Quantifying Watershed Restoration Benefits in Community Water Partnership Projects

Phase II Report

Prepared for:

The Coca-Cola Company

in collaboration with

The Nature Conservancy
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EXECUTIVE SUMMARY

The Coca-Cola Company is interested in gaining a better understanding of the watershed restoration benefits derived through its Community Water Partnership (CWP) Projects. This report describes the outcomes of an effort to quantify those benefits and advance the development of computational methodologies for this purpose. The work described in this report builds on previous “Phase I” activities described in a full report (LimnoTech and TNC, 2008) and summarized in a recent White Paper (DePinto, et al., 2009).

For many of the CWP projects reviewed as part of this project, watershed restoration benefits are being realized through multiple activities. To date, a total of 47 activities implemented through 39 CWP projects have been quantified. The remaining projects were not quantified because implementation is still in its early stages, available information was insufficient to make an estimate, or the types of benefits are not quantifiable.

The current estimate is that the projects implemented by the end of this year (2009) will provide a benefit of approximately 28.4 billion liters/year, representing 21% of the product volume generated by TCCC facilities. Projects implemented by the end of 2013 are estimated to provide a beneficial gain of water of approximately 51.0 billion liters/year, representing 30% of the product volume generated by TCCC facilities (Table ES-1). An annual increase in product volume of 5.25% was assumed (per information provided by Greg Koch).

The pollution reduction benefits of these activities were also estimated as part of this exercise. The primary focus of most of the CWP projects that address water quality problems is erosion control, so the reduction in sediment yield was estimated where relevant. The preliminary estimate is that the 47 CWP activities evaluated will reduce sediment load in 2009 by 2,995,945 metric tons/year, increasing to 3,544,869 metric tons by 2013. These reductions will significantly improve the quality of receiving waters in those watersheds.

Table ES-1. Preliminary Estimate of Watershed Restoration Benefits

Year	Product Volume (billion L/yr)[1]	Estimated Quantity (billion L/yr)	Percent of Product Volume[1]
End of 2008	130.0	15.4	12%
End of 2009	136.8	28.4	21%
End of 2010	144.0	33.6	23%
End of 2011	151.6	38.4	25%
End of 2012	159.5	50.7	32%
End of 2013	167.9	51.0	30%

[1] Assumes a projected annual increase in product volume of 5.25% during 2009-2013.

Figure ES-1 shows the increase in estimated watershed restoration benefits compared to projected product volume through 2020. The ratio of benefits to product volume is also shown (black line). The graph will be refined and extended in time in the future as more information about ongoing projects becomes available, and new projects are implemented. Restoration benefits for ongoing infrastructure-dependent projects beyond 2013 will need to account for depreciation.

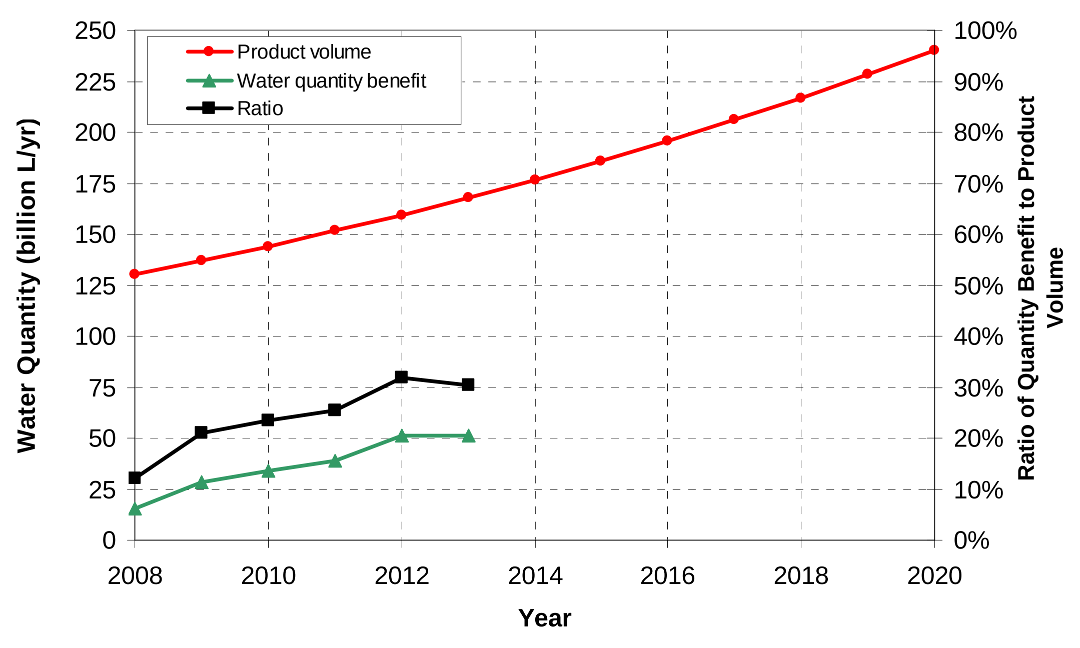

Figure ES-1. Projected Benefits Compared to Projected Product Volume

This report provides details on the quantification approach used to derived these estimates, describes the development of the computational engine, and discusses findings and associated recommendations.

1. INTRODUCTION

This document represents an essential component in the development of methods to support the advancement of water stewardship and sustainability. It builds on previous work conducted in 2008 (LimnoTech and TNC, 2008) and described in a recent White Paper (DePinto, et al., 2009). These previous "Phase I" activities focused on characterization of TCCC's Community Water Partnership (CWP) projects, identification of potential activities that would enhance water resources, and development of a conceptual framework for calculating those enhancements. The goal of this phase of work was to begin to build the computational portion of the conceptual framework, and to test its utility by using it to develop an initial estimate of the total water quantity and quality benefits derived from completed and ongoing CWP projects.

1.1 SUMMARY OF PHASE I PROJECT OUTCOMES

During Phase I, the project team reviewed all CWP projects and identified those that were primarily focused on water quantity and/or quality in the watershed within which they were implemented. Two other categories of projects are those directed at socio-economic benefits (i.e., water access), and those focused primarily on education or outreach.

The criteria for what "counts" as a watershed restoration activity in this context were determined to be those projects that are: 1) directed at the sustainable and equitable use of water; 2) focused on conserving or restoring water quantity and/or water quality; and 3) quantifiable in terms of their watershed restoration benefits.

Based on these criteria, nine categories of watershed restoration actions were identified through Phase I:

1. Agricultural land practice changes
2. Stormwater management
3. Land use/land cover alterations
4. Hydraulic/hydrologic waterbody alterations
5. Recaptured leakage from water systems
6. Wastewater treatment
7. Biologic management
8. Water reuse
9. Rainwater harvesting and aquifer recharge

These categories encompass a wide range of activities that can be targeted at almost any specific water quantity and/or quality problem that exists in a watershed. It is feasible, given sufficient data and information about the project, to quantify any of these actions to allow evaluation of their effect on the sustainable use of water in a watershed.

It is noteworthy that several of these watershed restoration actions have been identified as adaptation activities to reduce vulnerability to climate change. Specifically, the Intergovernmental Panel on Climate Change (IPCC) identified agricultural practice changes, hydraulic/hydrologic waterbody alterations, biologic management, water reuse, and rainwater harvesting as possible adaptation activities (IPCC, 2007; Bates, et al., 2008). Some of the restoration activities are also known to sequester carbon. For example, agricultural practices that improve water-holding capacity such as reduced tillage may also sequester carbon through both increased crop productivity and reduced soil respiration (Bates, et al., 2008). Tree plantings can also sequester significant quantities of carbon, and the slowing of forest degradation can significantly contribute to avoided emissions (Bates, et al., 2008). Furthermore, some of the restoration actions can result in an energy savings, with associated carbon-related benefits. For example, stormwater management practices that involve green infrastructure can reduce pumping and treatment needs, and reduce energy use overall. While these additional benefits are recognized, only the benefits on water quantity and quality are quantified in this report. The project team also developed a methodology and conceptualized a framework that could be used to quantify the water quantity and quality changes associated with projects such as those implemented through the CWP, as well as other potential projects that TCCC might undertake in achieving its water stewardship goals. The conceptualized tool is referred to as the Watershed Restoration Benefits Evaluation Tool (WRBET).

1.2 PHASE II OBJECTIVES

The goal of Phase II was to develop an initial estimate of the total water quantity and quality benefits derived from the CWP projects implemented to date, and to begin to build the computational engine of the WRBET. At the same time, there was interest in disseminating the conceptual framework developed in Phase I to the broader water stewardship community for review and comment, in the interest of further advancing these concepts and methods. This was accomplished during Phase II through the development of a White Paper that has been distributed to the Water Footprint Network for review and comment (DePinto, et al., 2009).

The quantification of watershed restoration benefits from CWP projects represents an exploration of methods as well as an evaluation of the challenges involved in compiling data inputs required for those computations. A wide variety of project and activity types were evaluated, with a range of data available to support the quantification process. Recommendations for improving the quantification process are provided in Section 3.

1.3 PHASE II APPROACH

Four steps were conducted as part of Phase II, as described in the following sections:

1. The list of CWP projects that have the potential to generate watershed restoration benefits was expanded to include new projects described in the 2009 Replenish Report;
2. Key data and information needed to quantify watershed restoration benefits were obtained and compiled;
3. Development of the “computational engine” of the WRBET was conducted; and
4. Watershed restoration benefits were estimated for selected activities.

1.3.1 Identification of CWP Watershed Restoration Projects

During Phase I, the approximately 140 Community Water Partnership (CWP) projects described in the 2008 Replenish report (TCCC, 2008) were categorized, and 47 projects (approximately one-third) were found to be focused primarily on water quantity and/or quality The 2009 Replenish report (TCCC, 2009) published in February, 2009 describes more than 200 CWP projects in 60 countries. On the publication date, 57 projects had been completed, and the remaining projects were in progress or scheduled to launch within the first quarter of 2009.

The new projects in the 2009 report were reviewed to identify projects that potentially involve activities that may fall into one of the nine categories of restoration activities. A total of 75 CWP projects were determined to potentially involve these types of activities based on the project descriptions in the 2009 Replenish report. A list of these projects is provided in Appendix A, along with the status of quantification work for each project.

As part of this review, the list of nine potential watershed restoration activity types developed during Phase I was revisited based on the additional information provided in the 2009 Replenish Report (TCCC, 2009) and the associated CWP database. No additional categories of qualifying activities were identified through this process.

1.3.2 Compilation of Data & Supporting Information

Site-specific data and information are needed for each project before restoration activities can be quantified. To accomplish this, a survey was developed that was directed at gaining a better understanding of the project objectives, specific restoration activities being implemented, important characteristics of the watershed within which the project is taking place, and other information specific to the watershed and the project. The full survey is provided in Appendix B. The level of detail provided in the responses received varied considerably. The project team followed up via email and phone calls with numerous contacts in an effort to obtain as much of the required information as possible.

1.3.3 Development of Computational Engine

The Phase I report provided specific recommendations with respect to developing a "Watershed Restoration Benefits Estimation Tool" (WRBET) to assist in quantifying water quantity and quality benefits resulting from specific actions within a watershed (LimnoTech and TNC, 2008). The approach recommended for constructing the WRBET involved the development of two primary components: 1) a *computational engine* to provide a suite of methods to perform the calculations required to quantify benefits, and 2) an *expert system* to interact with the user to obtain the necessary information to support the benefit calculations. In terms of software development, Phase II focused on the development of the computational engine component of the overall WRBET framework.

The Phase I report recommended that a suite of process-based methods be incorporated into the WRBET computational engine to quantify changes in water quantity and quality for a variety of physical conditions and management situations. Specific recommendations were made for methods to compute changes in various pathways of the hydrologic budget, including runoff and infiltration, evapotranspiration, and groundwater storage and outflow. The watershed hydrologic budget and Runoff Curve Number methods were proposed for use in quantifying changes in runoff and infiltration quantities. For water quality, the Modified Universal Soil Loss Equation (MUSLE) method was recommended for quantifying changes in sediment runoff and yield. Several existing watershed models were identified as sources for these methods, including *Hydrologic Simulation Program – FORTRAN* (HSPF), the *Soil & Water Assessment Tool* (SWAT), and the *Watershed Analysis Risk Management Framework* (WARMF).

The development of the computational engine involved encoding key watershed algorithms, which were adapted from the HSPF and SWAT model source codes. As noted above, these algorithms use various process- and empirically-based calculations to compute water runoff and infiltration, soil water storage and movement, evapotranspiration, and groundwater storage and outflow. Several of these methods, including the Runoff Curve Number method and the MUSLE served as the basis for quantifying water quantity and quality benefits for reforestation, revegetation, riparian buffer, and conservation activities identified for the collection of CWP projects. The hydrology approach represented in the computational engine is similar to the approach described by Limbrunner et al. (2006).

All of the methodologies and models selected as the basis for the WRBET computational engine were originally developed and applied in the United States. Modeling tools for predicting watershed quantity and quality have also been developed in a number of other countries, including the United Kingdom, Canada, Australia, the Netherlands, and Denmark (see Appendix C in the Phase I report for details). The rationale for selecting the proposed suite of U.S.-based tools was three-fold:

1. The proposed U.S.-based methods have a range of capabilities that are similar to, or more advanced than, watershed modeling tools developed in other countries.

2. The proposed methods are public domain and can be freely used and modified. As a result, these methods can be efficiently extracted from their native source codes and integrated into the WRBET computational engine. Conversely, several of the more advanced watershed modeling tools available internationally (e.g., Netherlands, Denmark) require substantial investment in commercial software products.

3. The SWAT model, including the associated Runoff Curve Number and Universal Soil Loss Equation methods, has been extensively applied to watersheds in a number of countries on several continents (Gassman et al., 2005). For example, peer-reviewed publications can be found in the literature for SWAT applications in India (Tripathi et al., 2003), Finland (Grizzetti et al., 2003), China (Zhang et al., 2003), Tunisia (Bouraoui et al., 2005), United Kingdom (Shepherd et al., 1999), and Greece (Varanou et al., 2002), among other locations outside of North America.

Additional details related to the development of the WRBET computational engine and the application of specific methods to support Phase II quantification work are provided in Appendix C.

1.3.4 Quantification of Restoration Benefits

The quantification of benefits from watershed restoration activities requires an accounting of the changes in the overall water budget of the local watershed system. As discussed in Section 1.3.3, numerous methods and modeling tools exist that can address these pathways. These quantitative tools generally fall into two categories: 1) empirically-based methods, which rely strongly on observations and data collected from study sites; and 2) process-based methods, which are derived from theoretical considerations and then calibrated and verified based on site-specific observations. In addition to these methods, a number of restoration benefits can be quantified using direct measurements based on available data. Simple and more complex empirical and process-based methods, as well as direct measurements were used to support the quantification work.

An example of a project using direct measurements is the quantification of reduced water use due to leak repair projects, such as the Big Spring Watershed Protection project. In this case, the water savings due to leak repairs was measured using meters, and the reported annual savings is the watershed restoration benefit. An example of the use of more complex empirical and process-based methods is a project involving cropland management, such as the Paw Paw River Watershed Restoration Project. In this case, The Runoff Curve Number method as implemented in the *Soil & Water Assessment Tool* (SWAT) (Neitsch et al. 2005) was used to estimate the decrease in surface water runoff for the conversion of conventionally-tilled straight row cropland to conservation tillage. The Modified Universal Soil Loss Equation (MUSLE) method (Williams, 1975) as implemented in SWAT was used to compute the change in sediment erosion and solids washoff that would occur as a result of converting conventionally tilled cropland to conservation tillage.

The changes in water quantity were estimated in units of million liters (ML) per year. Changes in water quality were estimated in units of metric tons (MT) per year.

2. QUANTIFICATION RESULTS

The initial review of information in the 2009 Replenish report and associated database indicated that 75 of the approximately 200 CWP projects (approximately one-third) potentially involve activities that may provide watershed restoration benefits (see Appendix A). Many of these projects were found to involve multiple restoration activities. For example, the TCCC-WWF Partnership Rio Grande/Rio Bravo project was determined to involve 11 restoration activities, including water transfers to support environmental flows, reforestation, and wastewater treatment. Eight of these activities could be quantified, and each activity was addressed separately.

For the purpose of this report, the term “project” refers to each of the approximately 200 projects described in the 2009 Replenish report. The term “activity” refers to the specific restoration actions that are being implemented under each project.

2.1 CHARACTERIZATION OF WATERSHED RESTORATION ACTIVITIES

A tally of the number of CWP projects that involve watershed restoration activities is provided by activity type in Table 2-1. The total number of projects shown in the table is larger than the 75 CWP projects determined to involve watershed restoration activities because many projects involve multiple activities. Approximately one-third (26) of the 75 projects involve agricultural land practice changes (e.g., irrigation improvements). Land use/land cover alterations (e.g., reforestation) are also a component of approximately one-third (23) of the 75 projects.

Table 2-1. CWP Projects by Activity Type

Activity Type	Number of CWP Projects
1. Agricultural land practice changes	26
2. Stormwater management	7
3. Land use/land cover alterations	23
4. Hydraulic/hydrologic waterbody alterations	9
5. Recaptured leakage from water systems	4
6. Wastewater treatment	7
7. Biologic management	6
8. Water reuse	3
9. Rainwater harvesting for aquifer recharge	8

The information obtained through this phase of work was sufficient to quantify benefits from 47 activities being implemented through 39 of the 75 CWP projects involving watershed restoration activities. The remaining projects/activities were not quantified because insufficient information was received within the project timeframe, or the project is in its early stages, or the benefits are not quantifiable.

2.2 ESTIMATES OF WATERSHED RESTORATION BENEFITS

This section provides the results of the quantification work to date. Water quantity and water quality benefits are discussed separately below. Additional details are provided in Appendices D and E. Appendix D is a spreadsheet that includes details on each activity with sufficient information to quantify. The total estimated benefit is provided in columns K and M of the sheet named “benefits tracker” in the attached Excel workbook. This quantity is adjusted based on TCCC’s percent contribution to the project (as shown in column I). For projects that TCCC did not solely fund, the total benefit was adjusted based on the estimated funding split. The total benefit is also adjusted according to the timeline for implementation, as shown in columns Q through V. For many of the projects, such as those directed by WWF, implementation follows years of study and negotiations, and those future benefits are reflected in the percentages shown in the table for the 2008-2013 period.

The supporting documentation for each project that was quantified is provided in individual fact sheets, which are included in Appendix E. Each fact sheet includes a basic description of the activity with watershed restoration benefits, contact information, the water quantity and/or water quality benefit that was estimated, the approaches used to make the estimates, and the source of data and information used to compute the quantity/quality benefits.

Several activities were investigated but not quantified as part of this phase of work because information was insufficient or the type of benefit could not be quantified. Fact sheets for these activities are included in Appendix F. This information will be useful in updating the CWP database as part of Phase III.

2.2.1 Water Quantity Benefits

The current estimate is that the projects implemented by the end of this year (2009) will provide a benefit of approximately 28.4 billion liters/year, representing 21% of the product volume by TCCC facilities. Projects implemented by the end of 2013 are estimated to provide a beneficial gain of water of approximately 51.0 billion liters/year, representing 30% of the product volume by TCCC facilities (Table 2-2). An annual increase in product volume of 5.25% was assumed (per information provided by Greg Koch).

Table 2-2. Preliminary Estimate of Water Quantity Benefits

Year	Product Volume (billion L/yr)[1]	Estimated Quantity (billion L/yr)	Percent of Product Volume[1]
End of 2008	130.0	15.4	12%
End of 2009	136.8	28.4	21%
End of 2010	144.0	33.6	23%
End of 2011	151.6	38.4	25%
End of 2012	159.5	50.7	32%
End of 2013	167.9	51.0	30%

[1] Assumes a projected annual increase in product volume of 5.25% during 2009-2013.

2.2.2 Water Quality Benefits

The pollution reduction benefits of these activities were also estimated as part of this exercise. The primary focus of almost every CWP project that addresses water quality was determined to be erosion control, so the reduction in sediment yield was estimated where relevant. The preliminary estimate is that the CWP activities evaluated will reduce sediment yield in 2009 by 2,995,945 metric tons/year, increasing to 3,544,869 metric tons by 2013 (Table 2-3). These reductions will significantly improve the quality of receiving waters in those watersheds.

Table 2-3. Preliminary Estimate of Water Quality Benefits

Year	Estimated Reduction in Sediment Yield (MT/yr)
End of 2008	2,737,551
End of 2009	2,995,945
End of 2010	3,114,210
End of 2011	3,236,647
End of 2012	3,544,869
End of 2013	3,544,869

2.2.3 Example Calculations

The six examples below illustrate how watershed restoration benefits were quantified for a selection of projects that are diverse in terms of geographic location, spatial scale, restoration activities, the types of benefits attained, and the complexity of the approaches used to quantify those benefits. The fact sheets in Appendix E provide details on these and the other CWP projects that were quantified as part of Phase II activities.

2.2.3.a Big Spring Watershed Protection, U.S.

Big Spring is an example of a leak repair project that involved a simple quantification approach based on readily available data, and resulted in a large benefit in terms of water quantity. Big Spring is an approximately 16 million gallon per day water source serving the Borough of Bellefonte in Pennsylvania. Coca-Cola (the CCDA Waters, LLC - Milesburg plant) offered to partner with the Borough Council to fund improvements in its infrastructure in lieu of increasing water fees. The Coca-Cola plant partnered with the Borough to support improvements and provide sonic testing of the piping system to detect and repair leaks from 2006 to the present.

Water savings from the detection and repair of leaks in the water supply distribution system were obtained through the CWP survey. Since 2006, third-party leak detection technicians have identified 90 leaks with estimated water savings of 1,990,520 gallons of water/day. Based on this information, a water savings in terms of reduced pumping of 2,750 ML/yr was estimated. For the 5-year projection it was assumed that the system would continue to function as in 2008. Additional water savings over the next 5 years as a result of the ongoing leak repair program were not quantified because data on future activities were not available at the time of the survey.

2.2.3.b Rainwater Harvesting and Aquifer Recharge, India

The India rainwater harvesting/aquifer recharge projects are examples of projects that were quantified using an empirical approach, and yielded large water quantity benefits. Coca-Cola India, in conjunction with partner organizations, is installing, restoring and maintaining rainwater harvesting and aquifer recharge structures to increase access to clean water and provide water for aquifer recharge. The objective is to collect rainwater for multiple uses including aquifer recharge. Currently, there are approximately 600 rainwater harvesting structures at approximately 270 locations in communities throughout India. Structures include rooftop and surface rainwater catchments that collect water for storage and distribution and/or infiltration to recharge aquifers. Examples of these structures include storage tanks, check dams, ponds, traditional step-wells and aquifer recharge shafts. Maintenance activities are conducted at the structures to promote efficient operation and prolonged lifespan.

The India Division has estimated the rainwater harvesting potential and estimated recharge of rainwater harvesting (RWH) and artificial aquifer recharge (AAR) projects using the following equation and coefficients:

***[Estimated Recharge]* = [*Catchment Area*] x [*Annual Precipitation*] x [*Catchment Coefficient*]**

where:

- [Catchment Area] (m^2) = surface area of the catchment(s) utilized to harvest precipitation for a given project;
- [Annual Precipitation] (m^2) = best available annual rainfall data for a given location; and
- [Catchment Coefficient] = coefficient representing the estimated efficiency for each catchment type.

For projects that utilize collected precipitation for artificial aquifer recharge and/or aquifer storage and recovery (ASR), the Division assumes that this value is equal to the value calculated using the above equation. In essence, 100% of the precipitation captured is assumed to be recharged.

India Division's estimates were provided in a spreadsheet. The total benefit in terms of recharge estimated is 2,658 ML/yr in 2008 and 3,249 ML/yr in 2009. These estimates do not include projects that the India Division is in the process of verifying.

The India project data will be further analyzed through a probabilistic modeling tool developed by Delta Consultants. The model more rigorously estimates the volume of rainwater captured by a rainwater harvesting (RWH) project and artificially recharged to the aquifer, if applicable, over a period of one year using readily available and limited site-specific information. The model is currently under revision based on a Subject Matter Expert (SME) review process instituted in March-April 2009. The RWH/AAR Probabilistic Model (Version 1.1) will be completed in May 2009. Upon finalization, India project data will be analyzed through the model, providing for more robust estimates of water quantity benefits.

2.2.3.c Conserving the Mekong: Tram Chim National Park, Vietnam

This example involves a hydraulic/hydrologic management project that was quantified using simple calculations and yielded a large benefit in terms of a change in direct streamflow. Tram Chim National Park (TCNP) is the site of a demonstration project of The Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme. Tram Chim is a depressed wetland area within the Plain of Reeds whose protected grasslands and Melaleuca forests offer valuable habitat for many species, including the Sarus Crane (*Grus antigone*). The project objectives are to mitigate flood and drought impacts, maintain groundwater levels and reduce saline water intrusion, and demonstrate a change in the way of thinking about management practices and policy.

A comprehensive examination of water management in the park showed that prevalent fire prevention practices resulted in retention of extra water during the dry season in the largest (4700+ ha) zone of the park. At the same time, failure of control structures led to premature drying in two smaller zones (750+ ha). Optimization of water level management in the largest zone (moving towards a more natural hydroperiod) and repair of the control structures for the other two zones will contribute to dry-season replenishment. This replenishment volume will mitigate flood and drought impacts in the Plain of Reeds as well as in the downstream Mekong Delta. It will also contribute to maintenance of groundwater levels in the Tram Chim vicinity and reduce saline water intrusion at the edge of the Mekong Delta.

The replenishment volume for the largest zone (Zone A1) was calculated as the added volume of water discharged from Zone A1 when operating under the revised Tram Chim target water levels. Monthly discharge volumes under the revised levels were calculated as the difference between beginning-of-month and end-of-month volumes as estimated from park elevation zone data in conjunction with the targets. The discharge volumes under the previous management plan were calculated using reported water levels for the years 2002-2006. The discharge volumes for 2002-2006 were calculated by converting monthly water levels into volumes, then averaging across all months. Replenishment for the smaller zones (A3 and A4) was calculated as the added volume of water stored in Zones A3 and A4, which were previously dry. Target water levels of 123 cm for Zone A3 and 137 cm for Zone A4 were selected as the comparison points. The total additional volume was estimated to be 11,400 ML.

In addition to increased water availability, these actions will lead to water quality improvements. In conjunction with mimosa eradication and Melaleuca restoration, water quality will improve through reduction of acidity and through increased filtration. These water quality benefits were not quantified due to insufficient data.

2.2.3.d Rio Grande/Rio Bravo Basin – Pandeño Spring, Mexico

Pandeño Spring is an example of a hydraulic/hydrologic management project that involved simple calculations and yielded a large benefit in terms of decreased groundwater pumping. This thermal spring is about 200 square meters in size and located near the Rio Conchos in Mexico. The spring is home to an endemic fish, the Julimes pupfish (*Cyprinodon julimes*), a new species being currently described and considered to be among the three vertebrates that live at the highest temperatures on the planet. It is among several springs impacted by increasing pumping that depletes the local groundwater supply.

The objectives of this project were to reestablish a viable population of endemic pupfish in Pandeño Spring, develop a demonstration project for a legal and administrative framework authorizing environmental flows, and establish the spring as a protected area. Technical studies to support water rights acquisition were conducted to determine the needs of the fish. It was determined that 70-80 L/sec in water rights ultimately needs to be secured. The 2009 savings was based on the quantity of water that was recently secured (50 L/sec, or 1,578 ML/yr). Projected future acquisitions of 25 L/sec (resulting in a total of 75 L/sec) were assumed to take place by 2011 based on information provided by WWF. Therefore the benefit obtained by 2011 was estimated to be 75 L/sec, or 2,370 ML/yr.

2.2.3.e Flint River Watershed Restoration, U.S.

The Flint River example illustrates how benefits were quantified for a project focused on agricultural land practice improvements related to improved irrigation practices through remote soil moisture monitoring. The objective was to provide a demonstration project for decreasing irrigation water use in the region. Based on previous studies it is known that remote soil moisture monitoring can reduce irrigation application by 1-2 applications per season. However, the reduction volume is dependent on rainfall which determines irrigation rate (currently 12 inches in a dry year, 10 inches in an average year, and 8 inches in a wet year). This ongoing project will track soil conditions in real time and reduce the number of applications based on crop need.

For simplicity, it was assumed that 100% of the water not pumped from the aquifer can be claimed as a benefit. In other words, it was assumed that only a small percentage of irrigation water percolates to the aquifer after an application, and that the rest is lost to plant uptake/transpiration, evaporation from the upper soil zone, and interflow/runoff. The water quantity benefit was calculated based on the pre- and post-project irrigation application rates provided by TNC in the survey response. The annual water savings in terms of reduced groundwater usage was estimated to be 154 million L/yr.

2.2.3.f Coca-Cola Reforestation Program, Mexico

This large-scale, multi-year project is an example of a land use/land cover alteration project with large benefits that were quantified using more complex empirical and process-based methods. TCCC, the Comision Nacional Forestal (Conafor), and Pronatura Mexico are reforesting 25,000 hectares of priority ecosystems (forests, jungles, and wetlands) that supply water to different towns nationwide. The objectives are to reduce runoff and increase infiltration, reduce sediment erosion/runoff, and restore forest habitat. Approximately 30 million trees will be planted in deforested lands to mitigate climate effects, restore habitat and biodiversity, rehabilitate aquifers and watersheds, and promote economic and community growth.

The decrease in runoff for the conversion of unforested land to forested land was estimated using the Runoff Curve Number method as implemented in the *Soil & Water Assessment Tool* (SWAT) (Neitsch et al. 2005). Water quantity calculations were focused on estimating the change in runoff volume because runoff serves as a useful indicator for both hydrologic improvements (e.g., enhanced baseflow) and reductions in sediment erosion/yield, and predictions of runoff are more certain than predictions for changes in baseflow for relatively small land areas. The benefit in terms of runoff reduction was estimated to be 9,400 ML/yr.

The Modified Universal Soil Loss Equation (MUSLE) method (Williams, 1975) as implemented in the *Soil & Water Assessment Tool* (SWAT) was used to compute the change in sediment erosion and washoff that would occur as a result of converting unforested land to forested land. The meteorological and physical datasets described above for the runoff calculation were used to support application of the MUSLE equation. Estimates of runoff volume were based on the Curve Number method, and daily maximum hourly rainfall intensities were estimated for year 2000. The reduced annual sediment yield was estimated to be 770,472 MT/yr.

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3. DISCUSSION OF FINDINGS

The results of the quantification work highlight the wide diversity of CWP projects, in terms of geographic location, spatial scale, project objectives, and outcomes. For example, CWP activities include installation of rain gardens and rain barrels to reduce stormwater impacts, rainwater harvesting to recharge aquifers, agricultural practice changes to reduce water used in irrigation, and restoration of environmental flows through large-scale water transfers. This diversity of activities is generating a wide range of watershed restoration benefits, which were quantified through this project using a variety of simple calculations and empirical and process-based methods.

The concepts and terminology surrounding water stewardship are evolving, and the use of the term "watershed restoration benefit" is being used in this report in place of the term "offset." Based on the outcomes of this quantification work, the word "restoration" was determined to be a fitting term for the benefits derived from CWP projects. As examples: rain gardens *restore* infiltration function in developed landscapes with high imperviousness; riparian buffers *restore* filtering functions that had been lost when riparian plants were removed for agriculture or other purposes; leak repairs reduce the water extracted from a river and, in doing so, help *restore* the natural flow regime; and reforestation reverses the stress on the natural hydrology that had been caused by the cutting of trees or fires and helps *restore* the natural hydrologic functions.

The primary findings of this phase of work are discussed below, with recommendations where appropriate. The findings are organized by key topic area.

3.1.1 CWP Project Objectives

The essential first step in the quantification process involved gaining an understanding of the water problem that led to the project, and the project objectives. The project objectives define the benefits to be quantified, and the methods for doing so. For some projects, the objectives were not immediately apparent from the description of the project activities, particularly when the objectives are stated very broadly (e.g., "conserve freshwater resources"). For this reason, the initial focus was to understand the specific water quality problems and goals of each project. With this information, the watershed restoration benefits to be quantified could be determined.

As an example, projects involving removal of invasive plants can serve one or more purposes. In some cases, invasive species control measures are implemented because the plants are crowding out native vegetation and reducing wetland plant diversity. In other cases the plants take up large quantities of water compared to native vegetation. In a third case, the plants are removed because they cause physical alterations to the hydrology of a river system by trapping sediment and impeding flow. In the first case, the concern is not that the plants are impacting water quantity or water quality (or this is unknown), so watershed restoration benefits were not quantified (but improvements to biodiversity were noted). In the second case where the invasive plants are "thirsty", the reduction in groundwater uptake or improvement in baseflow due to removal efforts may be quantified. In the case of physical alterations, the benefit can be quantified in terms of the change in hydrology and hydraulics (e.g., change in water level, flow, area of floodplain inundation). In this way, the project objectives drive the selection of the benefit that is quantified, and the method for doing so.

The objective of many of the CWP projects is to improve water quality by reducing erosion and associated sedimentation. Almost one-half of the 75 CWP projects that were identified as providing watershed restoration benefits involve activities directed at erosion control. This is not surprising, given the widespread consequences of erosion due to alterations of land cover and land uses. An example is the Gulf of Mexico, where nutrient loads due to erosion in the Mississippi River watershed have caused a “dead zone” to form off the coast of Louisiana. The Great Barrier and Mesoamerican Reefs, the focus of two TCCC-WWF Partnership projects, are another example of systems impacted by sediment and nutrient loads from watersheds where land disturbances have increased erosion.

The concepts related to watershed restoration benefits were evolving as this project progressed, and many contacts were not familiar with the purpose and basis for the quantification work. It will be important as this effort moves forward to be clear about the need to define specific objectives in the framework of watershed restoration benefits. This can be included in the guidance prepared as part of Phase III work.

3.1.2 Availability of Required Data and Information

A great deal of time and effort was expended to obtain the data and information required to quantify benefits. The survey developed through this phase of work provided a comprehensive list of the data and information needs, but many surveys were not returned, and the responses in the surveys that were returned were often insufficient. It was challenging in many cases to get in contact with the individuals with access to the necessary information, and there was often a need for numerous iterations. In some cases, important data needed to quantify benefits were not available. As an example, local daily precipitation data, a necessary requirement to quantify runoff reduction from reforestation projects, were found to be lacking or very limited for some projects.

The challenges associated with obtaining data and information precluded the inclusion of some projects in Phase II quantification work. It is recommended that the data gathering effort continue in the next phase of work, and that additional projects be quantified as feasible, including two TCCC-WWF projects: “Protecting the Mesoamerican Reef” and “Conserving the Mekong” (Chi River Watershed project) and CWP projects in the Philippines, provided that necessary data and information can be obtained.

The information-gathering effort can be reduced in the future by providing project implementers with guidance that includes the monitoring data and information that should be collected as the project progresses. In addition to providing guidance on defining project objectives, the guidance document should describe the site-specific information and monitoring data needed to quantify the benefits from each type of restoration activity. A list of specific questions similar to the survey prepared for this phase of work (see Appendix B) can be included in this guidance.

3.1.3 Interpretation of Quantification Results

The watershed restoration benefits provided in this report represent the change in water quantity and/or quality due to each individual CWP project activity. Ideally, it would be desirable to quantify the benefit in terms of the change in quantity and/or quality of the “blue water” of the watershed receiving the restoration action. However, assessing the actual impact of pollutant loads in the receiving stream, lake, reservoir, estuary, or aquifer requires an additional level of modeling and/or data collection and analysis. Because of the lack of sufficient data for the watersheds associated with most of the CWP projects, the benefits were quantified in terms of the local change in quantity and/or quality due to the project activity alone, and not in terms of its impact on the larger-scale watershed hydrology. Later phases of work will include compilation of the data needed to permit evaluation of the receiving water benefit, such as the increase in base flow in the river, increase in infiltration, or decrease in evapotranspiration loss.

It is important to note that no attempt was made during this phase of work to determine if the CWP projects that were quantified as part of this effort are located in the same watersheds as TCCC’s bottling plants. For this reason, the estimates of watershed restoration benefits are not linked to particular uses in the watersheds that may be impacted by TCCC’s water use.

The quantification results presented in this report represent the project team’s best estimate of watershed restoration benefits based on data and information available at the present time. The fact sheets in Appendix E provide clear descriptions of the data used and assumptions made as part of the quantification work. Many of the projects are ongoing, and the estimates can be refined as additional information and monitoring data become available as the project progresses.

3.1.4 Projects Generating the Greatest Benefits

The projects that are currently generating the largest watershed restoration benefits in terms of water *quantity* involve water transfers, reforestation/revegetation, ground restoration, land conservation, leak repair, irrigation improvements, and rainwater harvesting for aquifer recharge. The projects in these categories generating the largest benefits represent a total of 19 of the 47 project activities quantified, and these activities provide 99% of the ultimate total water quantity benefit. In terms of water *quality* (e.g., sediment reduction), the projects generating the largest benefit involve reforestation and revegetation, land conservation, and agricultural practice improvements.

Several of the CWP projects are designed to be demonstration projects, and the estimated present-day benefits are small. Examples include the TNC Flint River

Watershed Project, the USAID project in Nigeria to promote the use of small-scale irrigation methods, and the Rio Conchos pilot wastewater treatment project. The true benefits of these projects will be considerably larger if/when these projects are scaled up in the future.

3.1.5 Quantification of Reforestation Benefits

Converting barren or sparsely vegetated land to a mature native forest is generally considered to be a very beneficial action for restoring a watershed back toward its natural hydrology. However, reforestation affects many pathways in a watershed’s hydrologic budget. Furthermore, those changes will gradually be manifested over time as the forest matures. Therefore, quantification of the watershed restoration benefits of CWP reforestation actions required several assumptions. The annual runoff volume was computed using the Runoff Curve Number approach developed by the Natural Resources Conservation Service (NRCS). The annual sediment load was computed based on application of the Modified Universal Soil Loss Equation (MUSLE). The two benefits are computed separately; however, the estimated sediment erosion/washoff yield depends on the magnitude of the daily runoff estimates. The results of these calculations before (i.e., “pre-project”) and after (i.e., “post-project”) reforestation or securing land for conservation were used to evaluate the benefits of the project.

The rationale for estimating water quantity/quality benefits based on runoff volume reduction and sediment yield reduction is that the reforestation efforts are generally restoring the watershed to a more “natural” hydrology. For example, reduction in runoff represents a shift in the local hydrologic budget back to “natural” conditions. The presence of trees or other vegetation may increase evapotranspiration relative to pre-project conditions, but, again, this represents the natural condition. For conservation projects, the assumption is that the forested/vegetation land would be converted to a more degraded land use condition (e.g., agriculture or residential) if not secured for conservation. Therefore, the benefit is the runoff “savings” that occur as the result of not allowing the land to be developed. Based on this approach, the various CWP reforestation/revegetation and conservation projects comprise a significant contribution to the total watershed restoration benefits reported in Tables 2-2 and 2-3.

It should be noted that reforestation and soil conservation measures are generally reported in the literature to reduce peak flows and stormflows associated with deforestation, but the beneficial effects on base flows are less consistent and less well-documented (LimnoTech and TNC, 2008).

Water quantity and quality benefits associated with reforestation or revegetation were assumed to take effect in the year that plantings occurred. For conservation activities, benefits were assumed to be in effect at the point in time when the land was secured for conservation. These assumptions result in benefits becoming effective at the earliest point in time possible. In reality, the benefits associated with reforestation will tend to “ramp up” over time as the plantings grow and transform into a mature forest cover. A potential alternative to making reforestation benefits effective immediately would involve developing a schedule to represent the evolution of the forest cover from plantings to mature forest. For conservation projects, it could potentially be argued that benefits should not become effective until that point in time when development of the land would have occurred if the land had not been conserved. However, this information is often not available at the time the land is set aside.

To account for these issues and to refine the estimates of the benefits of these types of actions, it will be necessary to analyze the watershed response at a finer spatial and temporal scale and to consider the long-term development of the new conditions as the system matures. This will require more site data than it has been possible to acquire to date. The necessary data for refining this calculation will be included in the guidance that is developed during the next phase of this project.

3.1.6 Volume Equivalents of Water Quality Benefits

The benefits associated with CWP projects relative to water quality were quantified in terms of the change in mass loading and were not converted to a volume equivalent. There is interest in being consistent with the Water Footprint Network as to how grey water footprints are quantified and compared with blue and green water footprints. However, there is currently no consensus on how to express water quality changes in volume equivalents. The previous analysis of this question identified four possible approaches, which were summarized in Appendix D of the Phase I report (LimnoTech and TNC, 2008). Each of these approaches is summarized briefly below:

Waste Source Purification: This method focuses on the volume and quality of the waste source. The equivalent volume for a reduction in pollution is based on the percentage that the pollution load (or concentration) is reduced. Conceptually, it can be characterized as the percentage of the waste flow that is “purified.” It is simple to apply and requires little data but includes no consideration of actual receiving water impacts or benefits.

Water Body Purification: This method is similar to the waste source purification method but focuses on changes in the receiving water rather than the waste source. Conceptually, it can be described as the percentage of the receiving water that is cleaned up by a pollution control action. The core method only considers the incremental impacts and percentage of purification from the waste source, but refinements could consider the effect of other sources, background water quality, and/or a target for purification. This method is more complex and requires more data than waste source purification, but it considers actual water body impacts and benefits.

Waste Source Dilution: This method focuses on the waste source and the reduction in concentration or load. The equivalent volume is calculated by determining the equivalent clean water flow needed to dilute the waste source in order to achieve the same level of reduction in concentration as achieved with the actual pollution control action. This method does not consider receiving water conditions. This method is simple to apply and requires limited data but can result in some large, "unreal" calculations of benefits.

Water Footprint Reduction: This method involves calculating the grey water footprint for the waste source before and after the action is taken. The footprint approach involves calculating a dilution volume relative to a water quality target or criterion. This requires specification of a water quality target against which the footprint can be computed, but it does not consider actual impacts or benefits within a water body. Unlike the waste source dilution approach, this method has an implicit cap equal to the original grey water footprint.

The problem is that depending on the specifics of a particular project, each of these approaches can result in widely varying conversions to a volume metric for a given mass loading change. Other issues include the method by which multiple pollutant reductions are credited, and whether credit for pollution load reduction should be given if that action has no significant effect on a problem that exists in the receiving water body. The benefits, issues, and implementation details associated with converting pollutant loads to a volume currency require further investigation and discussion. Until a resolution of the issues is reached, it is recommended that the water quantity and quality components of water uses or restoration actions be accounted for separately, such that quantity changes only be used to address "blue" and/or "green" components of the footprint, and quality changes (i.e., pollutant load reductions) only be used to address the "grey" component of the footprint.

3.1.7 TCCC's Cost Share

The watershed restoration benefits provided in Table 2-2 and 2-3 for each year are the product of the computed restoration benefit (in ML/yr or MT/yr) and TCCC's cost share (as a percent). The estimates of TCCC's cost contribution were generally provided by the project contacts, who often indicated that they were unsure of the actual cost split, particularly for large projects involving multiple partners. The project team's research focused primarily on the technical details of the project activities, and far less time was dedicated to this important factor. The project team generally did not have access to financial information, and therefore relied primarily on the best estimates provided by contacts. If it was determined that the project would not have occurred without TCCC funding, the TCCC share was set at 100%. Another important question related to cost share to be resolved is the best way to handle situations where TCCC funding was used indirectly to achieve benefits (e.g., funding the writing of a grant).

The complexities related to TCCC's contribution could introduce a great deal of uncertainty into the final estimates of benefits. It is recommended that the cost information be further investigated in the next phase of work, and that the current estimates then be refined accordingly.

3.1.8 Future Projections

The watershed restoration benefits provided in Tables 2-2 and 2-3 are provided by year, for the 2008-2013 period. The annual estimates are derived from the percent complete in each year based on the information provided by the contacts on the implementation schedule. In many cases, activities are in the planning stages, and the certainty of successful implementation was based on the opinions of project managers. Where it appeared very likely that the project would proceed as planned, the predicted benefits were quantified. Where it was determined to be too early to know what specific activities will occur as a result of ongoing efforts, no attempt was made to quantify the benefits. As an example, much important progress has been made in the Yangtze River Basin related to building and operating “green dams.” Efforts have involved essential stakeholder “ice breaking”, but the ultimate outcomes are currently unknown. As another example, TCCC-WWF’s Southeast Rivers and Streams project has been primarily focused on influencing policies and regulations related to stormwater management that will ultimately reduce stormwater loads and related impacts, but it would be premature to quantify the benefits of those activities.

The benefits reported for each year are the benefits generated at the end of that calendar year. When an activity was reported to be completed during a given year, it “counted” toward the end-of-year benefit for that year.

It is important to note that the success of CWP projects in terms of attaining the full watershed restoration benefits and the length of time that a realized benefit will persist is not always known. Post-monitoring data are not often available for completed projects, and the success of ongoing or planned projects is uncertain. Furthermore, information on the long-term maintenance of existing projects is generally not available. As an example, for projects involving removal of invasive species, plans to continue removal are dependent on continued funding and other factors. For projects involving irrigation infrastructure improvements, the long-term maintenance of those systems is also dependent on continued funding. For this reason, benefits were projected out to 2013 and no longer, based on the assumption that the projects will continue to function for at least 5 years and “depreciation” of benefits is not necessary.

3.1.9 Additional Benefits Not Quantified

Through this project, water quantity and water quality benefits associated with a wide range of projects were successfully quantified. The scope of the Phase II effort does not, however, reflect the many other important benefits from these projects, including habitat improvement, increased biodiversity, and carbon sequestration. As an example, the removal of a small dam as part of TNC’s Etowah River Watershed Conservation Partnership project did not affect the flow regime and generate watershed restoration benefits, because it was a run-of-river dam. However, the dam removal did re-establish stream reach connectivity, thereby enabling fish passage and providing important habitat quality improvements. The best way to include these important benefits in a water certification framework warrants further discussion.

The estimates of watershed restoration benefits also do not include savings in energy use due to less water use or improvement in water quality. For example, some restoration activities such as reduced water use for irrigation result in lower energy use (and associated water use) because less water is pumped through the system.

The results presented in this report also do not consider the watershed restoration benefits from new projects without current commitments or planned expansions of current projects that extend beyond 2013. Furthermore, many of the CWP project activities are demonstration projects, and the benefits of related projects that were facilitated or created as a result of a TCCC-supported project are not included in the results. Other important benefits such as stakeholder engagement, promotion of sustainability, increased crop yields, and improved local economies are also not included in the quantification results.

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