ISLAMIC REPUBLIC OF AFGHANISTAN

# WATER WELL PUMPING REPORT OF KHODADADI'S WATER WELL

## (DRINKING WATER SUPPLY SYSTEM IMPROVEMENT PROJECT IN BARCHI AREA OF KABUL CITY, AFGHANISTAN)

**Date: January 06, 2021**

**Contractor:**

Delivering Excellence
DYNAMIC VISION

**Consultant:**

UNOPS

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# 1 Introduction

This report presents the interpretation of pumping test results which preformed for Khodadadi's Water Well.

In this stage Pamir has conducted pumping test on well to determine the borehole efficiency and to quantify aquifer characteristics, such as transmissivity, hydraulic conductivity, and storativity. The procedure include constant and recovery tests.

Pumping tests were carried out to establish the geological and hydrogeological characteristics of the aquifers. Constant pumping and recovery test have been conducted on one well which are located in Barchi area.

# 2 Project Objectives

The main objectives of this pumping test are to evaluate the existing aquifer(s) capacity for sustainable water supply in the project area. For this purpose, Khodadadi's well was pump tested within the project area.

# 3 Well Location

Khodadadi well is located behind the Bahar Sarab Business Center in district 13$^{th}$, Kabul, Afghanistan. The coordinate is Lat: 34.49881382, Long: 69.07115115.


Figure 1 Location of pump test water well

# 4 Aquifer Pumping Tests

Pumping tests were carried out to establish the geological and hydrogeological characteristics of the aquifer. For subject project, step test, pumping test and recovery test have been conducted on the well. Based on conducted pumping tests the aquifer parameters such as hydraulic conductivity, transmissivity, and storativity of aquifer has been determined.

## 4.1 Step Drawdown Pumping Test

This test proceeds through a sequence of constant-rate a control well to determine well performance characteristics such as well loss and well efficiency. Step test are designed to establish the short-term relationship between yield and drawdown for the well being tested. It consists of pumping the well in a series of steps, each at a different discharge rate, usually with the rate increasing with each step. The final step should approach the estimated maximum yield of the well.

## 4.2 Constant Pumping Test

In this test it is necessary to maintain pumping at the control well at a constant rate. This is the most commonly used pumping test method for obtaining estimates of aquifer properties. This test is carried out by pumping at a constant rate for a much longer period of time than the step test, and primarily designed to provide information on the hydraulic characteristics of the aquifer.

A constant pumping test was performed for proposed existing well to determine the characteristics of aquifer and the test continued until the dynamic water level reach to steady state.

## 4.3 Recovery Test

This test use water level (residual drawdown) measurements after the termination of pumping. Although often interpreted separately, a recovery test is an integral part of any pumping test. Recovery test is preformed out after pump is shut off.

## 4.4 Summary of Water Well Pumping Test results

Step drawdown pumping test were performed in this well with 10 lps (Step 1) discharge rate at 120 minutes then increased to 12 lps (Step 2) discharge rate at 120 minutes. Since pumping start water level reached from 57.35 to 176.40 meter with 119.05-meter drawdown after 4 hours in step 2, water well have been drying and muddy water pumped. Hence, the constant

pumping test with 6 lps discharge rate were performed at 24 hours pumping and water level reach to steady state from 57.35 to 92.40 meter with 35.05-meter drawdown.

**Table 1 Summary of Water Well Pumping Test Results and Well Specification**

| Step Drawdown Pumping, lps | | Constant pumping, lps | Drawdown, m | Well depth, m | Well dia. | Casing/ screen dia. | Screened thickness, m | Pump Position, m | Drop Pipe Dia. |
|---|---|---|---|---|---|---|---|---|---|
| Step1 | Step2 | | | | | | | | |
| 10 | 12 | 6 | 35.05 | 200 | 16 in. | 10 in. | 45 (acc. Log) | 185 | 4 in. |

## 4.5 Specific Yield

This is a crude indication of the efficiency of the well as an engineered structure, and is calculated by dividing the discharge rate ($m^3$/day) by the total drawdown. High specific yields generally indicate high transmissivities, low specific yield the opposite.

**Table 2 Pump Test Results**

| Sr. No. | Well Name | Depth of Well (m) | Discharge, Q (lps) | Discharge, Q ($m^3$/day) | Static Water Level, SWL (m) | Dynamic Water Level, DWL (m) | Drawdown, Sw (m) | Specific Yield of Well, Sy ($m^2$/day) |
|---|---|---|---|---|---|---|---|---|
| **1** | Khodadadi | 200 | 6 | 518.4 | 57.35 | 92.40 | 35.05 | 14.79 |
| **Specific Yield, Sy=Q/Sw = 518.4/35.05=14.79 $m^2$/d** | | | | | | | | |

## 4.6 Aquifer Characteristics

Hydraulic properties of the formation intersected by a well can be estimated from single-well tests by a curve-matching approach that fits an analytical solution to time-drawdown data of pumping tests. Numerous analytical solutions exist and are derived from the application of simplifying assumptions to Darcy's law. Hydraulic properties, such as transmissivity and storativity, are fitting parameters used to match the analytical solution to plots of drawdown against time. Type-curve method, such as Papadopulos–Cooper (1967), match an analytical solution to plots of drawdown against time.

Transmissivity (T), hydraulic conductivity (K) and storativity (S) were calculated by theoretical Papadopulos–Cooper-type curve's method in this program based on the pump well data for well.

**Table 3 Aquifer Characteristics' Summary of Calculation for Khodadadi Well**

| Sr. No. | Well Name | Q ($m^3$/d) | $s_w$ (m) | t (d) | $F(u_w,\alpha)$ | Uw | $r^2_{ew}$ ($m^2$) | $r^2_c$ ($m^2$) | α | K (m/d) | T ($m^2$/d) | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | Khodadadi | 518.4 | 22.5 | 0.0010 | 10 | $10^{-4}$ | 0.0413 | 0.0161 | $10^{-3}$ | 0.61 | 18.34 | $2.84*10^{-4}$ |

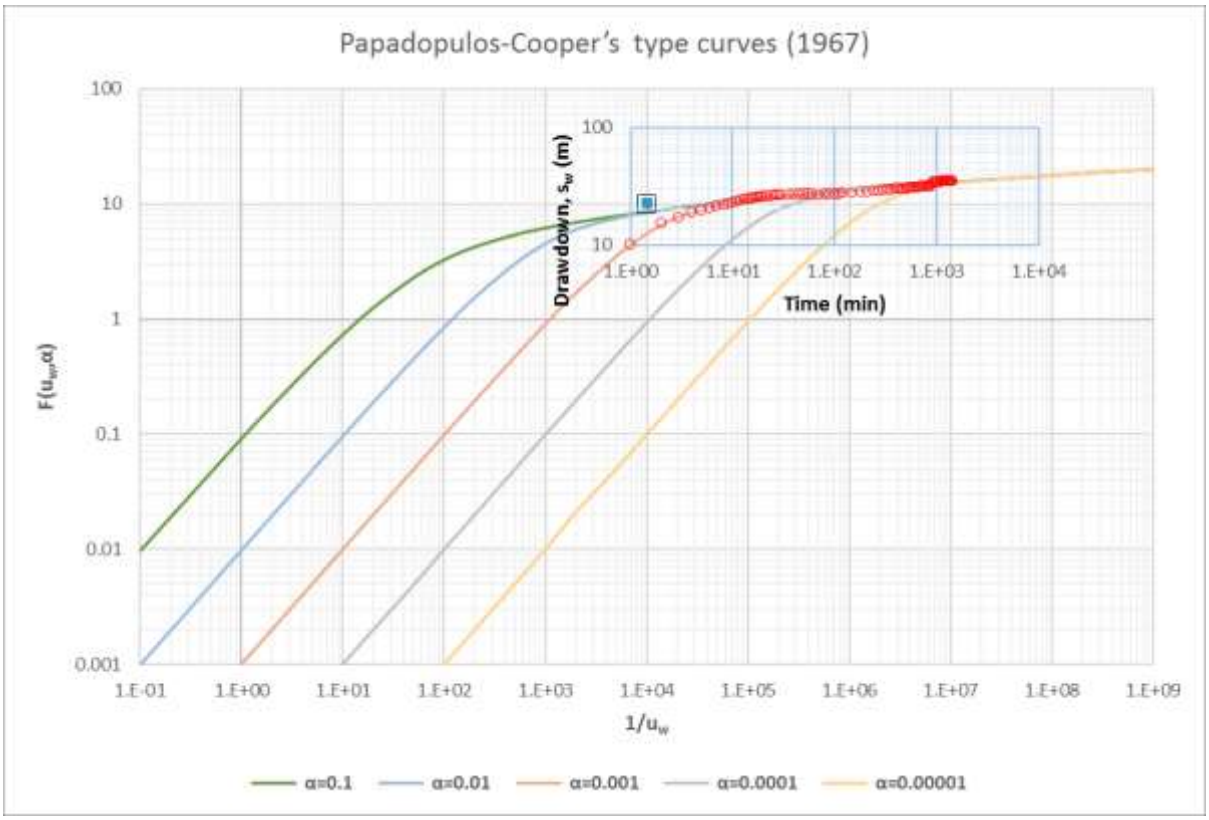



**Figure 2 Matching of observed time-drawdown curve with theoretical Papadopulos–Cooper-type curve for the Khodadadi's Well**

### 4.6.1 Transmissivity

This is the rate of flow of water under a unit hydraulic gradient through a cross-section of unit width across the entire saturated section of an aquifer.

Transmissivity is a measure of the capability of the aquifer to transmit groundwater through a one-meter-wide band over its full depth, under a one meter or unit gradient. The units of transmissivity are $m^3$/day/meter, which simplifies to $m^2$/day. Transmissivity is equivalent to hydraulic conductivity multiplied by the aquifer thickness. Aquifer transmissivity is most easily determined from aquifer pumping tests.

- Transmissivity given Papadopulos-Cooper's method by

$$KD = \frac{Q}{4\pi S_w} F(u_w, \alpha)$$

Where

T=KD= transmissivity in $m^2$/day

Q= pumping discharge rate in $m^3$/day

$S_w$= drawdown in m

$F(u_w, \alpha)$ = Papadopulos-Cooper's curve function

Note: $F(u_w, \alpha)$, $1/u_w$, $s_w$ and $t$ have been arbitrary selected based on superimpose the data curve on the type curve at match point (blue dot) coordinates on below graphs. Coordinates of match points have been presented in table 3.

Thus,

$$KD = \frac{518.4}{4 \times 3.14 \times 22.5} \times 10 = 18.34\ m^2/d$$

### 4.6.2 Hydraulic Conductivity

Hydraulic conductivity is a fundamental parameter that governs the flow of liquids such as groundwater through aquifers and permeable geological layers. Specifically, hydraulic conductivity is a quantitative measure of the capacity of a geological formation or other porous media to transmit a specific fluid. It is determined by the characteristics of both the porous medium and the fluid of interest. The hydraulic conductivity of aquifer is determined based analyzing of pumping test results.

- Hydraulic conductivity given by

$$K = \frac{T}{D}$$

Where

K= hydraulic conductivity in m/day

T= transmissivity in $m^2$/day

D= aquifer thickness in m (given 30m according to geophysical study report)

Thus,

$$K = \frac{18.34}{30} = 0.61\ m/d$$

### 4.6.3 Storativity

The storativity of a confined aquifer is defined as the volume of water released from storage per unit surface area of the aquifer per unit decline in hydraulic head. Storativity is also known by the term storage coefficient.

- In a confined aquifer, storativity is defined according to Papadopulos Cooper's method as

$$S = \frac{u_w}{r_{ew}^2} 4KDt$$

Or by other way $S = \frac{r_c^2}{r_{ew}^2}\alpha$

Where

S= Storativity in dimensionless

$r_{ew}$= radius of well (0.4064/2=0.2032m)

$r_c$=radius of casing (0.254/2=0.127m)

thus,

method 1: $S = \frac{0.0001}{0.0413} \times 4 \times 18.34 \times 0.0010 = 1.78 \times 10^{-4}$

method 2: $S = \frac{0.0161}{0.0413} \times 0.001 = 3.90 \times 10^{-4}$

**Hence, average Storativity**

$$S = \frac{(1.78 \times 10^{-4}) + (3.90 \times 10^{-4})}{2} = 2.84 \times 10^{-4}$$

**Reference:**

1. American Water Works Association, 2006, AWWA Standards for Water Wells (AWWA A100 – 06)
2. Analysis and Evaluation of Pumping Test Data 2nd edition, G.P. Kruseman and N.A. de Ridder, 2000
3. Ground Water and Wells, Fletcher Driscoll, Johnson Division, 1986.
4. USACE-AED Design Requirements: Well Pump & Well Design, for Various Locations, Afghanistan. February 2012, Version 2.1.

# APPENDIX A

## WATER WELL PUMPING TEST FORMS

**PAMIR GEOTECHNICAL SERVICES COMPANY**

## STEP DRAWDOWN PUMPING TEST

| | | | | | |
|---|---|---|---|---|---|
| **Project:** | DRINKING WATER SUPPLY SYSTEM IMPROVEMENT PROJECT IN BARCHI AREA OF KABUL CITY, AFG | | | | |
| **Site:** | Khodadadi Well | **Coordinate:** | Lat: 34.49881382, Long: 69.07115115 | | |
| **Well Depth (m):** | 200 | **Pump Position (m):** | 185 | **Pump Type:** | Submersible |
| **Static Water Level (m):** | 57.35 | **Casing/Screen Type:** | Steel - 10 in | **Screen Position (m)** | uknown |
| **Dynamic Water Level (m):** | 176.40 | **Height of Measuring Point (m):** | 0.5 | Measuring with Water Level Indicator | |
| **Drawdown (m):** | 119.05 | **Discharge Rate (lps):** | 10 | **Start Date:** | 01.01.2021 |

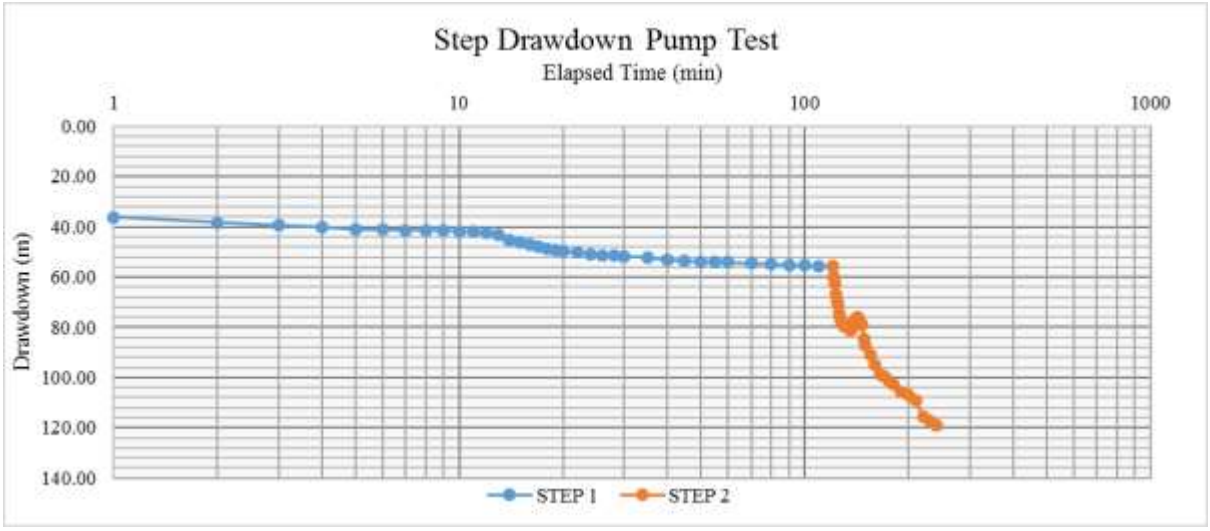
| Time | Elapsed Time (min) | Depth to Water (m bmp) | Drawdown (m) | Q (lps) | Comments |
|---|---|---|---|---|---|
| **STEP 1** | | | | | |
| 10:10 AM | 0 | 92.40 | 35.05 | 10 | |
| | 1 | 93.50 | 36.15 | " | |
| | 2 | 95.57 | 38.22 | " | |
| | 3 | 96.78 | 39.43 | " | |
| | 4 | 97.46 | 40.11 | " | |
| | 5 | 98.32 | 40.97 | " | |
| | 6 | 98.48 | 41.13 | " | |
| | 7 | 98.58 | 41.23 | " | |
| | 8 | 98.67 | 41.32 | " | |
| | 9 | 98.82 | 41.47 | " | |
| | 10 | 99.03 | 41.68 | " | |
| | 11 | 99.42 | 42.07 | " | |
| | 12 | 99.84 | 42.49 | " | |
| | 13 | 100.56 | 43.21 | " | |
| | 14 | 102.48 | 45.13 | " | |
| | 15 | 103.73 | 46.38 | " | |
| | 16 | 104.20 | 46.85 | " | |
| | 17 | 105.20 | 47.85 | " | |
| | 18 | 105.97 | 48.62 | " | |
| | 19 | 106.56 | 49.21 | " | |
| | 20 | 107.08 | 49.73 | " | |
| | 22 | 107.56 | 50.21 | " | |
| | 24 | 108.30 | 50.95 | " | |
| | 26 | 108.68 | 51.33 | " | |
| | 28 | 108.89 | 51.54 | " | |
| | 30 | 109.06 | 51.71 | " | |
| | 35 | 109.40 | 52.05 | " | |
| | 40 | 110.37 | 53.02 | " | |
| | 45 | 110.87 | 53.52 | " | |
| | 50 | 111.08 | 53.73 | " | |
| | 55 | 111.22 | 53.87 | " | |
| | 60 | 111.43 | 54.08 | " | |
| | 70 | 111.85 | 54.50 | " | |
| | 80 | 112.14 | 54.79 | " | |
| | 90 | 112.46 | 55.11 | " | |
| | 100 | 112.68 | 55.33 | " | |
| | 110 | 112.90 | 55.55 | " | |
| | 120 | 113.10 | 55.75 | " | |

**PAMIR GEOTECHNICAL SERVICES COMPANY**

## STEP DRAWDOWN PUMPING TEST

| | | | | | |
|---|---|---|---|---|---|
| **Project:** | DRINKING WATER SUPPLY SYSTEM IMPROVEMENT PROJECT IN BARCHI AREA OF KABUL CITY, AFG | | | | |
| **Site:** | Khodadadi Well | **Coordinate:** | Lat: 34.49881382, Long: 69.07115115 | | |
| **Well Depth (m):** | 200 | **Pump Position (m):** | 185 | **Pump Type:** | Submersible |
| **Static Water Level (m):** | 57.35 | **Casing/Screen Type:** | Steel - 10 in | **Screen Position (m)** | uknown |
| **Dynamic Water Level (m):** | 176.40 | **Height of Measuring Point (m):** | 0.5 | Measuring with Water Level Indicator | |
| **Drawdown (m):** | 119.05 | **Discharge Rate (lps):** | 10 | **Start Date:** | 01.01.2021 |

| Time | Elapsed Time (min) | Depth to Water (m bmp) | Drawdown (m) | Q (lps) | Comments |
|---|---|---|---|---|---|
| | | **STEP 2** | | | |
| 12:10AM | 120 | 113.10 | 55.75 | 12 | |
| | 121 | 117.44 | 60.09 | " | |
| | 122 | 119.96 | 62.61 | " | |
| | 123 | 124.25 | 66.90 | " | |
| | 124 | 127.00 | 69.65 | " | |
| | 125 | 128.33 | 70.98 | " | |
| | 126 | 131.94 | 74.59 | " | |
| | 127 | 133.62 | 76.27 | " | |
| | 128 | 135.58 | 78.23 | " | |
| | 129 | 136.72 | 79.37 | " | |
| | 130 | 136.87 | 79.52 | " | |
| | 131 | 136.98 | 79.63 | " | |
| | 132 | 137.29 | 79.94 | " | |
| | 133 | 137.38 | 80.03 | " | |
| | 134 | 137.68 | 80.33 | " | |
| | 135 | 138.30 | 80.95 | " | |
| | 136 | 138.42 | 81.07 | " | |
| | 137 | 137.51 | 80.16 | " | |
| | 138 | 135.42 | 78.07 | " | |
| | 139 | 134.67 | 77.32 | " | |
| | 140 | 133.93 | 76.58 | " | |
| | 142 | 133.33 | 75.98 | " | |
| | 144 | 134.36 | 77.01 | " | |
| | 146 | 136.21 | 78.86 | " | |
| | 148 | 141.77 | 84.42 | " | |
| | 150 | 144.45 | 87.10 | " | |
| | 155 | 148.26 | 90.91 | " | |
| | 160 | 152.42 | 95.07 | " | |
| | 165 | 155.93 | 98.58 | " | |
| | 170 | 156.97 | 99.62 | " | |
| | 175 | 158.52 | 101.17 | " | |
| | 180 | 159.94 | 102.59 | " | |
| | 190 | 163.14 | 105.79 | " | |
| | 200 | 164.44 | 107.09 | " | |
| | 210 | 166.62 | 109.27 | " | |
| | 220 | 173.11 | 115.76 | " | |
| | 230 | 174.50 | 117.15 | " | |
| | 240 | 176.40 | 119.05 | " | |


Step Drawdown Pump Test
Elapsed Time (min)
1
10
100
1000
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
Drawdown (m)
STEP 1
STEP 2

**PAMIR GEOTECHNICAL SERVICES COMPANY**

## CONSTANT PUMPING TEST

| | | | | | |
|---|---|---|---|---|---|
| **Project:** | **DRINKING WATER SUPPLY SYSTEM IMPROVEMENT PROJECT IN BARCHI AREA OF KABUL CITY, AFG** | | | | |
| **Site:** | **Khodadadi Well** | **Coordinate:** | **Lat: 34.49881382, Long: 69.07115115** | | |
| **Well Depth (m):** | 200 | **Pump Position (m):** | 185 | **Pump Type:** | Submersible |
| **Static Water Level (m):** | 57.35 | **Casing/Screen Type:** | Steel - 10 in | **Screen Position (m):** | uknown |
| **Dynamic Water Level (m):** | 92.40 | **Height of Measuring Point (m):** | 0.5 | Measuring with Water Level Indicator | |
| **Drawdown (m):** | 35.05 | **Discharge Rate (lps):** | 6 | **Start Date:** | 12.31.2020 |

| Time | Elapsed Time (min) | Depth to Water (m bmp) | Drawdown (m) | Q (lps) | Comments |
|---|---|---|---|---|---|
| 9:40 AM | 0 | 57.35 | 0.00 | 6 | |
| | 1 | 67.45 | 10.10 | " | |
| | 2 | 72.63 | 15.28 | " | |
| | 3 | 74.26 | 16.91 | " | |
| | 4 | 76.45 | 19.10 | " | |
| | 5 | 77.30 | 19.95 | " | |
| | 6 | 78.04 | 20.69 | " | |
| | 7 | 78.76 | 21.41 | " | |
| | 8 | 79.34 | 21.99 | " | |
| | 9 | 79.85 | 22.50 | " | |
| | 10 | 80.51 | 23.16 | " | |
| | 11 | 80.93 | 23.58 | " | |
| | 12 | 81.20 | 23.85 | " | |
| | 13 | 81.53 | 24.18 | " | |
| | 14 | 81.85 | 24.50 | " | |
| | 15 | 82.10 | 24.75 | " | |
| | 16 | 82.41 | 25.06 | " | |
| | 17 | 82.67 | 25.32 | " | |
| | 18 | 82.87 | 25.52 | " | |
| | 19 | 83.02 | 25.67 | " | |
| | 20 | 83.24 | 25.89 | " | |
| | 22 | 83.41 | 26.06 | " | |
| | 24 | 83.60 | 26.25 | " | |
| | 26 | 83.67 | 26.32 | " | |
| | 28 | 83.72 | 26.37 | " | |
| | 30 | 83.78 | 26.43 | " | |
| | 35 | 83.97 | 26.62 | " | |
| | 40 | 84.23 | 26.88 | " | |
| | 45 | 84.40 | 27.05 | " | |
| | 50 | 84.41 | 27.06 | " | |
| | 55 | 84.41 | 27.06 | " | |
| | 60 | 84.37 | 27.02 | " | |
| | 70 | 84.20 | 26.85 | " | |
| | 80 | 84.25 | 26.90 | " | |
| | 90 | 84.41 | 27.06 | " | |
| | 100 | 84.55 | 27.20 | " | |
| | 110 | 84.70 | 27.35 | " | |
| | 120 | 84.90 | 27.55 | " | |
| | 150 | 85.28 | 27.93 | " | |
| | 180 | 85.62 | 28.27 | " | |
| | 210 | 85.94 | 28.59 | " | |
| | 240 | 86.22 | 28.87 | " | |
| | 270 | 86.51 | 29.16 | " | |
| | 300 | 86.72 | 29.37 | " | |
| | 330 | 86.91 | 29.56 | " | |
| | 360 | 87.08 | 29.73 | " | |
| | 390 | 87.29 | 29.94 | " | |
| | 420 | 87.43 | 30.08 | " | |
| | 450 | 87.54 | 30.19 | " | |
| | 480 | 87.69 | 30.34 | " | |
| | 510 | 87.83 | 30.48 | " | |
| | 540 | 87.98 | 30.63 | " | |
| | 570 | 88.06 | 30.71 | " | |
| | 600 | 88.15 | 30.80 | " | |
| | 630 | 88.25 | 30.90 | " | |

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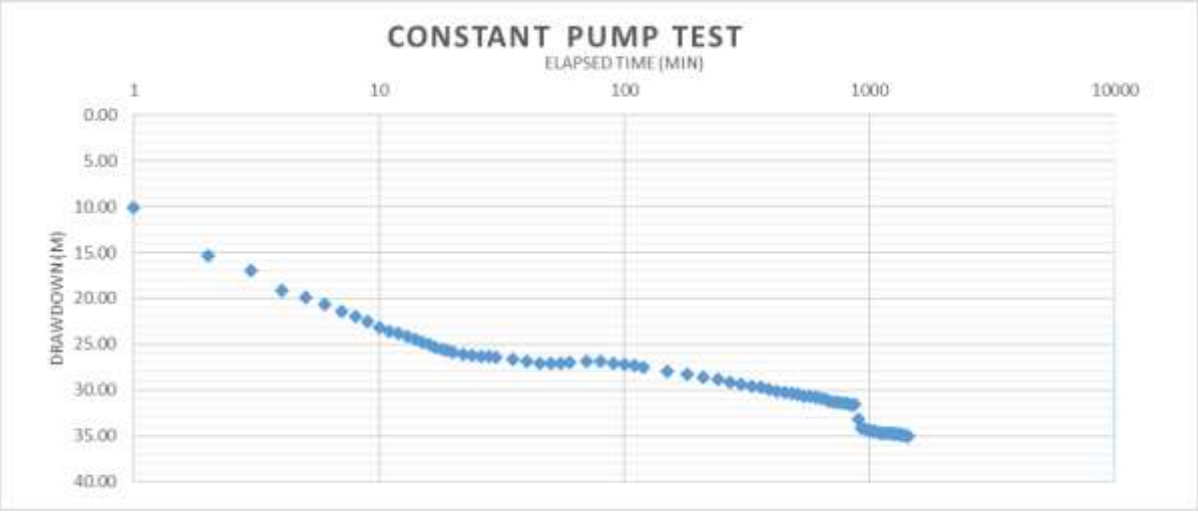
## CONSTANT PUMPING TEST

| | | | | | |
|---|---|---|---|---|---|
| **Project:** | **DRINKING WATER SUPPLY SYSTEM IMPROVEMENT PROJECT IN BARCHI AREA OF KABUL CITY, AFG** | | | | |
| **Site:** | **Khodadadi Well** | **Coordinate:** | **Lat: 34.49881382, Long: 69.07115115** | | |
| **Well Depth (m):** | 200 | **Pump Position (m):** | 185 | **Pump Type:** | Submersible |
| **Static Water Level (m):** | 57.35 | **Casing/Screen Type:** | Steel - 10 in | **Screen Position (m):** | uknown |
| **Dynamic Water Level (m):** | 92.40 | **Height of Measuring Point (m):** | 0.5 | Measuring with Water Level Indicator | |
| **Drawdown (m):** | 35.05 | **Discharge Rate (lps):** | 6 | **Start Date:** | 12.31.2020 |

| Time | Elapsed Time (min) | Depth to Water (m bmp) | Drawdown (m) | Q (lps) | Comments |
|---|---|---|---|---|---|
| | 660 | 88.34 | 30.99 | " | |
| | 690 | 88.56 | 31.21 | " | |
| | 720 | 88.63 | 31.28 | " | |
| | 750 | 88.69 | 31.34 | " | |
| | 780 | 88.74 | 31.39 | " | |
| | 810 | 88.83 | 31.48 | " | |
| | 840 | 88.95 | 31.60 | " | |
| | 870 | 88.94 | 31.59 | " | |
| | 900 | 90.53 | 33.18 | " | |
| | 930 | 91.52 | 34.17 | " | |
| | 960 | 91.58 | 34.23 | " | |
| | 990 | 91.70 | 34.35 | " | |
| | 1020 | 91.80 | 34.45 | " | |
| | 1050 | 91.85 | 34.50 | " | |
| | 1080 | 91.92 | 34.57 | " | |
| | 1110 | 92.00 | 34.65 | " | |
| | 1140 | 92.03 | 34.68 | " | |
| | 1170 | 92.07 | 34.72 | " | |
| | 1200 | 92.05 | 34.70 | " | |
| | 1230 | 92.08 | 34.73 | " | |
| | 1260 | 92.12 | 34.77 | " | |
| | 1290 | 92.17 | 34.82 | " | |
| | 1320 | 92.20 | 34.85 | " | |
| | 1350 | 92.22 | 34.87 | " | |
| | 1380 | 92.27 | 34.92 | " | |
| | 1410 | 92.36 | 35.01 | " | |
| | 1440 | 92.40 | 35.05 | " | |

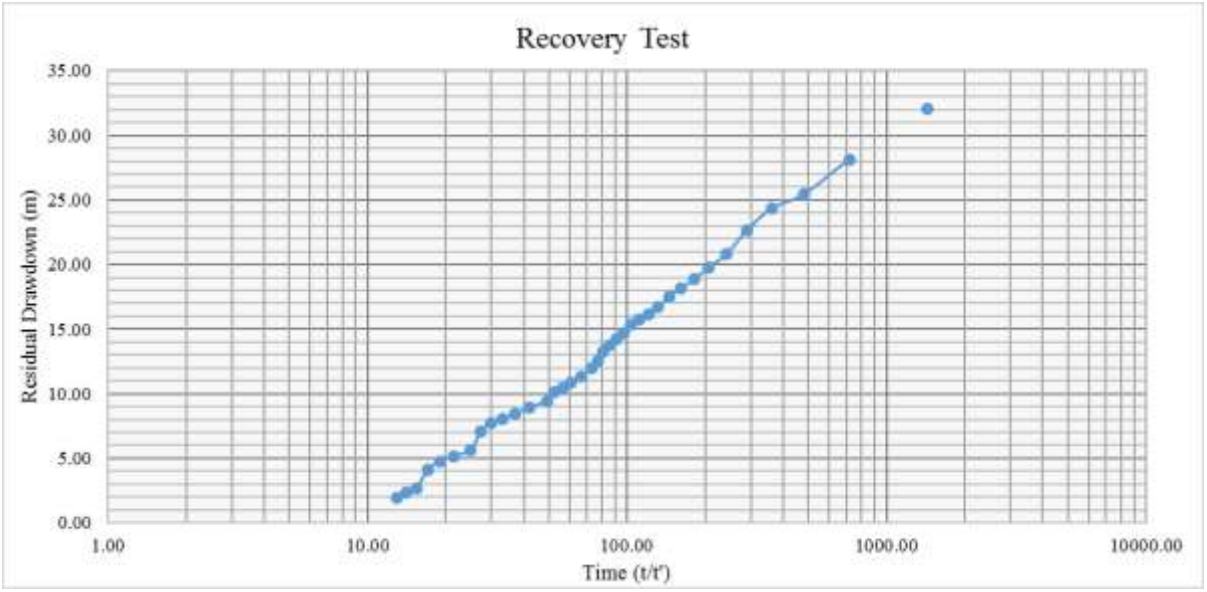


**PAMIR GEOTECHNICAL SERVICES COMPANY**

**RECOVERY TEST**

| | | | | | |
|---|---|---|---|---|---|
| **Project:** | **DRINKING WATER SUPPLY SYSTEM IMPROVEMENT PROJECT IN BARCHI AREA OF KABUL CITY, AFG** | | | | |
| **Site:** | **Khodadadi Well** | **Coordinate:** | **Lat: 34.49881382, Long: 69.07115115** | | |
| **Well Depth (m):** | 200 | **Pump Position (m):** | 185 | **Pump Type:** | Submersible |
| **Static Water Level (m):** | 57.35 | **Casing/Screen Type:** | Steel - 10 in | **Screen Position (m)** | uknown |
| **Dynamic Water Level (m):** | 92.40 | **Height of Measuring Point (m):** | 0.5 | Measuring with Water Level Indicator | |
| **Drawdown (m):** | 35.05 | **Discharge Rate (lps):** | 6 | **Start Date:** | 01.01.2021 |

| Time | Time Since Pumping Started, t (min) | Elapsed Time (min) | t/t' | Depth to Water (m bmp) | Residual Drawdown (m) | Comments |
|---|---|---|---|---|---|---|
| | 1440 | 0 | 0.00 | 92.40 | 35.05 | |
| | 1441 | 1 | 1441.00 | 89.44 | 32.09 | |
| | 1442 | 2 | 721.00 | 85.48 | 28.13 | |
| | 1443 | 3 | 481.00 | 82.8 | 25.45 | |
| | 1444 | 4 | 361.00 | 81.7 | 24.35 | |
| | 1445 | 5 | 289.00 | 80 | 22.65 | |
| | 1446 | 6 | 241.00 | 78.13 | 20.78 | |
| | 1447 | 7 | 206.71 | 77.16 | 19.81 | |
| | 1448 | 8 | 181.00 | 76.2 | 18.85 | |
| | 1449 | 9 | 161.00 | 75.5 | 18.15 | |
| | 1450 | 10 | 145.00 | 74.9 | 17.55 | |
| | 1451 | 11 | 131.91 | 74.03 | 16.68 | |
| | 1452 | 12 | 121.00 | 73.53 | 16.18 | |
| | 1453 | 13 | 111.77 | 73.12 | 15.77 | |
| | 1454 | 14 | 103.86 | 72.7 | 15.35 | |
| | 1455 | 15 | 97.00 | 72.04 | 14.69 | |
| | 1456 | 16 | 91.00 | 71.54 | 14.19 | |
| | 1457 | 17 | 85.71 | 71.12 | 13.77 | |
| | 1458 | 18 | 81.00 | 70.64 | 13.29 | |
| | 1459 | 19 | 76.79 | 69.87 | 12.52 | |
| | 1460 | 20 | 73.00 | 69.3 | 11.95 | |
| | 1462 | 22 | 66.45 | 68.66 | 11.31 | |
| | 1464 | 24 | 61.00 | 68.2 | 10.85 | |
| | 1466 | 26 | 56.38 | 67.8 | 10.45 | |
| | 1468 | 28 | 52.43 | 67.46 | 10.11 | |
| | 1470 | 30 | 49.00 | 66.77 | 9.42 | |
| | 1475 | 35 | 42.14 | 66.3 | 8.95 | |
| | 1480 | 40 | 37.00 | 65.83 | 8.48 | |
| | 1485 | 45 | 33.00 | 65.43 | 8.08 | |
| | 1490 | 50 | 29.80 | 65.08 | 7.73 | |
| | 1495 | 55 | 27.18 | 64.4 | 7.05 | |
| | 1500 | 60 | 25.00 | 63 | 5.65 | |
| | 1510 | 70 | 21.57 | 62.51 | 5.16 | |
| | 1520 | 80 | 19.00 | 62.12 | 4.77 | |
| | 1530 | 90 | 17.00 | 61.45 | 4.10 | |
| | 1540 | 100 | 15.40 | 60.01 | 2.66 | |
| | 1550 | 110 | 14.09 | 59.7 | 2.35 | |
| | 1560 | 120 | 13.00 | 59.31 | 1.96 | |

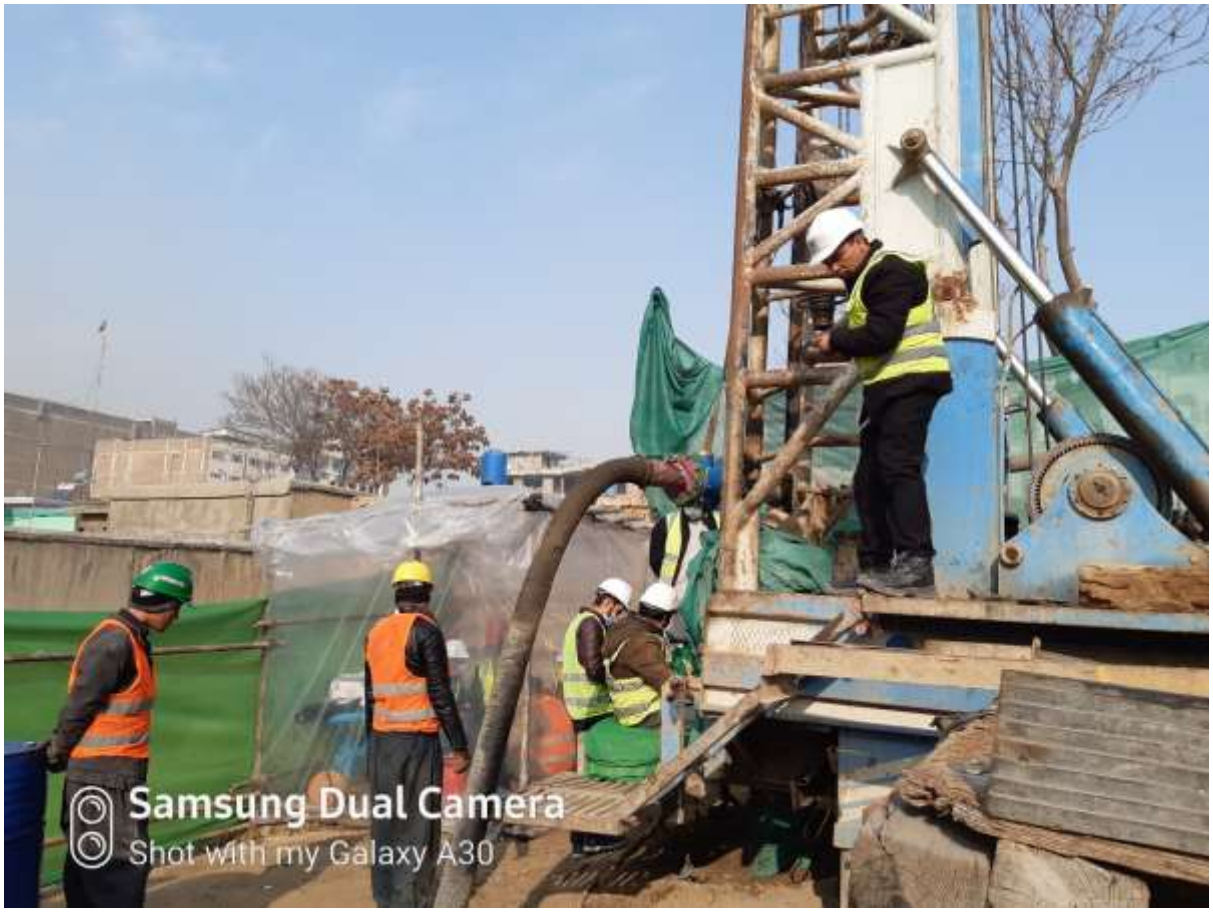

Recovery Test
Residual Drawdown (m)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
1.00
10.00
100.00
1000.00
10000.00
Time (t/t')

# APPENDIX B

## PHOTOGRAPH


Samsung Dual Camera
Shot with my Galaxy A30


Samsung Dual Camera
Shot with my Galaxy A30


Samsung Dual Camera
Shot with my Galaxy A30


Samsung Dual Camera
Shot with my Galaxy A30