# Watershed Interventions for Kurlod and Botoshi

## Phase I

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## Table of Contents

## List of Figures

## List of Tables

# Executive summary

**Background**

The thirteen habitations of Kurlod and Botoshi villages in Mokhada taluka, Palghar district, face severe water stress in the summers despite having an annual rainfall of 2-3 meters. Through a joint collaboration between Aroehan, Siemens CSR, and the Technology and Development Solutions Cell (TDSC) at IIT Bombay, a series of watershed interventions have been planned to alleviate the stress. The aim of the project is to increase water availability for both drinking and livelihood opportunities, and is planned to be implemented in two phases over two years.

Phase I of the project will be implemented between January-March 2015 and Phase II between January-March 2016. Broadly, Phase I consists of interventions to address the drinking water availability and quality problems, while Phase II will consist of interventions to meet livelihood water needs. This report presents interventions planned for Phase I, and tentative interventions planned for Phase II.

**TDSC Outputs**

As per the project Terms of Reference (TOR), TDSC will provide technical guidance towards planning and design of the interventions, Aroehan will manage the implementation, and Siemens will assist with funding and overall steering. A copy of the project proposal is included in the Annexure.

The table below lists the outputs planned as TDSC deliverables at the start of the project and their current status:

**Table 1 - TDSC planned outputs and current status.**

| TDSC planned outputs | Current status |
|---|---|
| Status assessment of habitations and existing structures, and identification of possible Round 1 and Round 2 interventions | Complete |
| Set-up of monitoring systems: training of villagers on monitoring of well levels | Complete but with limited success – volunteers are not measuring well levels consistently |
| Data collection and observations on-site for Round 1 interventions | Complete |
| Analysis of secondary data on farmlands to determine desired storage capacity at target habitations for Round 1 | Incomplete since the data was not available. However, this step is more important for Phase II interventions where new bunds will be planned around local irrigation water demand. |
| Assessment of possible project allocations (NREGA, IWMP) | Majority of Phase I interventions involve repair of structures, which are not covered by NREGA and IWMP. Project allocations will play a larger role in Phase II. |
| Planning, design and cost calculations for Round 1 interventions | Complete |

**Summary of planned interventions**

The table below summarizes the interventions planned for Phase I and Phase II. Phase II interventions listed here are tentative and not a complete list; Phase II intervention plans will evolve and grow as Phase I interventions are implemented and their impact is evaluated.

**Table 2 - Planned Phase I and Phase II interventions for each habitation**

| Habitation | Interventions for Phase I | Expected Impact after Phase I | Tentative Interventions for Phase II |
|---|---|---|---|
| Kurlod | Bund repair for well recharge; well platform and drain construction | Longer duration of water in well, and improved sanitation around well | New subsurface bund for well recharge |
| Pethechapada | Well repair | Protection of well from siltation in monsoons | New bund for well recharge |
| Jambhulpada and Shedyachapada | Installation of netted cover for well | Protection of well from leaves and debris | |
| Raipada | Reconstruction of buried well | Creation of an additional drinking water source | Loose boulder check on stream; farm bunds on all farms upstream to well |
| Manipada | Well repair | Protection of well from siltation | |
| Wadpada | No interventions planned | -- | Subsurface bund for well recharge and/or new bund for irrigation storage |
| Botoshi | Contour trenches for well recharge; well platform and drain construction | Well recharge and improvement in soil moisture, and improved sanitation around well | |
| Kirkeriwadi | Well repair and de-siltation | Protection of well from siltation in monsoons | |
| Bhelpada | No interventions planned | -- | New bund for irrigation storage; farm bund upstream of well |
| Markatwadi | New well; contour trenches for well recharge | Creation of an additional drinking water source, well recharge and improvement in soil moisture | |
| Bhojpada | Well repair and de-siltation; new bund construction for irrigation storage | Protection of well from siltation, creation of surface water storage for irrigation | Construction of bridge over stream |

**Summary of quantity of material for Phase I**

Almost every watershed intervention planned under Phase I will involve construction with Plain Cement Concrete (PCC) or Reinforced Cement Concrete (RCC) and/or excavation of soil or silt. The approximate volume of construction material and excavation required has been calculated for each intervention. The total volumes for each material for Phase I interventions are provided in Table 3 below.

**Table 3 – Approximate construction/excavation volumes for Phase I interventions**

| **Material for construction/excavation** | **Total volume (m3)** |
|---|---|
| PCC | 29 |
| Masonry | 103 |
| Soil **excavation** (contour trenches and new wells) | 224 |
| Silt **excavation** (for well and bund enhancement) | 43 |

# 1 Introduction

The Kurlod-Botoshi watershed project is planned as a joint collaboration between Aroehan, Siemens CSR, and the Technology and Development Solutions Cell (TDSC) at IIT Bombay. Kurlod and Botoshi are neighboring tribal villages in Mokhada block, Palghar district, that face severe water scarcity, particularly in the summer months of February, March, April, May and June. The aim of this project is to increase water availability in the area for both drinking and livelihood purposes, and is planned to be implemented in two phases, over two years. This report presents the watershed interventions proposed for Phase I, whose implementation will begin in January 2015.

The report begins with a short background on Kurlod and Botoshi and the water stress levels in each habitation. Next, the current status of water assets and proposed interventions for each habitation are described in detail; this section forms the core of the report. The report concludes with a summary of all proposed interventions and an annexure with technical and design details of specific interventions.

## 1.1 Kurlod and Botoshi

Kurlod and Botoshi have a combined population of approximately 2600 souls, split over 13 habitations with individual populations ranging from 15 to 450. Kurlod is approximately 158 km from Mumbai (typically a 5 hour drive), and 55 km from Kasara (typically a 2-3 hour drive). Botoshi is closer to Kasara by an hour.


**Figure 1 – Map showing geographical location of Kurlod village.**

The habitations are all either close to the Pinjal River, seen in the image below, or by a stream that drains into the river.

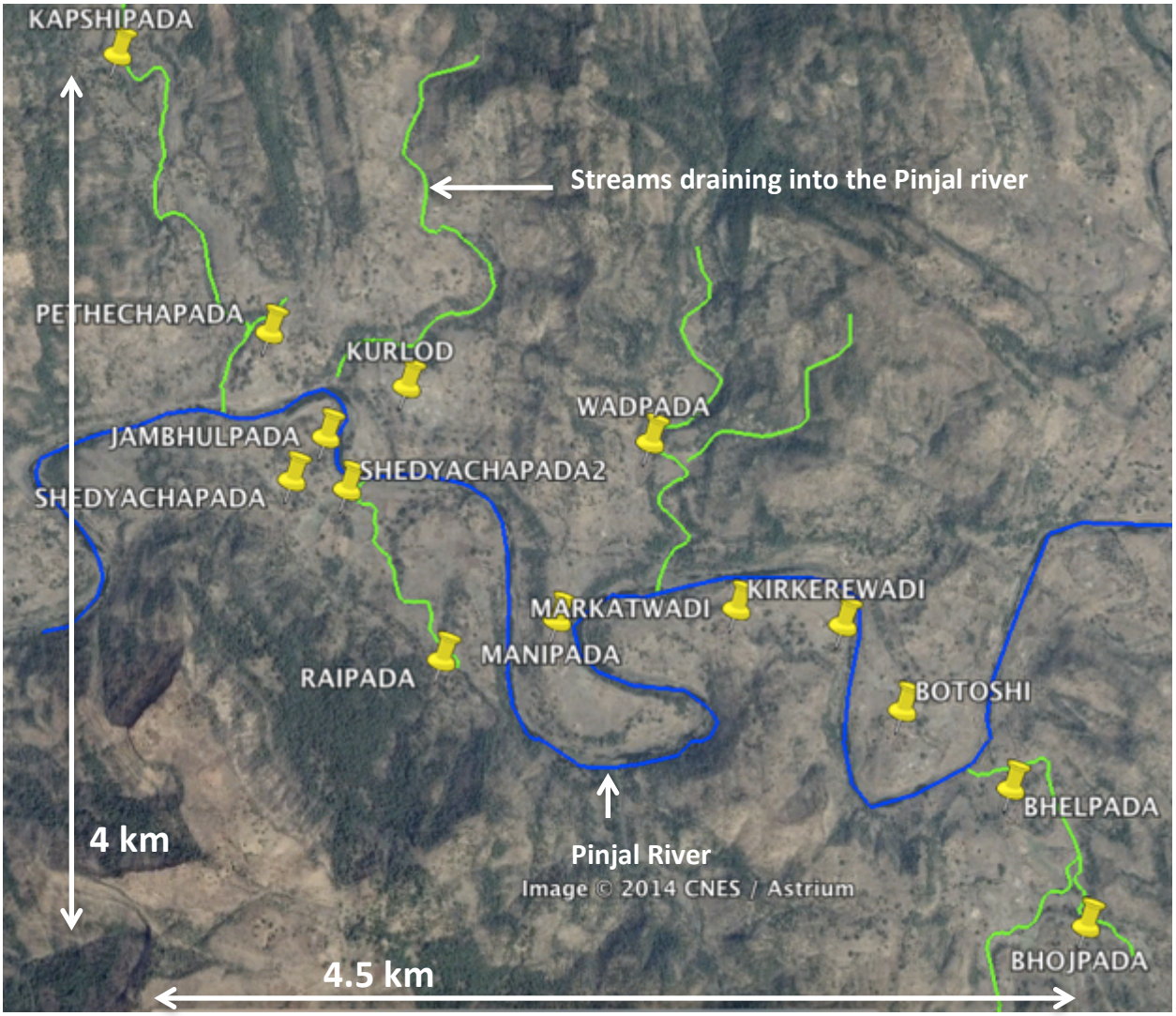


Figure 2 - Google Earth image showing layout of habitations in Kurlod and Botoshi.

## 1.2 Water stress assessment

From May-July 2014, Mohit Singhal and Mukul Kaushik, two students from IIT Roorkee, conducted a status assessment of the drinking water stress in the 13 habitations of Kurlod and Botoshi[1]. Their findings were verified and updated during field visits by TDSC between September and December 2014. The table below indicates specific challenges of drinking water security for each habitation.

**Table 3 - Planned Phase I and Phase II interventions for each habitation**

| Habitation | Pop. | Primary well lasts until… | Problems of water quality in primary well | Problems of accessibility to water sources |
|---|---|---|---|---|
| Kurlod | 400 | May | | |
| Pethechapada | 450 | December | | Difficult access to potential primary well |
| Jambhulpada and Shedyachapada | 150 | Year round | Quality problem due to tree overhanging the well | |
| Raipada | 80 | Year round | Major quality problem post-monsoons | |
| Manipada | 60 | October | | Difficult access to potential primary well |
| Wadpada | 100 | March | | One of the two wells is at a much lower elevation than the habitation |
| Botoshi | 400 | May | | |
| Kirkirewadi | 40 | Year round | Quality problem in the summer months | Primarily well gets submerged during monsoons |
| Bhelpada | 450 | June | | |
| Markatwadi | 150 | November | | Steep 30 m drop to reach water source from habitation |
| Bhojpada | 340 | Year round | | Primary well get cut off by stream during the monsoons |
| Kapshipada | 15 | Year round | | |

[1] The complete water stress assessment report can be found along with other project-related outputs at http://www.ctara.iitb.ac.in/tdsc/kurlod
-botoshi

## 1.3 TDSC site visits

With support from Aroehan, the TDSC team visited Kurlod and Botoshi over multiple trips in order to complete the following steps for each habitation:

- Verify and update physical well data and usage patterns
- Study key water assets and surrounding area to determine feasibility and suitability of various possible watershed interventions, and discuss options with villagers and Aroehan staff
- Collect data and observations on topology, land use, and hydro geological properties at planned intervention sites to finalize and produce detailed recommendations

Since September 2014, TDSC made four visits spanning a total of 13 days to all habitations (except Kapshipada). The table below summarizes the key details of the visits.

**Table 4 - TDSC site visit details**

| Visit Dates (2014) | Habitations visited | Agenda |
|---|---|---|
| Sept 13-14 (2 days) | Botoshi, Pethechapada, Kurlod, Manipada, Wadpada | Kick-off visit: understand challenges facing the region, examine water assets in each habitation visited |
| Oct 11-12 (2 days) | Botoshi, Manipada, Kirkirewadi, Manipada | Collect water samples at Raipada and Kirekirewadi, and collect measurements of bunds at Manipada and Botoshi to estimate their storage capacity |
| Oct 27-29 (3 days) | Kurlod, Pethyechepada, Botoshi, Markatwadi, Kirkirewadi, Bhelpada, Bhojpada | Study all water assets in habitations visited, with focus on bunds and proposed bund locations in Kurlod and Bhojpada; conduct training program for villagers to collect well level data in primary wells |
| Nov 24-28 (5 days) | All habitations (except Kapshipada) | Inspect all primary wells, bunds, and sites of planned interventions to collect final measurements and observations |

# 2 Watershed interventions for Kurlod and Botoshi

This section presents the current status of water assets of each habitation and the watershed interventions proposed by TDSC. Here, 'watershed intervention' refers to a physical solution towards increasing groundwater and surface water storage near the habitations in order to improve the quality and increase the availability of water for drinking and/or irrigation purposes.

## 2.1 Parameters in watershed intervention planning

The planning of watershed interventions for a specific location is a complex task with several dependent parameters and constraints that may be social, economic, political, environmental or technical in nature. For example, all of the following (and more) have been considered when planning the interventions for each habitation in Phase I: well usage patterns, condition of existing water assets, feasible construction methods, water quality issues, land ownership, hydro-geological properties and topography, and rainfall.

Mokhada as a region presents a unique set of challenges for watershed intervention planning. The area is hilly, with hard rock protruding from or covering the ground surface in many parts, and varying (but mostly shallow) soil depth. The scope for large-scale groundwater recharge is limited, although groundwater recharge efforts covering small areas are possible in specific locations.

Through extensive discussions with villagers, staff from Aroehan, and others who have planned watershed interventions in this region, TDSC has gained a deeper understanding of the types of interventions that would be suitable and likely to make an impact in the region. TDSC has also developed an understanding of the available options and methods for construction of new assets and repair of existing assets. In several of the habitations, it is evident that blasting was used while constructing wells and bunds. This practice is risky and not encouraged by Aroehan; blasting can produce large cracks around the water asset that can drain any water stored. No interventions have been proposed here will require blasting.

TDSC studied various watershed manuals prior to the visits to understand the requirements and scope of impact of a range of watershed interventions. One manual was especially useful as a reference: The National Rural Employment Guarantee Act (NREGA) Watershed Works Manual, prepared by Samaj Pragati Sahayog (SPS).

## 2.2 Types of Interventions

The following table summarizes the types of interventions planned for Kurlod and Botoshi, and each type's purpose and intended impact.

**Table 4 - Types of interventions proposed for Kurlod and Botoshi**

| Intervention Type | Purpose (Drinking / Irrigation) | Intended impact | Key parameters |
|---|---|---|---|
| Construction of new wells | Drinking | Creation of safe drinking water source close to the habitation that will provide water year round | Soil depth at location (distance to hard rock), flow patterns and level of groundwater at location, distance of well to habitation |
| Construction of new bunds | Drinking and/or irrigation | Storage of surface water for supporting rabi crop and/or recharging nearby well | Distance to fields and nearby wells, width of stream at bund location, properties of embankment, catchment area of bund, rainfall |
| Repair of existing wells | Drinking | Improved water quality | Condition of existing well wall and lining |
| Repair of existing bunds | Drinking and/or irrigation | Plugging of leakages in existing bund to increase surface water storage for rabi crop and/or recharge nearby well | Cause and extent of leakage, material of construction, bund dimensions, and location and elevation profile to nearby wells |
| Digging of contour trenches | Drinking and/or irrigation | Greater infiltration of rainwater into the soil upstream of well, resulting in increased well recharge | Soil depth, ground slope, topology (surface water flow direction), location of wells to be recharged |
| Solution for improving water quality of a well | Drinking | Fewer cases of waterborne illnesses | Type and source of contamination |
| Construction of path to well | Drinking | Safer access to wells that are difficult to reach | Well usage patterns, condition and slope of existing pathway, distance from habitation to well |

## Proposed Interventions

The rest of this section describes details of the interventions proposed for the habitations of Kurlod and Botoshi villages. For each habitation, a brief description of the drinking water scenario and existing assets is presented, followed by details about the proposed intervention and its location. A note about tentative planned interventions for Phase II is also included.

## 2.3 Kurlod habitation: Current scenario and proposed interventions

Kurlod habitation has a population of 400, and has four wells and a bund, shown in the map below. The primary well is marked as KUR-W4, which is just upstream of a bund (KUR-B1), and it lasts until May. KUR-W1 has water through the year but no one uses it because it is near a mortuary. KUR-W2 lasts only until October, and KUR-W3 lasts until February.

The following interventions are proposed for Kurlod:

- **Phase I:** Repair of existing bund (KUR-B1) in order to recharge Well 4
- **Phase II:** New subsurface bund to recharge W3


Figure 3 - Google Earth image of Kurlod habitation.

### 2.3.1 Phase I intervention for Kurlod: Repair of Bund-1 to recharge Well 4

**Current status:** Kurlod's existing bund stands on a stream that flows into the Pinjal River. The bund has a significant leakage problem; by the end of November virtually all the water stored leaks out. Large cavities and cracks can be seen at the base and in the body of the bund.

Kurlod's primary well, Well 4, lies 50 m upstream of the bund. TDSC conducted an elevation survey that determined that repairing the bund (so that it holds water up to its Full Storage level – FSL) will help recharge W4 such that the well holds water beyond May, and quite possibly through to the monsoons. Well 4 is also used by villagers of Pethechapada, so increasing recharge into the well will have considerable impact. Dimensions of the bund are provided in the table below:

**Table 5 - Dimensions of existing bund at Kurlod habitation**

| Bund height downstream | Bund height upstream | FSL Length | Total Length |
|---|---|---|---|
| 2 m | 1.5 m | 19 m | 27 m |

**Figure 4 - Photo of the existing bund (upstream) near Kurlod, water is leaking from the base.**

**Intervention details:** There is a difference of 0.85 m between the FSL level of the bund and the water level in the well, which indicates that if the bund is full it will help recharge the well (detailed calculations shown in Annexure). TDSC proposes building an RCC wall along the upstream side of the bund, and filling the space between the wall and the bund with concrete, such that the bund will act as a support to the wall. The wall will have a foundation into the ground that will prevent leakage through the base of the wall, as shown in the schematic below:

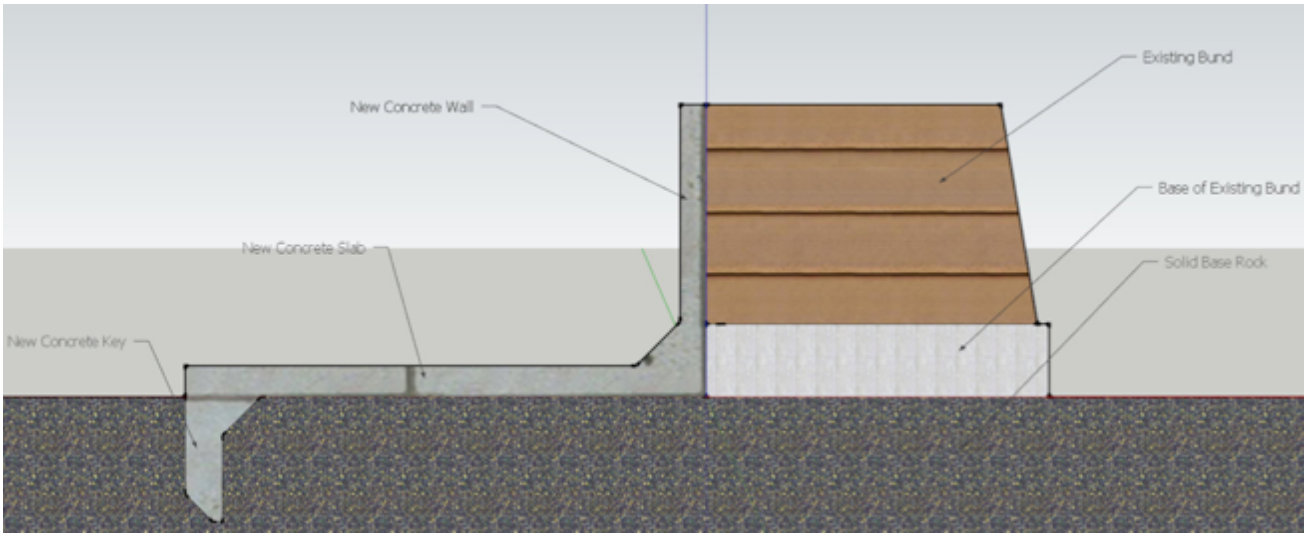


Figure 5 - Schematic of proposed Kurlod bund repair plan.

**Pre-implementation activities:** The following activities should be performed prior to construction:

- De-siltation of storage area upstream of bund
- Excavation of silt and soil (till base rock) immediately upstream of bund in order to location cracks and leakage points

### 2.3.2 Phase II intervention for Kurlod: New subsurface bund to recharge Well 3

**Current status:** Kurlod's Well 3 lasts until February, and could be used as an alternative drinking water source if its duration is extended with the help of a recharge structure. The stream that feeds the well has subsurface flow that lasts until May. If this flow is impounded upstream of the well, the accumulated water can help recharge Well 3 and extend its life by 1-2 months.

**Phase II planned Intervention:** A subsurface bund is tentatively proposed to be located 40 m upstream of well 3. The location of the bund has been chosen after studying the topography of the area and determining the most likely direction of groundwater flow.

## 2.4 Pethechapada: Current scenario and proposed interventions

Pethechapada has a population of 450 and has three wells, shown in the map below. Well 3 is the primary well buts lasts only until December. There is water in Well 1 through the year but is not being used currently because of heavy siltation in the well, partly due to a large hole in the well wall. Villagers have dug a well pit near Well 1, which is used for drinking water. Well 2 lasts until March, but the water quality is very poor (stagnant, smelly) so it is not used at all.

The following interventions have been planned for Pethechapada:

- **Phase I**: Repair Well 1 wall and lining to prevent silt from entering and construct a pathway to the well
- **Phase II**: Construction of a new bund on minor stream downstream of Well 3


Figure 6 - Google Earth image of Pethechapada.

### 2.4.1 Phase I intervention for Pethechapada: Repair of Well 1 wall, de-siltation, and pathway to well

**Current Status:** Pethechepada's Well 1 lasts through the year but is not used because the well water has too much silt. There is a large hole at the base of the wall, through which muddy water may be entering during the monsoons. The well is also difficult to access.


Figure 7 - Photo of Pethechepada's Well 3 showing hole at base of platform.

**Intervention details:** TDSC proposes plugging the hole in the well to prevent muddy surface water from entering it during the monsoons, de-silting of the well, and constructing a concrete pathway to the well.

**Quantity of material:**

- **Pathway construction** (Dimensions of pathway: Length: 100 m, width: 1 m, thickness: 0.15 m)
  **Volume of material: 15 $m^3$ of PCC**
- **Repairing hole in wall**
  **Volume of material: 1 $m^3$ of PCC**
- **De-silting of well**
  **Volume of silt to be excavated: 40 $m^3$**

**Note**: Volume of the excavation is calculated for 1 m depth. Actual number may vary depending on the site conditions.

### 2.4.2 Phase II intervention for Pethechapada: New bund downstream of Well 3

**Current status:** Well 3 lies along a minor stream that recharges both Well 2 and Well 3. Well 3 runs dry in December, but villagers report that the stream flows through the year, which can be explained by the steep gradient of the stream. The stream's elevation drops steadily as it flows past Well 3, such that the stream is almost 3 m below Well 3 just a short distance downstream of it, which limits recharge to the well after the monsoons.

Figure 8 - Photo of Pethechepada's Well 3 from the stream that recharges it (downstream).

**Phase II planned intervention:** In Phase II, TDSC proposes a new bund approximately 35 m downstream of Well 3, which will be at least 3 m in height above ground. At an FSL of 3 m, the water stored in the bund will be able to recharge Well 3 so that it lasts beyond December and also for irrigation.

## 2.5 Shedyachapada & Jambhulpada: Current scenario and proposed interventions

Shedyachapada and Jambhulpada are two small neighboring habitations with a combined population of 150. There are two wells in the vicinity of the habitations, as shown in the image below, but both habitations use JAM/SHED W1 since it lasts through the year. Leaves and bird droppings that fall in from an overhanging tree compromise the quality of the water, however.


Figure 9 - Google Earth image of Shedyachapada and Jambhulpada.

### 2.5.1 Phase I intervention – Installation of a protective net cover for Well 1

**Current status:** Shedyachapada and Jambhulpada have a well that lasts through the year that is accessible to both habitations; the only problem is presence of bacteria and debris in the well due to leaves and bird droppings.

**Intervention details**: There is just one intervention planned for Shedyachapada and Jambhulpada: the placement of a protective net over the well. Inexpensive well covering nets are available in the market and are straightforward to install.

Figure 10 - Photo of primary well of Shedyachapada and Jambhulpada.

## 2.6 Raipada: Current scenario and proposed interventions

Raipada has a population of 80 and currently has one well (Well 1) that lasts through the year but that had a major water quality problem just after the monsoons, in October. The water had appeared reddish and undrinkable until the well was cleaned and the issue was resolved. TDSC collected a water sample in November suspecting a high concentration of iron, but did not find exceptionally high concentrations of iron. Villagers expect that this water quality problem will re-appear after the next monsoons and that the well will need to be cleaned again.

In earlier years, villagers from Raipada used another well which provided clean water through the year, but which was washed away by the rains. There is a bund within the fields (B1 in image below), about 250 m from the habitation, which has minor leakage and holds water until February. There is an additional bund that is broken from the middle, holds no water and has little scope for repair.

There are multiple interventions planned for Raipada:

- **Phase I:**
    - Reconstruction of old primary well
    - Leakage repair of existing bund
- **Phase II:**
    - Loose boulder check on minors streams feeding main stream
    - Farm bunds on all farms upstream to W1


Figure 11 - Google Earth image of Raipada.

### 2.6.1 Phase I intervention for Raipada – Leakage repair of existing bund

**Current status:** Raipada's existing bund (see photos below) holds water until February, and was built with the intention of providing water for irrigation. Physical details about the bund are in the table below. The bund has minor leaks in a few places: if they are repaired the bund would retain water beyond February, and a pumping system can be installed in the future to pump water to the fields for a second crop.

Table 6 - Dimensions of existing bund at Raipada

| Total Length | Width of bund | Bund height upstream |
|---|---|---|
| 28 m | 1 m | 1.6 m |

Figure 12 - Photos of Raipada's Bund 1.

**Intervention details:** TDSC proposes plugging the minor leaks in the bund during Phase I so that the bund can store water beyond February and reliably support a second crop. The fields around the bund are approximately 1 m higher in elevation, so a temporary pumping system could be installed to transport water relatively inexpensively to the nearby fields.

### 2.6.2 Phase I intervention for Raipada – Reconstruction of broken well

**Current status:** A few years ago, Raipada was using different well as its primary well. This well was situated by the stream that flows near the habitation, and was washed away by the force of the water. It is possible to see the remnants of the well – it is currently filled with silt as seen in the image below.

Figure 13 - Buried well in Raipada.

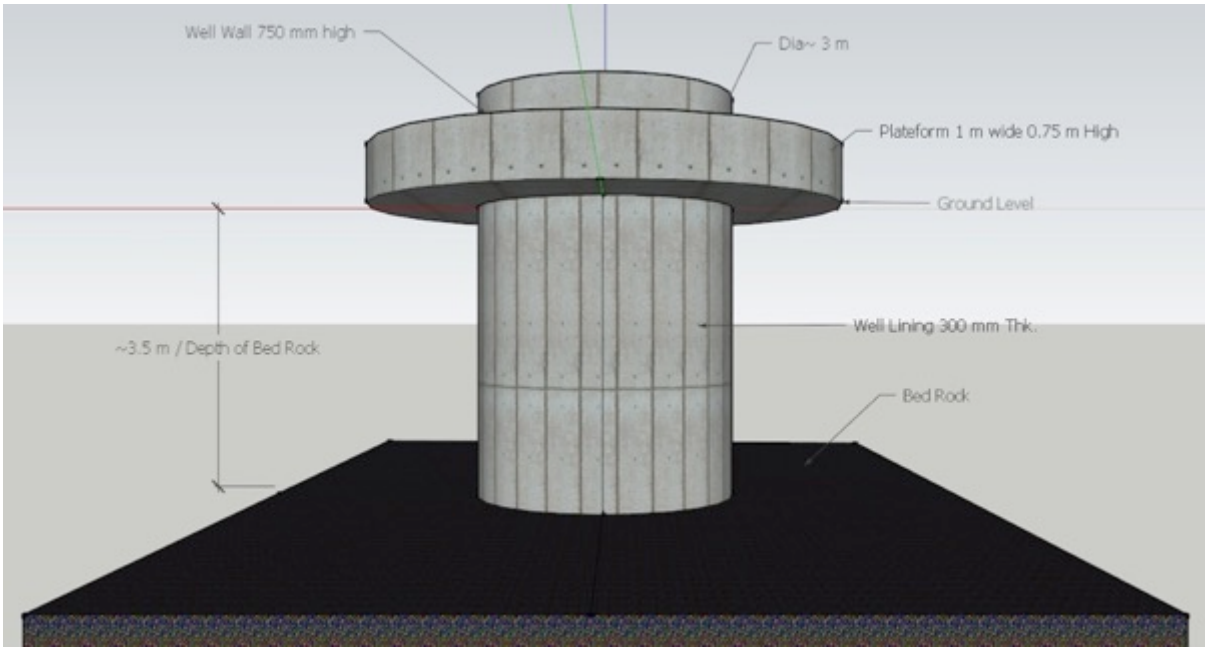


Figure 14 – Diagram of proposed new well in Raipada.

**Intervention details:** TDSC proposes reconstructing the broken well in Raipada. This will first involve excavating around 3.5 feet of soil that has filled the well (depth will depend on location of the bed rock and may change during construction), and then constructing a new wall and platform around the well with total height of 1.5 m. 1.5 m of height is to protect the well from overflowing stream in the Monsoons.

**Quantity of material:**
Well dimensions: diameter: 3m, depth (approx.): 3.5 m, thickness of lining: 0.3 m, height of wall: 0.75 m, width of platform: 1m, height of the platform: 0.75m
**Volume of material to be excavated:** 35.6 $m^3$ of soil
**Volume of material for masonry lining:** 14.1 $m^3$
**Volume of material for masonry platform:** 10.8 $m^3$

### 2.6.3 Phase II interventions for Raipada

Two tentative interventions are planned as part of Phase II for Raipada:

- **Construction of loose boulder checks on the minor streams feeding the main stream**: this will hold back silt from entering the stream leading to the bund, and help maintain the storage capacity of the bund.
- **Construction of farm bunds on all farms upstream to W1:** farm bunds have many advantageous effects for farmers – they increase soil moisture and reduce soil erosion of land. In Raipada's case, farm bunds upstream of W1 will slow down large volumes of runoff, increasing seepage into the ground and providing a source of recharge for Well 1.

## 2.7 Manipada: Current scenario and proposed interventions

Manipada has a population of 60 and two wells, one that holds water through the year (Well 2) and one that dries in October (Well 1). Well 2 is a large well which could be a primary well but it is difficult to reach – the walk to the well includes going through about 50 m of dense vegetation and a 15 m drop in elevation. As a result, after Well 1 dries in October, villagers in Manipada use river pits for drinking water (see images below).

Manipada also has a partially constructed bund built on the Pinjal River, left incomplete due to the arrival of the monsoons before structure was fully built. If the bund is completed, it could hold up to Completing this bund may be out of the scope of this project since the bund is on the Pinjal River and therefore very large.

There are two interventions proposed for Manipada, both for **Phase I**:

- Construction of pathway and stairway to Well 2
- Repair of damaged well wall of Well 2


Figure 15 - Google Earth image of Manipada.

Figure 16 - Photo of river pit used by villagers in Manipada.

### 2.7.1 Phase I intervention for Manipada: construction of pathway to Well 2

**Current status:** Well 2 could be a primary source of water but villagers are choosing to drink from river pits instead, likely because of the poor access to the well. Well 2 is rather inaccessible because a 35 m dense patch of vegetation on a steep slope must be crossed to reach it. River pits are likely to have poorer quality water than a dug well; if Well 2 can be made more accessible, villagers in Manipada may be convinced to use the well as a drinking water source.

**Intervention details:** TDSC proposes clearing a pathway through the dense vegetation in between the habitation and Well 2 (approximately 75 m in length, though this length may change depending on site conditions).

**Quantity of material:**
Pathway – Dimensions: length: 75 m, width: 1 m, thickness: 0.15 m
**Volume of PCC: 11.25 $m^3$**

### 2.7.2 Phase I intervention for Manipada: Repair of Well 2 wall

**Current status:** A section of base of the wall around Well 2 is severely damaged, as shown in the image below. If the wall is not repaired, that section may break off during one of the subsequent monsoons, and allow the inflow of surface water directly into the well.

**Intervention details:** TDSC proposes repairing the lining and platform of Manipada's Well 2.

Figure 17 - Photo of broken section of Manipada's Well 2 wall

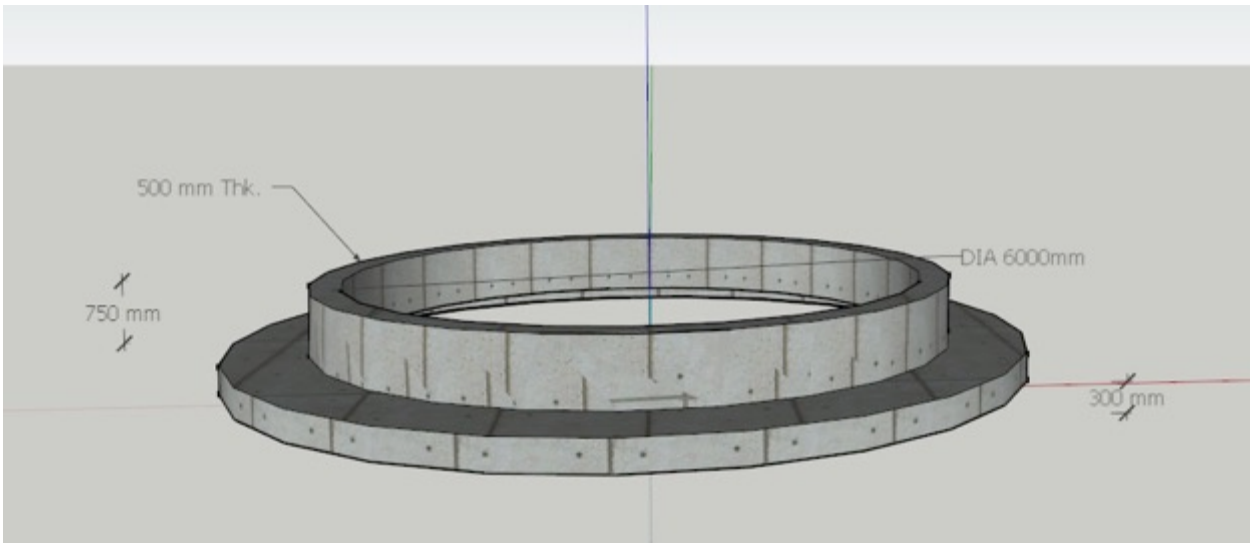


Figure 18 – Diagram for the repair of Manipada's Well 2

**Quantity of material:**
Well dimensions: diameter: 6 m, depth 5.8 m, lining thickness: 50 cm
**Volume of material for new masonry lining (only well wall part): 7.1 $m^3$**
**Volume of material for new masonry platform: 7.5 $m^3$**

**Note:** This well is located on a slope, and hence dimensions of the platform may change during actual construction**.**

## 2.8 Wadpada: Current scenario and proposed interventions

Wadpada has a population of 100, and 2 wells shown in the image below. Well 1 dries in October, while Well 2 dries in March, after which villagers rely on the Pinjal River for all purposes. Well 2 is on the bank of a major stream, and is fairly deep at 8 m. Well 1 is very shallow – less than 3 m in depth, but it has reached hard rock and cannot be deepened without blasting, which is not advisable.


Figure 19 - Google Earth image of Wadpada.

### 2.8.1 Phase II interventions for Wadpada

Based on site visits and discussions with villagers, two options for an intervention have been discussed, one of which will be planned for **Phase II**:

- New bund downstream of Well 2 to recharge Well 2 (location 1 on map)
- New bund 50-100 m upstream of Well 2, to store water for irrigation (location 2 on map)

Figure 20 - Photo showing team measuring the stream width at proposed location #1.

## 2.9 Botoshi habitation: Current scenario and proposed interventions

Botoshi has a population of 400 and 5 wells, four of which dry in October and one that lasts until May (Well 5 in the image below). Well 5 is the primary well with good water quality up until the summers, during which time the villagers rely on river pits. The rest of the wells are mostly unused. There is a broken bund (BO-B1 in image below), which is on the Pinjal River. During the monsoons, water flows several feet over the broken sections of the bund, making it unsafe to cross the river and cutting the habitation off from the road.

The following intervention has been planned for **Phase I** at Botoshi**:** Contour trenches around Well 5 to increase recharge of well.


Figure 21 - Google Earth image of Botoshi habitation.

### 2.9.1 Phase I intervention for Botoshi: Contour trenches around Well 5

**Current status:** Well 5 lasts until May, which is within two months of the monsoons. It lies on a small patch of land that is relatively flat, but at the same is it is close to the foothills of a few gently sloping hills. As a result, Well 5 is an appropriate candidate for contour trenching; extending the water availability in Well 5 up to the monsoons may be possible with this intervention.

**Intervention Details:** TDSC proposes building contour trenches in the area shown in the images above. The basic design outputs of the trenches (total number of trenches, number of rows, distances between trenches) have been calculated for the area delineated above, which is approximately 7500 $m^3$. The designs were prepared using guidelines from the NREGA Watershed Works Manual by Samaj Pragiti Sahayog.

Key design outputs are shown below (calculations and additional details can be found in Annex 2)

**Trench dimensions: 5 m x 0.5 m x 0.5 m**
**Total number of trenches: 54**
**Number of rows: 4**
**Distance between rows: 18.5 m**

**Quantity of Material**

Total volume of soil to be excavated: 68 $m^3$.

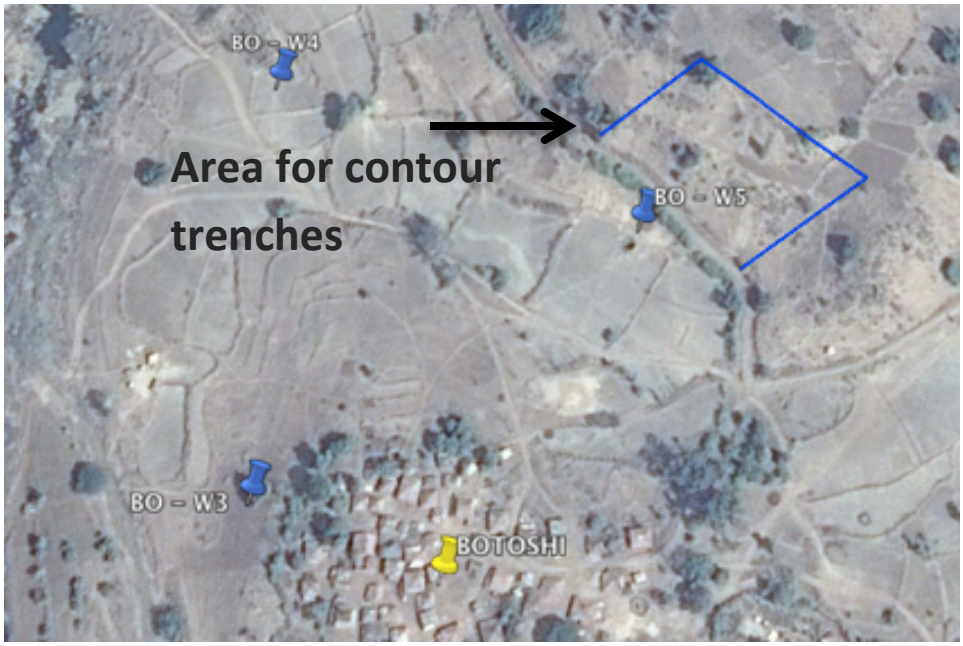


Figure 22 - Image showing planned area for contour trenches in Botoshi.

## 2.10 Kirkirewadi: Current scenario and proposed interventions

Kirkirewadi is a small habitation with a population of 40. It has a single well (W1 in image below) which lasts through the year but whose water quality deteriorates from April-May, after which villagers shift to using river water. The well gets submerged during the monsoons by at least 1 meter.

The following **Phase I** interventions for Kirkirewadi are targeted at securing the primary well and improving its quality and yield:

- Increase wall height of primary well to 2 m and construct a surrounding support structure
- Fix breakages in well lining, remove silt from well base for improving recharge

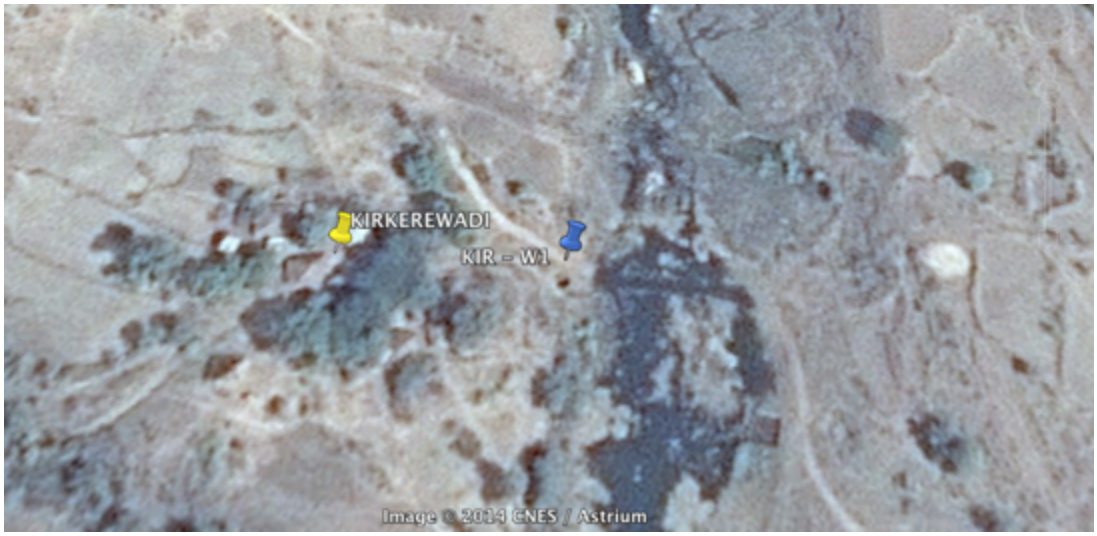


Figure 23 - Google Earth image of Kirkirewadi.

### 2.10.1 Phase I intervention for Kirkirewadi: Increase well wall height and build supporting structure

**Current status:** The primary well in Kirkirewadi stands on the bank of a stream, and during the monsoons the stream levels rises to a point where it submerges the well by over 1 m (see photo below).

**Intervention details:** To prevent the well from getting submerged, TDSC proposes increasing the wall height by 2 m, and building a supporting structure around the wall on which villagers can stand to collect water.


Figure 24 – Photos of primary well in Kirkirewadi.

## 2.10.2 Phase I intervention for Kirkirewadi: Fix well lining and clear well base

**Current status:** The lining of Kirkirewadi's well is damaged, as seen in the photo below. The damaged lining comprises the well's ability to filter out contaminants, and affects the water quality of the well. Additionally, there is an accumulation of silt at the base of the well, which may be slowing the recharge into the well.

Figure 25 - Photo showing damaged well lining of Kirekirewadi's primary well

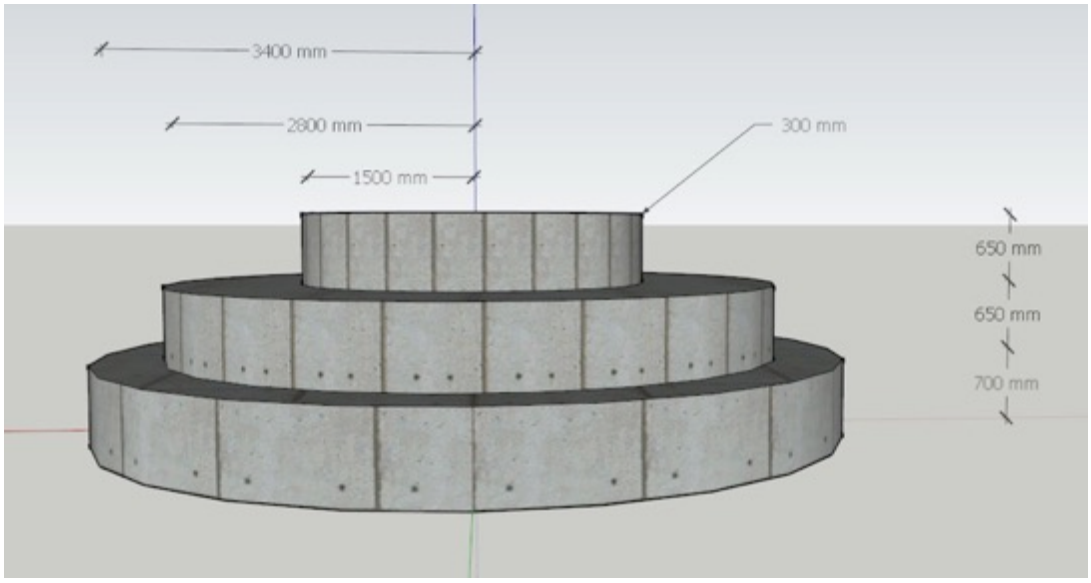


Figure 26 – Diagram of proposed platform for Kirkirewadi's primary well.

**Intervention details:** TDSC proposes repairing the lining of the well wall and clearing out the silt at the base of the well.

**Quantity of material:**
Dimensions of the well: diameter: 3 m, depth: 5 m
**Volume of material for masonry for platform: 32.1 $m^3$**
**Volume of masonry for new lining: 14.1 $m^3$**
**Volume of silt to be removed: 3.5 $m^3$**

**Note:** Depth of excavation (taken as 1 m for calculation) will depend on the extent of siltation.

## 2.11 Bhelpada: Current scenario and proposed interventions

Bhelpada is the largest habitation in Botoshi with a population of 450. It has one well that lasts until June, after which villagers rely on the river. There is a broken bund approximately 500 m from the habitation.


Figure 27 - Google Earth image of Bhelpada.

### 2.11.1 Phase II interventions for Bhelpada

There are two tentative interventions planned for **Phase II** for Bhelpada:

- **Farm bunds near upstream of primary well:** Farm bunds will help increase recharge flow into the primary well, improve soil moisture and reduce soil erosion
- **New bund close to broken bund:** The site of the broken bund is suitable for a new bund for storing water for irrigation.

Figure 28 - Photo of Bhelpada's broken bund.

## 2.12 Markatwadi: Current scenario and proposed interventions

Markatwadi has a population of 150 and has three wells, shown in Figure 29 below. None of the three wells can be used the whole year. Well 1 dries in November, Well 2 holds water through the year but is incompletely constructed, and Well 3 is filled with silt (but earlier held water until March). Photos of each well are shown below (Figures 30, 31 and 32) Well 2 and 3 are by the river and both get submerged during the monsoons. After Well 1 dries in November, villagers rely on the river.

There is a 30 m elevation difference between the habitation and the river and no usable well lasting through the year, which makes Markatwadi a particularly high stress habitation. Earlier, Well 1 was a preferred water source because it is almost on the same elevation as the habitation. However, an attempt to deepen the well using blasting created cracks which drains much of the water now. In November, TDSC found the well mostly dry but still receiving seepage water from upstream, which was being used by a few households.

Two interventions are proposed for Markatwadi, both for **Phase I**:

- Construction of new well (location marked below)
- Contour trenches to recharge well 1 (area marked below)

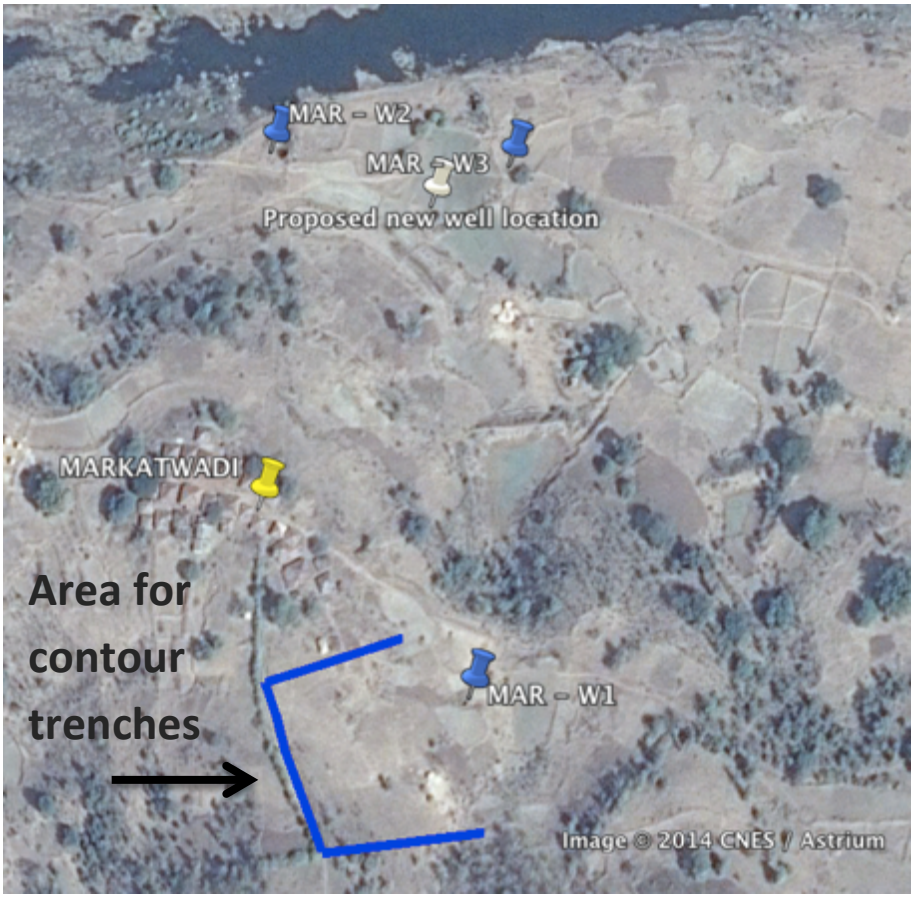


Figure 29 - Google Earth image of Markatwadi.

Figure 30 – Photo of Markatwadi Well 1 in November

Figure 31 – Photo of incomplete Markatwadi Well 2 (the lining does not even reach ground level).

Figure 32 – Photo of Markatwadi Well 3 showing silt accumulation almost up to groundlevel

### 2.12.1 Phase I intervention for Markatwadi: New well

**Current status:** When considering possible interventions for Markatwadi, the feasibility of repairing Wells 2 and 3 were first considered, but a few issues emerged with this option. Firstly, Well 2 and 3 both get submerged during the monsoons, which will limit their use. Additionally, since Well 2 is a recent construction that is still incomplete, repairing it will require prior permission from the Gram Panchayat and contractor. Well 3, even if repaired, will provide water only up till March. Given these challenges, TDSC proposes constructing a new well which can supply water through the year. After the water availability in the well is ascertained, TDSC will propose a solution for easy accessibility using solar pumping. Note, however: in the case of Markatwadi, additional probing may be required to ascertain the best intervention.

**Intervention details:** TDSC proposes constructing a new well in Markatwadi at the location shown in the Google Earth image above. The location was chosen based on its proximity to a clear drainage line we observed in October that passes through many cultivatable lands having farm bunds. In November, we observed subsurface flow in two shallow pits (less than 1 feet deep) upstream to the proposed location, which further suggests there will be a lasting source of recharge at this location.

The well diameter should be 3 m, and the depth is tentatively planned to be 3.5 m, although this will depend on the depth to hard rock.

**Quantity of material:**
Well dimensions: diameter: 3 m, depth: 3.5 m
**Volume of silt to be excavated: 48.5 $m^3$**
**Volume of material for masonry lining: 12.9 $m^3$**
**Volume of material for masonry platform: 4.3 $m^3$**

**Note:** Depth of the well will depend on location of the bedrock and may change during construction.

Figure 33 - Photo of site of proposed new well in Markatwadi (where the people are standing).

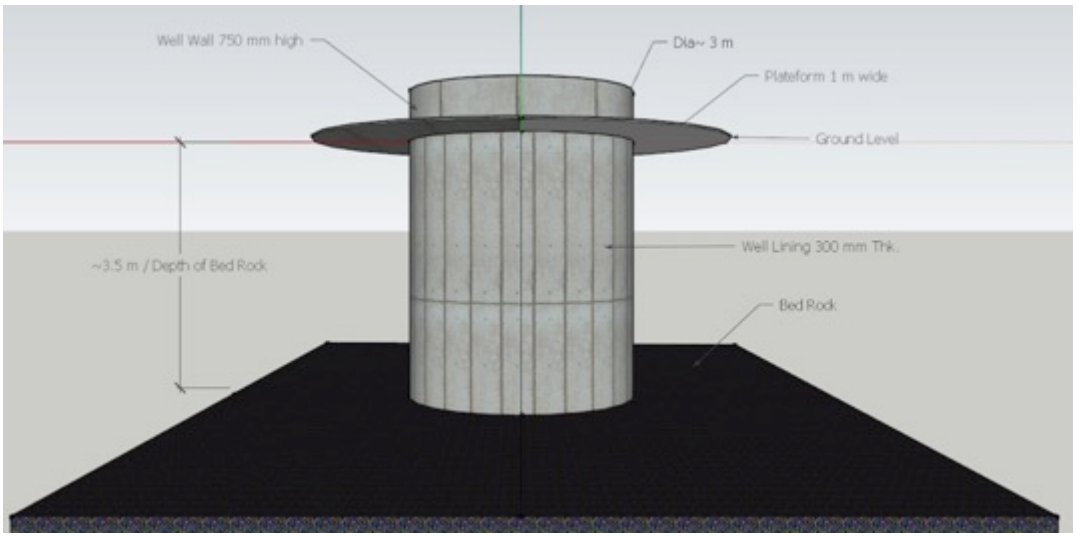


Figure 34 – Schematic for proposed new well in Markatwadi

## 2.12.2 Phase I intervention for Markatwadi: Contour trenches for Well 1

**Current status:** Markatwadi's Well 1 is downstream of a slope that is suitable for contour trenching, and where there is currently no vegetation cover (see image below). Constructing contour trenches on this hill will increase recharge into Well 1 and improve the soil moisture in the area.


Figure 35–Photo showing site for contour trenching upstream of Markatwadi Well 1.

**Intervention Details:** TDSC proposes building contour trenches in the area shown in the images above. The basic design outputs of the trenches (total number of trenches, number of rows, distances between trenches) have been calculated for the area delineated above, which is approximately 8000 $m^3$. The designs were prepared using guidelines from the NREGA Watershed Works Manual by Samaj Pragiti Sahayog.

Key design outputs are shown below (calculations and additional details can be found in Annex 2)

**Trench dimensions: 5 m x 0.5 m x 0.5 m**
**Total number of trenches: 58**
**Number of rows: 4**
**Distance between rows: 18.5 m**

**Quantity of Material**

Total volume of soil to be excavated: 72 $m^3$.

## 2.13 Bhojpada: Current scenario and proposed interventions

Bhojpada has a population of 340 and has five wells, two of which hold water all year round (Well 1 and 1b). The Google Earth image below shows the locations of all five wells. Well 1 and 1b are the primary wells, and lie adjacent to each other and on the bank of a stream that leads to the Pinjal River. These wells are inaccessible during the monsoons because an overflowing stream cuts them off. The other three wells in Bhojpada (Well 2, 3, 4 and 5) run dry in October.

Bhojpada also has two bunds (B1 and B2 in image below). Bund 2 is almost entirely broken from the middle and cannot be repaired. Bund 1 is leaking but can be greatly enhanced by repairing the structure and removing silt from the downstream end.

The following interventions have been proposed for Bhojpada:

- **Phase I**:
    - Well 1 repair
    - Bund 1 enhancement: repair bund structure, remove downstream silt
- **Phase II**: Solution for accessing to Well 1 and 1b


Figure 36 - Google Earth image of Bhojpada.

### 2.13.1 Phase I intervention for Bhojpada: Well 1 repair

**Current status:** There is scope for improving the condition of Well 1 (one of the primarily wells). The lining of Well 1 currently has a large hole, with a broken bamboo pipe going through it (see image below). Muddy surface water could easily enter the well directly through the break, compromising well's water quality. The space immediately around the well is being used for washing purposes, which is creating an additional source of contaminated water to enter the well.

Figure 37 – Damaged well lining

**Intervention details:** TDSC proposes repairing the lining of Bhojpada's Well 1, and building a platform for the well along with a designated area specifically for washing and cleaning. The schematic are shown in the figure below.

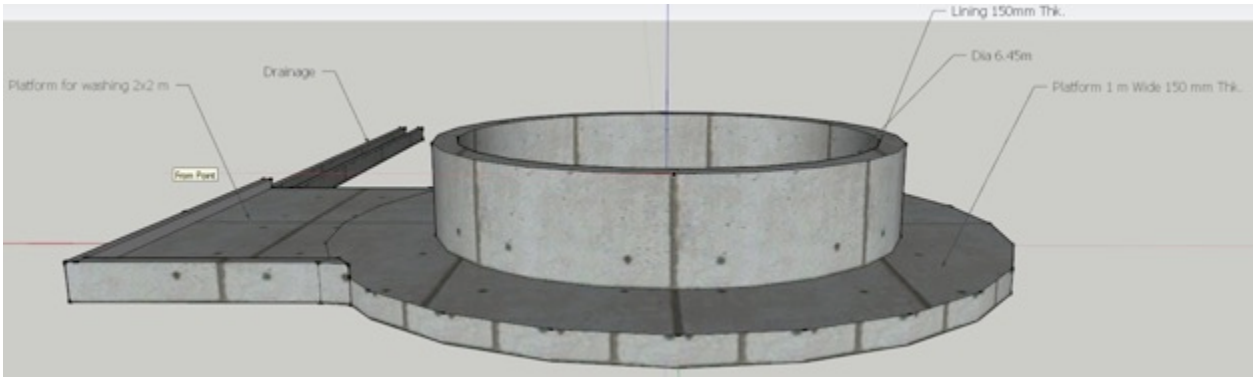


Figure 38 – Diagram of proposed platform for Bhojpada Well 1

**Quantity of Material:**

**Basic Info:** Well-1 measured dimensions are:

Well Diameter = 6.45 m

Well Depth = 7 m

Wall Height = 0.54 m

Water Level = 2.3 m ( on Nov 2014 )

**Basic Info:** Well 1(b) is smaller than Well-1. The measured parameters are:

Well Diameter = 3.80 m

Well Depth = 2.50 m

Wall Height = 0.65 m

Water Level = 1.30 m ( Nov. 2014 ).

**Quantity of material**

Volume for the lining: 1.6 $m^3$

Volume for platform (2x2x0.15 m) : 0.6 $m^3$

Volume for drain: 0.15 $m^3$

## 2.13.2 Phase I intervention for Bhojpada: Bund 1 enhancement

**Current status:** Bhojpada Bund 1 (seen in the Google Earth image above and photo below) is situated by the fields, which are approximately 8 m higher in elevation. There is almost no water stored behind the structure because of leakage, but the bund structure appears to be repairable. If the bund is repaired and can store water up to its FSL, that water could be used as a source of irrigation water. The bund is leaking at two places, and has accumulated silt.

Figure 39 - Photo of Bhojpada Bund 1 (left side is downstream)`

Figure 40 - Photo showing leakage from base of Bhojpada Bund 1 (upstream side).

Figure 41 - Leakage from base of Bhojpada bund (downstream).

**Intervention details:** TDSC proposes repairing the bund leakage and removing the silt behind the bund.

### 2.13.3 Phase II intervention for Bhojpada: Construction of pathway to Well 1, 1b

**Current status:** The path to the primary wells (Well 1 and 1b) gets submerged during the monsoons. TDSC proposes providing a solution that allows better accessibility to Bhojpada's primary water source during the monsoons; this could be either through building a short footbridge over the stream or by providing a small-scale pumping solution that allows water to be pumped into the habitation year round.

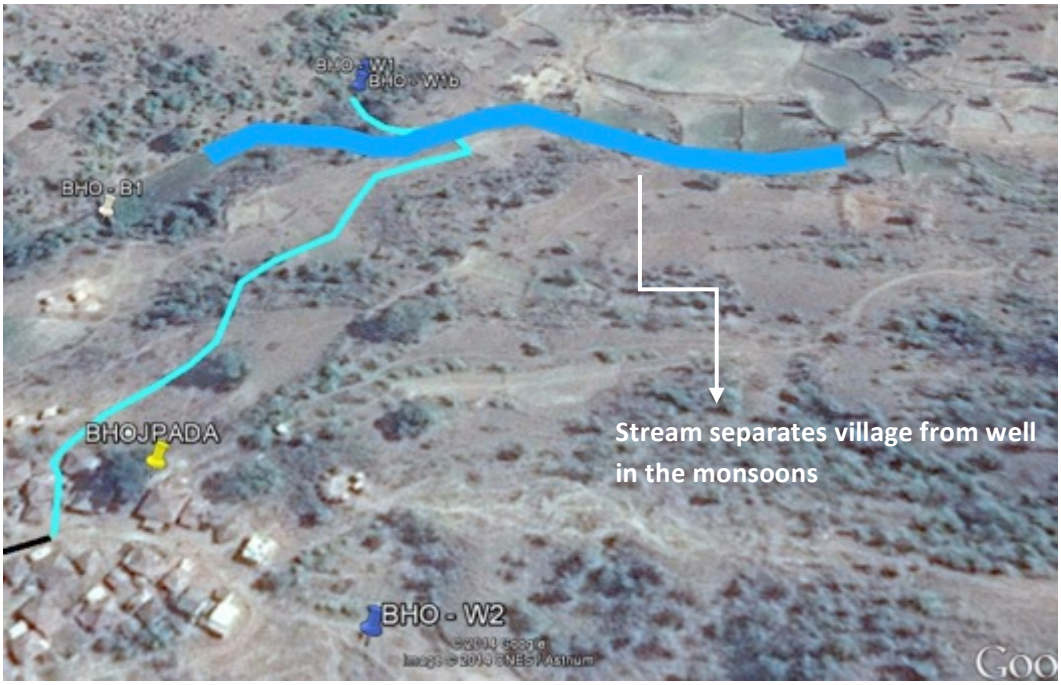


**Image of stream separating well from village**

## 2.14 Total quantity of material for Phase I

Almost every watershed intervention planned under Phase I will involve construction with Plain Cement Concrete (PCC) or Reinforced Cement Concrete (RCC) and/or excavation of soil or silt. The approximate volume of construction material and excavation required has been calculated for each intervention. The total volumes for each material for Phase I interventions are provided in Table 3 below.

**Table 7 – Approximate construction/excavation volumes for Phase I interventions**

| Material for construction/excavation | Total volume (m3) |
|---|---|
| PCC | 29 |
| Masonry | 103 |
| Soil **excavation** (contour trenches and new wells) | 224 |
| Silt **excavation** (for well and bund enhancement) | 43 |

# Annexure Contents

1. **Project proposal document (Terms of Reference)**
2. **Contour trench design calculations**
3. **Storage capacity estimation of Kurlod's bund**
4. **Quantity of materials calculations**

# TDSC Budget Proposal for Kurlod-Botoshi Watershed Intervention Project

***Background***

This document presents a budget proposal for an engagement between Aroehan and the Technology and Development Solutions Cell (TDSC), CTARA, IIT Bombay towards planning, design, and monitoring of watershed intervention projects in habitations in the Kurlod and Botoshi villages.

The Kurlod-Botoshi watershed project is planned as a joint collaboration between Aroehan, Siemens CSR and TDSC, in which Aroehan will manage the implementation, TDSC will provide technical guidance towards planning, design and implementation, and Siemens will assist with funding and overall steering. The aim of the project is to increase water availability for both drinking and livelihood opportunities, and is planned to be implemented over two years.

***Summary of initial study***

In the summer of 2014, Mohit Singhal and Mukul Kaushik, two students from IIT Roorkee, conducted a status assessment of the water stress in the 13 habitations of Kurlod and Botoshi. They used their findings and observations from the field to propose a series of interventions that could increase drinking water security and water for irrigation in the two villages. These suggested interventions included five new bunds, one new well, three bund repairs, and three well repairs.

The tables below present the findings from the water stress assessment and the possible interventions identified through the study:

***Table -- Summary of possible interventions****

| Habitation | DW stress | Intervention | Purpose |
|---|---|---|---|
| Botoshi | **High Stress** | Old Bund Repair | Connectivity + Livelihood |
| | | Old Well Repair | Drinking |
| Kurlod | **High Stress** | New Bund | Livelihood |
| | | Contour trenching | Drinking |
| Markatwadi | **High Stress** | New Bund | Drinking + Livelihood |
| | | New Well | Drinking |
| | | Old Well Repair | Drinking |
| Wadpada | **High Stress** | New Bund | Drinking+Livelihood |
| | | Contour trenching | Drinking |
| Pethechapada | **Medium Stress** | New Bund | Drinking+Livelihood |
| Raipada | **Medium Stress** | Old Well Repair | Drinking |
| Bhojpada | **Low Stress** | New Bund | Drinking+Livelihood |
| | | Old Bund Repair | Livelihood |
| Manipada | **Low Stress** | Old Bund Repair | Drinking+Livelihood |

* Possible interventions are identified for eight of the 13 habitations – the remaining are five Low Stress habitations: Kirkirewadi, Shedyachapada, Jambhulpada, Bhelpada, and Kapshipada

***Role of TDSC***

The aim of the Kurlod-Botoshi watershed project is to increase water availability for both drinking and livelihood purposes. There is a high degree of drinking water stress in several of the habitations. In addition, there is scope for farmers in the region to increase their annual income by planting a rabi crop; and currently, the primary limiting factor is water for irrigation. The interventions planned through this project will ideally address both these needs. A proposal for design and implementation of interventions in phases is to be prepared for the same.

TDSC will provide technical support in three phases over the two-year duration of the project, where some interventions will be implemented (by a contractor chosen by Aroehan) in the summer of 2015 (Round 1) and some in 2016 (Round 2). Data collection and monitoring work will be a significant part of all three phases, since the design approach uses data on the water assets in each area to determine the location and type of intervention that would be most effective.

***Proposed two-year timeline***

The three proposed phases of TDSC's role and action items within each are outlined below. A tentative timeline for the three phases is shown in Figure 1 below. There will be overlap across the phases, and certain activities such as monitoring water assets and investigating allocations to government schemes will be a part of all three phases.

- Phase 1: 6 months
    - Status assessment of all habitations
    - Data collection and monitoring
    - Design of Round 1 interventions whose implementation begins by Jan-Feb 2015
    - Process planning for all structures (integration with IWMP, NREGA)
- Phase 2: 12 months
    - Continuation of data collection and monitoring activities
    - Planning and design of Round 2 interventions whose implementation will begin in Jan-Feb 2016
    - Integration of implementation process with government schemes
- Phase 3: 12 months
    - Monitoring and evaluation of Round 1 and 2 interventions
    - Integration of implementation process with government schemes

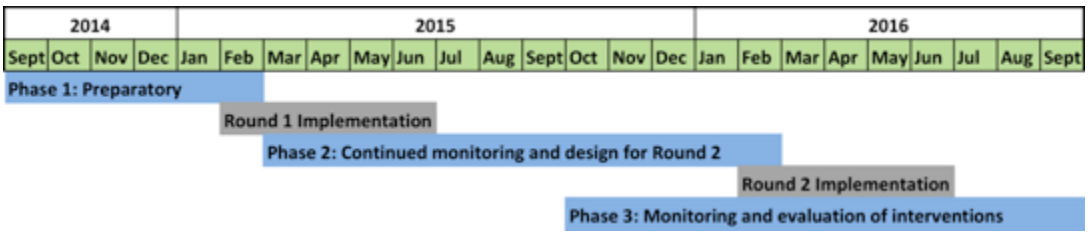


Figure 42 -- Timeline of TDSC's Phases

***Categorization and planning ofinterventions***

The planned interventions can be broadly divided into three categories, which will aid in the planning and prioritization of interventions:

1. Augmentation interventions: repair or reconstruction of existing structures (wells, bunds)
2. Supplementary interventions: measures to increase the usability or effectiveness of existing structures (e.g. adding a pumping system at an existing bund)
3. New assets: creation of new structures independent of existing ones

The planning and design process will differ based on the type of intervention. For augmentation interventions (repair/reconstruction), we would conduct an assessment of the cause of failure or damage of the existing structure and the probable results of repairing it. Supplementary interventions could be identified during meetings with villagers at each habitation and visits to existing structures. To design a new structure, we would collect data at each habitation over several months on parameters such as the water level in nearby wells, topography, nature of stream embankments and water demand around the proposed location.

The project is intended to be carried out over two years, with two rounds of implementations: Round 1 in Summer 2015, and Round 2 in Summer 2016. Since the first two types of interventions (augmentation and supplementary) require less monitoring data, TDSC proposes to plan and design primarily for the augmentation and supplementary interventions for Round 1, and the new assets for Round 2. This division is not firm: some new structures can also be planned for Round 1 if it is required and there is sufficient data is already available.

***Preparatory Phase Activities***

The preparatory phase will last 6 months, from September 2014 to February 2015. During this phase, the TDSC team will conduct a status assessment of all habitations, begin data collection and monitoring activities, and identify, design and prioritize the interventions for implementation this summer. As explained in an earlier section, TDSC proposes that the first round of implementation be for Augmentation and Supplementary interventions (repair, reconstruction, and supplements to existing structures), and the second round for new structures, since the latter would benefit from data collected over a longer period of time. There are likely to be 5-8 Augmentation and Supplementary interventions in Round 1, based on the previous summer's findings.

Annex 1

The table below lists the specific activities that TDSC will conduct during Phase 1, their approximate durations and visits that will take place for each activity.

| | 2014 | | | | 2015 | |
|---|---|---|---|---|---|---|
| | Sept | Oct | Nov | Dec | Jan | Feb |
| **Phase 1 Activities, timeline and visit schedules** | | | | | | |
| Status assessment of habitations and existing structures, and identification of possible Round 1 and Round 2 interventions | 3-4 visits covering all habitations and structures | | | | | |
| Set-up of monitoring systems: training of villagers on monitoring of well levels, stream flow | | | | | | |
| Data collection and observations on-site for Round 1 interventions | | 3-4 visits to Round 1 target habitations* | | | | |
| Analysis of secondary data on farmlands to determine desired storage capacity at target habitations for Round 1 | | | 2-3 visits to verify data at target habitations | | | |
| Assessment of possible project allocations (NREGA, IWMP) | | | 2-3 visits to agencies (MI, IWMP) | | | |
| Planning, design and cost calculations for Round 1 interventions (5-8 interventions) | | | | 2-3 visits to reconfirm details, receive feedback from villagers | | |
| Output delivery to Aroehan, contractor and other stakeholders | | | | | 2-3 visits for meetings with contractor and other stakeholders | |

*Target habitations for Round 1 will likely include Botoshi, Markatwadi, Raipada, Bhojpada, and Manipada, since these habitations each have one or more damaged structures.

# Contour trench design calculations

Contour trenches have been proposed at specific sites for two habitation: Botoshi and Markatwadi. The tables below present the design calculations and relevant dimensions for both sites:

**Contour trench design for Botoshi**

| | | Input / Output | |
|---|---|---|---|
| Runoff coefficient (C) | C | 0.4 | |
| Daily rainfall (R) | R | 0.03 | m |
| Area of runoff land(A) | A | 7500 | $m^2$ |
| Volume of water flow(Q) | Q=C*R*A | 90 | $m^3$ |
| % of runoff to be captured(a) | a | 75 | % |
| **Net flow (Q')** | Q'=Q*a/100 | 68 | $m^3$ |
| Length of the contour trenche(L) | L | 5 | m |
| Hight(H) | H | 0.5 | m |
| Width(B) | B | 0.5 | m |
| Volume of Each trench(V) | V=L*B*H | 1.3 | $m^3$ |
| No. of times trench is filled daily(f) | f | 1 | |
| Effective volume of trench(V') | V'=V*f | 1.3 | $m^3$ |
| **No of trenches required(n)** | n=Q'/V' | 54 | |
| Distance between the two trenches(b) | b | 2.5 | m |
| **Total length of the trenches($L_t$)** | $L_t$=(L+b)*n | 405 | m |
| **Distance between rows of trenches(d)** | d=A/Lt | 18.5 | m |
| length of the longest section of the ridge area (Lr) | Lr | 80 | m |
| **Number of rows of contour trenches(N)** | N=$L_r$/d | 4 | |
| **Total Volume of excavation(Soil)** | | 68 | $m^3$ |

## Contour trench design for Markatwadi

| | | Input / Output | |
|---|---|---|---|
| Runoff coefficient (C) | C | 0.4 | |
| Daily rainfall (R) | R | 0.03 | m |
| Area of runoff land(A) | A | 8000 | $m^2$ |
| Volume of water flow(Q) | Q=C*R*A | 96 | $m^3$ |
| % of runoff to be captured(a) | a | 75 | % |
| **Net flow (Q')** | Q'=Q*a/100 | 72 | $m^3$ |
| Length of the contour trenche(L) | L | 5 | m |
| Hight(H) | H | 0.5 | m |
| Width(B) | B | 0.5 | m |
| Volume of Each trench(V) | V=L*B*H | 1.3 | $m^3$ |
| No. of times trench is filled daily(f) | f | 1 | |
| Effective volume of trench(V') | V'=V*f | 1.3 | $m^3$ |
| **No of trenches required(n)** | n=Q'/V' | 58 | |
| Distance between the two trenches(b) | b | 2.5 | m |
| **Total length of the trenches($L_t$)** | $L_t$=(L+b)*n | 432 | m |
| **Distance between rows of trenches(d)** | d=A/Lt | 18.5 | m |
| length of the longest section of the ridge area (Lr) | Lr | 80 | m |
| **Number of rows of contour trenches(N)** | $N=L_r/d$ | 4 | |
| **Total Volume of excavation(Soil)** | | 72 | $m^3$ |

Annex 3

# Storage capacity estimation of Kurlod's bund

For calculating the total storage capacity of Kurlod's existing bund, the team used the tube-scale instrument for measuring elevation differences between points at increasing distances from the bund, up until the point where the elevation is the same as the bund's FSL height. The distance between this point and the bund would be the length component of the storage volume capacity. The width of the stream at each point (P1 - P8 below) is marked. The dimensions of the trapezoid making up the storage area are thus found – the volume can be calculated to get the storage capacity. **For Kurlod's bund, the capacity was found to be 18 lakh liters.**

Elevation Measurements:

| **Points** | **Width of *Nala*** | **Elevation in Tube** | **Distance between resp. points** |
|---|---|---|---|
| P1 (FSL) | 19.1 meter | 72 cm | 19.8 meter |
| P2 | 14.4 meter | 206 cm | |
| P2 | 14.4 meter | 121 cm | 19.8 meter |
| P3 | 13.4 meter | 119 cm | |
| P3 | 13.4 meter | 121 cm | 20.6 meter |
| P4 | 14.2 meter | 128 cm | |
| P4 | 14.2 meter | 145 cm | 20.8 meter |
| P5 | 13.8 meter | 119 cm | |
| P5 | 13.8 meter | 121 cm | 20.8 meter |
| P6 | 10.1 meter | 127 cm | |
| P6 | 10.1 meter | 142 cm | 20.4 meter |
| P7 | 9.9 meter | 110 cm | |
| P7 | 9.9 meter | 164 cm | 20.5 meter |
| P8 | 15.4 meter | 89 cm | |

# Quantity of materials calculations

The tables below present key dimensions and calculations for determining the quantity of materials for interventions under Phase I.

| Name/intervention | Dimentions/ quatity | Units | Material |
|---|---|---|---|
| **2. Pethechepada** | | | |
| **2.1 Pathway construction** | | | |
| Length | 100 | m | |
| Width | 1 | m | |
| Thickness | 0.15 | m | |
| Volume of material | 15 | $m^3$ | PCC |
| **2.2 De-silting** | | | |
| Dia of well | 5.8 | m | |
| Depth to till excavation | 1 | m | |
| Volume of excavation | 39.6 | $m^3$ | Silt |
| **2.3 Repaire of hole in well** | | | |
| Volume of material | 1 | $m^3$ | PCC |
| **3. Raipada** | | | |
| **3.1 Well construction** | | | |
| Dia of well | 3 | m | |
| Depth of well | 3.5 | m | |
| thickness of lining | 0.3 | m | |
| height of well wall | 0.75 | m | |
| Volume of excavation | 35.6 | $m^3$ | Soil |
| Volume of lining | 14.1 | $m^3$ | Masonry |
| thickness of plateform | 0.75 | m | |
| Width of plateform | 1 | m | |
| Volume of the plateform | 10.8 | $m^3$ | Masonry |
| **4.Manipada** | | | |
| **4.1 Well Plateform** | | | |
| Dia of the well | 6 | m | |
| Depth of the well | 5.8 | m | |
| Hight of the well wall | 0.75 | m | |
| Thickness of well lining | 0.5 | m | |
| Volume of lining | 7.1 | $m^3$ | Masonry |
| Width of the Plateform | 1 | m | |
| Thickness of plateform | 0.3 | m | |
| Volume of the plateform | 7.5 | $m^3$ | Masonry |
| **4.2 Pathway construction** | | | |
| Length | 75 | m | |
| Width | 1 | m | |
| Thickness | 0.15 | m | |
| Volume of material | 11.25 | $m^3$ | PCC |

| Name/intervention | Dimentions/ quatity | Units | Material |
|---|---|---|---|
| **5. Kirkidewadi** | | | |
| **5.1 Well Plateform construction** | | | |
| volume of material | 32.1 | $m^3$ | Masonry |
| **5.2 De-siltation** | | | |
| Dia of well | 3 | | |
| Depth of de-silation | 1 | | |
| volume of excavation | 3.5 | $m^3$ | Silt |
| **5.3 New Well Lining** | | | |
| Well depth | 5 | | |
| Thickness of well lining | 0.3 | | |
| Volume of the lining | 14.1 | | Masonry |
| **6.Markatwadi** | | | |
| **6.1 Well construction** | | | |
| Dia of well | 3 | m | |
| Depth of well | 3.5 | m | |
| thickness of lining | 0.3 | m | |
| height of well wall | 0.75 | m | |
| Volume of excavation | 48.5 | $m^3$ | Soil |
| Volume of lining | 12.9 | $m^3$ | Masonry |
| thickness of plateform | 0.3 | m | |
| Width of plateform | 1 | m | |
| Volume of the plateform | 4.3 | $m^3$ | Masonry |
| **6.2 Counter trenching** | 72 | $m^3$ | Soil |
| **7. Bhojpada** | | | |
| **7.1 Well lining and platform** | | | |
| Dia of well | 6.45 | m | |
| Wall hight | 0.54 | m | |
| Thickness of lining | 0.15 | m | |
| Voulume of lining | 1.6 | $m^3$ | PCC |
| Volume of 2x2x0.15 m platform | 0.6 | $m^3$ | PCC |
| Volume of drain | 0.15 | $m^3$ | Masonry |
| **8. Botoshi** | | | |
| **8.1 Counter trenching** | 68 | $m^3$ | Soil |