The Afghanistan Engineering Support Program assembled this deliverable. It is an approved, official USAID document. Budget information contained herein is for illustrative purposes. All policy, personal, financial, and procurement sensitive information has been removed. Additional information on the report can be obtained from Firouz Rooyani, Tetra Tech Sr. VP International Operations, (703) 387-2151.

TETRA TECH

November 29, 2014

[redacted], COR
[redacted], ACOR
Office of Economic Growth and Infrastructure (OEGI)
U.S. Agency for International Development
Great Massoud Road
Kabul, Afghanistan

Re: **USAID Contract No. EDH-I-00-08-00027-00 / Task Order No. 1**
Afghanistan Engineering Support Program (AESP)

Work Order WO-A-0098
Kabul Basin Aquifer Recharge, Revision 2
Data Review and Feasibility Study Elements

[redacted]:

Please find transmitted herewith our revised memo that incorporates comments received from USAID on November 22, 2014.

This technical memorandum is in response to a request from USAID to review existing technical documentation to determine if a full feasibility study addressing the implementation of an Aquifer Recharge System (ARS) in the Kabul River Basin would be a logical step forward. This memo also includes a discussion of key pre-feasibility study elements and data requirements needed to move forward should a full feasibility study be indicated.

Based on the literature search performed by Tetra Tech on the documents listed in Appendix 1, attached hereto, it is Tetra Tech's opinion that there are no documented geologic or hydro-geologic conditions that would preclude the recommendation of a feasibility study for the Kabul Basin.

We look forward to supporting the USAID OEGI mission during 2014 and to strengthen our partnership while building a brighter future for Afghanistan.

Please contact me at your convenience should you have any questions or comments regarding this report.

Respectfully,
Tetra Tech, Inc.

[redacted]

[redacted] PE, BCEE
Chief of Party (AESP)

TETRA TECH

MEMO

To:	[redacted]
Cc:	[redacted]
From:	[redacted]
Date:	Revised November 29, 2014
Subject:	WO-A-0098 Kabul Aquifer Recharge Pre-Feasibility Study – Review of Documents-Revision 2

This memo addresses a request from USAID to Tetra Tech (Tt) to review existing scientific literature and documentation to determine if a feasibility study is warranted for the implementation of an Aquifer Recharge System (ARS) in the Kabul Basin urban and peri-urban surrounding areas.

An ARS, also known as a Managed Aquifer Recharge, is the practice of optimizing recharge of an aquifer under controlled conditions to store water for later extraction or to achieve environmental benefits.

Water is typically added to an appropriate aquifer by infiltration via surface structures such as ponds, basins, galleries and trenches or injection via wells.

There are many potential sources of recharge water including stormwater, treated wastewater and water from surface watercourses or aquifers.

Some pre-treatment of the source water may be beneficial before recharging the aquifer to ensure that the quality of the groundwater is maintained or improved. The level of treatment required, if any, will generally depend on a risk assessment and would be addressed in a feasibility study.

Benefits of ARS

Managed aquifer recharge schemes have the potential to increase water availability by generating water supplies from sources that may otherwise be wasted, and they can provide environmental, social and economic benefits.

Benefits include: improved maintenance of wetlands, opportunity for storage of water in times of surplus to meet need in times of demand, prevention of salt-water intrusion, increased water availability for irrigation use, and augmentation of drinking water supplies.

Managed aquifer recharge also has the potential to improve water quality through natural processes. It may assist in the removal of nutrients such as phosphates and organics, the degradation of chemicals such as disinfection by-products, and pathogen die-off.

Limitations of ARS

An ARS is not feasible everywhere due to hydrogeological, environmental, or cost constraints. In some cases where stormwater or treated wastewater is used for irrigation or other non-potable uses, direct use of the water could be preferable to managed aquifer recharge.

There is the potential for managed aquifer recharge to play an important role in the sustainable management of water in the Kabul River Basin, however there are a number of environmental, health, and social issues associated with the process that need to be considered.

<u>Literature Review</u>

A list of relevant literature was provided by USAID for evaluation pertaining to the potential for ARS implementation in the Kabul River Basin. Additional literature references were provided on 9 October, 2014 by USAID. (See attached document summary table for a list of publications reviewed). Based on the literature reviewed, the following information is provided.

General Background

The area of interest for this pre-feasibility study is known as the Kabul River Basin which is located in central eastern Afghanistan. Depending on the study being quoted, the basin covers between 54,000 km^2 and 86,000 km^2, and is divided into four to eight sub-basins.

Hydrogeology

Groundwater in this basin is generally confined to three water-bearing strata.

Logar Aquifer

The geology of the Logar aquifer is well characterized by investigations performed by the Soviets, Germans, and Canadians since 1963. This geologic unit ranges up to 50 meters in thickness and is associated with the Logar River system. The aquifer has a loamy cover layer of at least 10 m thickness, which is very sandy and therefore permeable. Such constitution allows for seepage of irrigation water and other superficial water. Below these loams there are sandy gravels with thinly bedded loess and conglomerate. With increasing depth, these gravels become more strongly cemented, so that the lower half of the aquifer consists mainly of conglomerates, which are mostly water bearing. The total depth of the aquifer is approximately 60 to 70 m below ground surface. The basal aquiclude consists of fine grained neogenic sediments that are of minor importance for groundwater flow.

Paghman Aquifer

This water-bearing strata is associated with the Paghman major river system. The alluvium is composed of Neocene sandy gravels with some lenses of conglomerate and sandstone as well as layers of silty and clayey material. The thickness of the aquifer is up to 100 m. Typical wells in the vicinity do not exceed 65 m below ground surface. The wells in the south have a higher yield than those in the north. Most of the well areas have a very thin cover layer that only have a minor protective effect on the groundwater [1]. Only the cover layers of wells AF07 and AF6A present a significant thickness. Groundwater recharge takes place by river bank infiltration mostly between November and May when the Paghman River carries water.

Allowdin Aquifer

Although there are no borings in the area with known lithologic logs, and the E-logs of the BGR from 1966 are too far away to allow a conclusion about the subsurface structure, it can be stated that the whole area overlying this aquifer has a cover layer of reworked loess of several meters thick. These sediments consist mainly of clay and silt. Therefore, they have a certain protective effect on the underlying aquifer, which is formed by sandy gravels alternating with sandy sections and cemented conglomerates. These sediments also have outcrops in the river bed of nearby Kabul River at some sites. With 3.4 m below natural ground level, the groundwater level measured on June 7th, 2010 was very high. The aquifer is therefore likely confined or at least semi-confined.

Groundwater Recharge and Flow Direction

The majority of water recharge for this basin is provided by surface infiltration from the Paghman, Kabul, and Logar River systems. Calculations performed on data obtained in the early 2000's indicate the annual recharge rate is on the order of 380 Mm^3/yr [2]. In broad terms, this basin is balanced (i.e. recharge and withdrawal are approximately equal). Although, evidence suggests that certain sub-basins within the Kabul Basin are at a water deficit (withdrawal exceeds recharge), while other sub-basins have a water surplus (recharge exceeds withdrawal). It should be noted that this information is based on data collected several years ago and may be significantly different today.

1 - "Managed Aquifer Recharge (4)" – Government of Western Australia, Department of Water

2 - "Afghanistan – An Overview of Groundwater Resources and Challenges" Vincent W. Uhl Uhl, Baron, Rana Associates, Inc. Washington Crossing, PA, USA

Flow direction of the groundwater fluctuates slightly. During the infiltration period, the flow direction is typically from southeast to northwest, whereas it flows from southwest to northeast during the dry season. During the review process, Tetra Tech identified several areas that will require clarification or resolution during any subsequent feasibility study. These issues include:

1. The status of proposed dam construction and design plans. Documentation indicated there are proposed dam projects in the river basin. The status of these projects are important because any dam constructed within the potential aquifer recharge area will alter existing data for the basin regarding water use, stream volume, and stream characteristics.
2. The current status of documented infrastructure projects regarding drinking water distribution. Potential recharge options will rely on accurate drinking water data.
3. The status of current collection systems including leak detection and resolution, collection and conveyance, and additional municipal connections. It is important to understand current and expected water demands and additional water supply demands due to leaking infrastructure.
4. The current status of documented and planned sanitation infrastructure projects. Water quality plays an important role in groundwater recharge. Untreated sanitary discharge is a significant element that affects ground water quality. The ARS is not intended to address sanitary issues however, the ARS must take into account the current and proposed sanitary conditions when determining recharge locations.
5. The status of any pre-existing or planned water agreements with neighboring countries. There is a possible potential for decreased flow and water quality downstream as a result of an aquifer recharge system
6. The specific planned use and ownership for water generated from an aquifer recharge system should be established prior to the feasibility study. Anticipated uses include:
    a. Municipal domestic water use
    b. Industrial
    c. Agriculture
    d. Energy generation
7. The recharge volume expectations should be established during the feasibility study. Different types of aquifer recharge systems are designed depending on these expectations. These include:
    a. seasonal storage supply
    b. emergency storage
    c. groundwater level restoration
8. The current and planned future usage demand for the Kabul River basin. Many different estimates are available, but the most current estimate will be required in order to adequately evaluate potential aquifer recharge options.

Estimating and measuring groundwater recharge is challenging and contains a high degree of uncertainty. Accordingly, it is sometimes subject to large errors. A good understanding of the intended scope of the project including the items listed above and all available data is key to successfully evaluating a potential recharge project.

Predicted Data Needs

The key to successfully evaluating a potential recharge project is the initial investigation of the target aquifers, source water quality, receiving water quality, and the potential area of hydrogeological effect. Because of the level of uncertainty included in estimating recharge rates, various techniques should be used to develop a range of recharge rates. The selection of a recharge method should be determined by the objectives of the study, available data, and the ability to collect supplementary data. The items outlined below are some of the data available and anticipated to be used during the feasibility study. Additionally, some items identify site-specific data that will be needed during the feasibility study.

- Municipal Drinking Water

- Locations and number of municipal wells (latitude/longitude) – JICA 2014 (2) indicates 40 production wells. JICA 2011 (16) lists water supply wells (total of 52) by name and the designated managing office. Coordinates for all existing municipal wells are unknown but anticipated to be available. JICA 2011 (16) also indicates additional municipal wells were anticipated by 2015. It is unknown if these wells have been installed. Current data needs to be obtained prior to initiating a feasibility study.

- Type of wells – JICA 2011 (16) – 52 municipal wells. USGS 2005 (1) – 148 monitoring wells.

- Land use data/mapping – JICA 2014 (2) and JICA 2012 (15) document land use data for the upper Kabul River basin.

- Municipal/Monitoring well specifics (elevations, screen and bottom depths, etc.) – 26 wells with specific construction materials are documented in the 2011 Well Rehabilitation Report (8). USGS 2005 (1) has elevations and depths for monitoring wells (no screen depths).

- Well construction details/logs – not included in any provided documents. Well construction data is necessary to understand the geology of the area. If this data is not available, the general geology of the area that is documented in many of the reports will be used.

- Type of aquifers – Existing documentation indicates that a shallow unconfined alluvial aquifer and a deep Neogene aquifer exist throughout the study area. JICA 2011 (16) indicates that the deep Neogene aquifer has minimal or no recharge – therefore only the shallow alluvial aquifer should be considered for aquifer recharge systems.

- Operational data (capacity, withdrawal rates, etc.) – Operational data for the existing water supply system are presented in many of the documents provided. It is anticipated that if any additional specific operational data are required, they will be made available.

- Water quality – many of the documents provided indicate that water quality outside of the immediate urban area is of drinking water quality. However, water quality within the urban area has microbial contamination. Therefore, only aquifer recharge systems outside of the urban area are proposed for feasibility evaluation.

- Zones of influence - Supply zones are identified in many of the documents provided. However, actual zone of influence for each existing well is not documented. If an expansion of the existing water supply system is required to implement any ARS, a zone of influence determination may be required (either part of feasibility study or pre-design activities).

- Potential contamination sites that could impact recharge efforts and municipal wells – Other than common contamination related to poor sanitary conditions, additional contamination or sources were not identified.

- Geological/Hydrogeological Characterization (including percolation, hydraulic conductivity, transmissivity, storativity and gradient) - General geology and hydrogeology of the Kabul Basin are documented in many of the reports provided. However, site-specific characterization will be required (specific proposed area(s) of aquifer recharge system(s)) in order to adequately evaluate geology and hydrogeology in the feasibility study.

- Characterization of Source Water(s) – Average annual flows and volumes are presented in many of the documents provided. Some small-scale investigation(s) may be required in order to obtain site-specific data, including localized flows and volumes, bank measurements, etc.

- Climate data – Precipitation and evaporation rates are presented in many of the documents provided. It is anticipated that a representative range of values for these parameters may be ascertained from the existing documents.

Many of the reports provided by USAID discuss some of the needed data but do not include all of the raw data that will be necessary during the feasibility study. The ARS options evaluated during the feasibility study will depend on what data is available at that time.

Initial Proposed Aquifer Recharge Systems (ARSs) to be included in Feasibility Study

Listed below are some of the proposed ARS systems to be considered during the feasibility study. The feasibility study is not limited to this list and the available data will drive what recharge options are feasible and considered.

- Percolation Tanks and Recharge Weirs – These could be used to minimize the seasonal fluctuation of groundwater levels as a result of snowmelt. This option would also require an expansion of the existing water supply system to tap into water outside of the Kabul area (to minimize contamination in existing wells).

- Infiltration Basin or Pond – This would require the diversion of an existing stream (any upgradient stream identified with applicable characteristics - flow, volume, etc.) into an aquifer. This would also involve some existing water supply expansion.

- Underground Dam - If the depth to bedrock is shallow where source water would be accessed, snowmelt/stream water could be retained in the shallow aquifer up gradient of contaminated areas and accessed as needed.

Summary of Findings

Based on the literature search performed by Tetra Tech on the documents listed in Appendix 1, it is Tetra Tech's opinion that there are no documented geologic or hydro-geologic conditions that would preclude the recommendation of a feasibility study for the Kabul Basin.

As noted previously herein, the annual aquifer recharge rate of the Kabul River Basin is on the order of 380 Mm^3/yr. The principal goal of any future feasibility study should be to determine the expected improvement in the Kabul Basin aquifer recharge rate and the tangible benefits resulting from a specified investment in aquifer recharge systems.

Appendix 1: Document Summary Table

Document Number	Report/Document Name	Date	Author/Company	Format of Document
1	Inventory of Ground-Water Resources in the Kabul Basin, Afghanistan	2005	USGS	PDF
1a	AGS_wells_report	Unknown	KSBU	Microsoft Excel
2	Study on Water Resources Development and Utilization Necessary for Water Supply to Kabul Metropolitan Area	March 2014	Japan International Cooperation Agency (JICA)	PDF
3	Water Security: Afghanistan Transboundary Water Resources in Regional Context	October 2013	Rainer Gonzalez Palau/Civil-Military Fusion Center (CFC)	PDF
4	Water Supply Kabul - Improvement of Technical Operations Capabilities of KSBU (Kabul Strategic Business Unit) Extension of the Kabul Water Supply System	September 2012	KSBU	PDF
5	An Overview of Groundwater Resources and Challenges	2003	Uhl, Baron, Rana Associates Inc Washington Crossing, PA, USA	PDF
6	AWARD Technical Assistance - Kabul River Basin Profile	March 2013	Landell Mills	PDF
7	Water Resources of Afghanistan and It's Climate Change Impact	August 25, 2013	M. Naim Eqrar, University of Kabul	Microsoft Powerpoint
8	Well Rehabilitation Report	September 2011	JV Fichtner W&T - IGIP - BETS	PDF
9	Availability of Water in the Kabul Basin	May 2010	USGS	PDF
10	Water Strategy, Final Kabul Basin Report, Version 4.0	June 17, 2012	Pell Frischmann, Exeter (for World Bank)	PDF
11	Managed Aquifer Recharge	Unknown	unknown	PDF
12	The Study for the Development of the Master Plan for the Kabul Metropolitan Area in the Islamic Republic of Afghanistan	September 2009	JICA	PDF
13	Water Management in Islam	2001	International Development Research Centre	PDF
14	The Study on the Kabul Metropolitan Area Urban Development in the Islamic Republic of Afghanistan	September 2006	JICA	PDF
15	Feasibility Study on Urgent Water Resources Development and Supply for Kabul Metropolitan Area - Interim Report	February 2012	JICA	PDF
16	The Study on Groundwater Resources Potential in Kabul Basin in the Islamic Republic of Afghanistan	March 2011	JICA	PDF
17	Water Resources Potential, Quality Problems, Challenges, and Solutions in Afghanistan	July, 2013	DACAAR	PDF