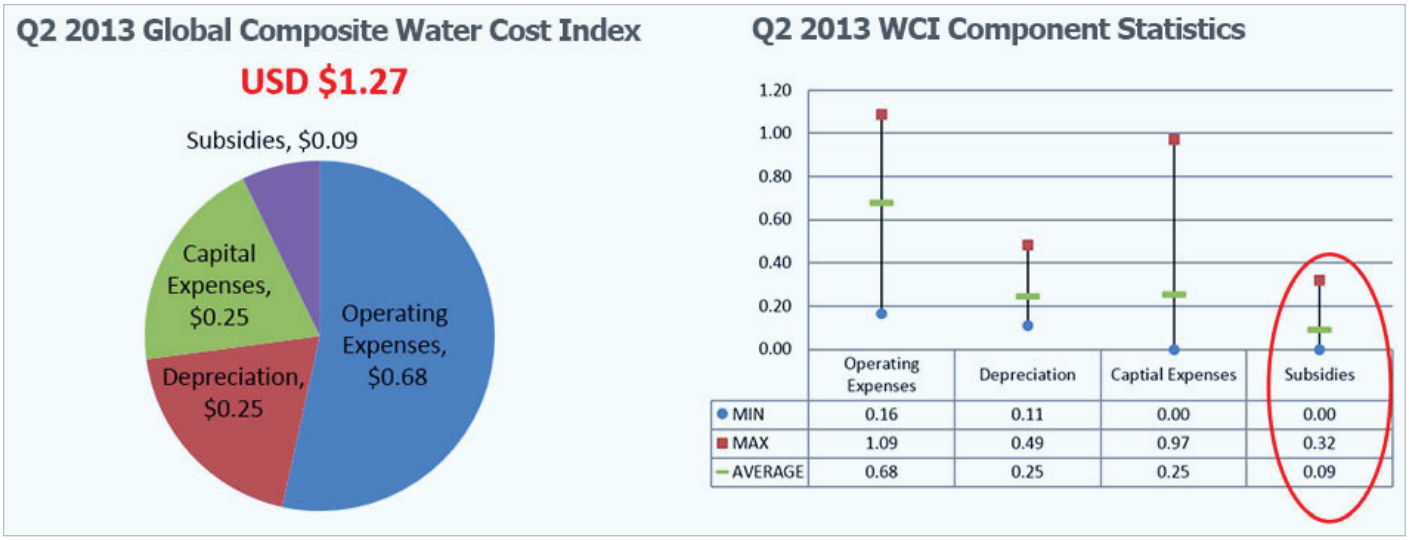
**FIGURE 4. A BETTER BENCHMARK FOR THE WATER INDUSTRY – CPI VS WCI**




[3] CPI is the All Urban Consumers CPI-U as calculated by the US Department of Labor Bureau of Labor Statistics: US Dept. of Labor Statistic CPI-U

In addition to attracting private investment into the water industry, public investment (i.e., tax-exempt municipal finance) will also improve as credit agencies raise bond ratings to reflect the risk reduction.. WCIs will also help water managers operate their business and improve efficiency by providing users with customizable analysis tools, including: 1) WCI applications using IBM's calculation agent to make pro-forma projections (through extrapolation algorithms) about future water costs, and 2) Project finance applications that perform what-if scenarios about proposed capital spending programs and their impact on overall water production costs.

## DATA ANALYSIS




Looking ahead, the time when water utilities will employ third-generation financial data and products in the same manner as the energy industry is not in the far distant future. With pension funds in need of reliable, long-term asset allocation, Wall Street in need of ever-growing industry segments for risk, and water companies in dire need of capital, the time has come for such innovations to be realized. Once again, the WCI will serve as an ideal input for determining a price. Indeed, the Index could in time become the foundation for a global market in water risk and trading.

Once complete, the index can be used to ring-fence and manage risk exposure to major water infrastructure projects. To take one specific example, the Jordan Red Sea Project seeks to take in and desalinate water at the Red Sea and deliver it via pipeline to severely water-stressed Amman, Jordan and the Dead Sea. The geopolitical upside of a successful outcome to this project is obvious, but total project costs run upwards of $25 billion dollars. Billions have already been pledged by major governments and the World Bank has recently given its seal of approval. However, private investment will certainly be required. If the index could be used to create hedging instruments to underwrite the investment exposures of private financiers in situations such as the dire one faced in Jordan, so enabling the investment to take place, it would be a valuable tool in changing how business gets done in the water industry and in extending and revamping the world's water infrastructures.

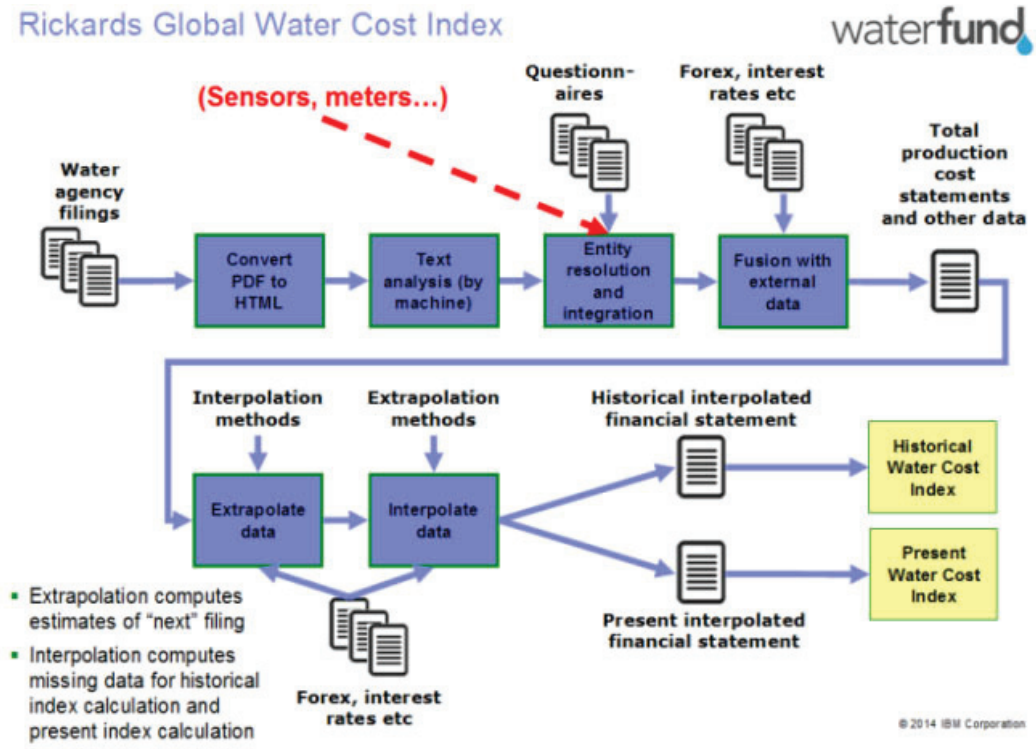
## INDEX CALCULATION

IBM constructs and operates the official Calculation Agent using an algorithm that can be simply expressed by the following formula:

***(energy costs + operating expenses + capital expense + interest expense) / volume of water supplied***

As straight-forward as the WCI formula appears, the actual computation is far more complex as the graphic below shows.

### TECHNICAL ARCHITECTURE OF IBM CALCULATION AGENT FOR WATER COST INDEX




The construction and calculation of the index is a genuinely ground-breaking application of analytic techniques for unstructured data. Water agency data, if published at all, is highly variable in quality and format. The context of any given data value (footnotes, additional comments, or even just placement on the flow of the text) may be critical to how it should be interpreted. Additionally, treatment of numerous ancillary items such as accrued pension liabilities, energy and capital subsidies need to be carefully considered. These and other issues make achieving the consistency required to build an index a highly challenging exercise.

Fortunately, Waterfund and IBM Research's Accelerated Discover Lab have the expertise and technical capabilities to capture, dissect, refine, and ultimately produce reliable Water Cost Indices. Values

for all cost variables are standardized, and have single, well-defined semantics. This allows for a direct comparison of relevant costs for each producer. The data is then manually reviewed and adjusted to produce the finished result. Consistency in the calculation methodology is critical to produce like-for-like outputs. The specific technical challenges that must be overcome to scale IBM's index calculation agent are as follows:

### ANALYZING UNSTRUCTURED PUBLIC DATA:

A key source of financial information is the audited financial reports that individual agencies publish periodically for the benefit of their shareholders, financiers, or general public. These documents are usually text documents (in pdf or html format) that need to be analyzed to identify the financial information reported within various sections of large (100+ page) documents. These documents are typically for human consumption and processing them programmatically raises multiple challenges such as the ability to accurately analyze various concepts of interest such as financial tables or footnotes mentioning cost variables, and the need to process various types of text documents.

### ISOLATING COST VARIABLES AND IDENTIFYING BOTH DIRECT AND INDIRECT COST SUBSIDIES:

The cost variables that contribute to the true cost of production are reported in various parts of the financial statements depending on whether they are "explicitly reported costs" or "hidden costs". For instance, operating expenses is typically reported as expenditure in the Income Statement, while government grants may be reported as revenue in the Income Statement; further breakdown of individual costs such as operating expenses may be elaborated in textual notes associated with the financial statements. The ability to extract the individual cost variables from various parts of the reports and combine them from multiple filings over time to create a complete temporal view for each producer is important.

### ACCOUNTING FOR FILING DISCREPANCIES:

Agencies occasionally change, over time, their reporting formats or the way in which they break down specific financial details. The ability to identify these discrepancies while combining data from multiple filings and resolving them, either programmatically or through intelligent alerting of a data steward is a key requirement.

### ADDRESSING MISSING INFORMATION:

Agencies report their financial information periodically, usually quarterly or annually, and even this information is typically available only after a lag of a few months. Therefore, the last available financial report could be over a year old in many cases. Additionally, data reported in financial statements may

be incomplete (e.g., the cost of raw water may not be reported, and must be estimated). In order to have a complete and up-to-date Water Cost Index for all regions, it is imperative to address this missing data problem by estimating the missing values using advanced statistical techniques.

Each location will have its initial WCI backdated five years and reported on a quarterly basis. The performance of a water producer can now be benchmarked against other producers in the same geographic region or globally. A producer can be benchmarked on individual cost variables as well, which provides additional insight into their cost structure and the relative risk it presents. The individual WCI locations will be able to be broken down for further analysis and combined to create regional sub-indices. Waterfund plans for the Water Cost Index to eventually cover 25% of the world's GDP or roughly 100 of the largest cities.

**CONCLUSION:**

The WCI is a ground-breaking innovation in several respects. First, it addresses a problem with water valuations that is many hundreds of years old, and will enable desperately needed capital investment into the water sector. Second, the WCI and other data derived from the calculation will provide financial analysis tools that help the water industry improve efficiency. Finally, the calculation process represents the current "state of the art" in automated analysis of highly unstructured data – a major contribution to the current movement around "Big Data". Waterfund and IBM are pleased to have presented their innovation as an example of the kind of approaches needed to combat the effects of global population and urbanization on earth's water resources

**Waterfund LLC**
801 Brickell Avenue, Suite 900
Miami, Florida, 33131
Email: scott.rickards@worldswaterfund.com