

# **Water Conservation**

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# **WATER CONSERVATION GUIDE**

## **1. INTRODUCTION:**

Water Conservation Programme is one of the very important programme, the Govt. of Maharashtra has decided to implement with a view to improve the lifestyle of the people in rural areas and thereby achieve the rural development. To develop agriculture from water resource development and to solve serious drinking water problem is the need of the time.

The Maharashtra Irrigation commission has estimated that maximum 30% area of the state can be brought under irrigation by utilizing all available water resources to the fullest possible extent. This means that remaining 70% area will still depend upon rainfall. Also the groundwater development has been the result of the various schemes implemented by the state. This has created imbalance in groundwater recharge and development. Therefore groundwater table is decreasing day by day and this has badly effected on agriculture development and drinking water availability. The state of Maharashtra received rainfall for a period of 4 months only, maximum run off i.e. more than 80% is also within this period. Therefore we have to depend upon groundwater and surface water arrested in the rivers for remaining period of 8 months. Considering these facts it is necessary to improve groundwater table by arresting rainfall and develop water resource at village level. Also it is necessary to utilize available water to the minimum possible extent, control on excess groundwater withdrawal and give proper direction to water uses for various aspects.

Considering geographical and geological structure of the state of Maharashtra, it is very important to arrest runoff water, make it percolate, and store through water conservation programme. Economic growth is achieved in 'Ralegan Siddhi, Adgaon, Palaskheda etc. villages through integrated watershed development programme. Considering mini watershed as a unit, if water conservation programme is implemented in proper technical manner it is possible to raise the percentage of recharge to 25 to 30% easily from the present 15% . For this purpose Groundwater Surveys & Development Agency, Soil Conservation, Minor Irrigation and Social Forestry Department have to implement this programme jointly and in a planned time schedule. If sufficient funds are made available by the State Government to start all works concerning development from ridge to valley. This programme will be very much effective and successful provided proper co-ordination between the employees of above mentioned departments, exchange of technical expertise and knowledge, work scheduling and quality, involvement of rural people etc. is achieved.

## 2. Introduction of Water Conservation Programme.

### 2.1. Programme-

- To increase groundwater storage by arresting rain water.
- Groundwater development at local level.
- To implement water conservation programme in scientific manner and raise the recharge rate from 15 to 25-30% by considering mini watershed as a unit.

### 2.2. Programme Implementing Agencies :-

- Groundwater Surveys & Development Agency.
- Soil Conservation and watershed area management department.
- Minor Irrigation (Local Sector).
- Social Forestry Department.
- Forest Department.
- Voluntary Organisations.

### 2.3. Purpose of Water Conservation Programme.

- To minimize loss on account of run off water.
- Runoff water management and its use for useful works.
- To minimize soil erosion and silting.
- To minimize the intensity of flood on down slopes.
- To improve groundwater recharge.
- To make proper use of natural land resources in the watershed areas.
- To develop forest and fodder growing areas.
- To adopt proper land use pattern.
- To manage irrigation and water sanitation.
- To control water logging and salinity problems.

### 2.4. Priority areas for the programme.

- The villages, where in drinking water scarcity was felt, and water is supplied by tankers or bullock carts during the last scarcity.
- The villages having less recharge capacity in 12 watershed areas which are identified by the Central Groundwater Board and the Groundwater Surveys & Development Agency.
- The villages falling under Grey, Dark and over developed watersheds which are classified by Groundwater Surveys & Development Agency.
- The villages where in the works undertaken by the Agriculture Department are in progress and more than 50% works are completed.
- The areas where in water bearing strata is favorable for recharge.
- The areas where minimum essential rainfall is available for effective implementation of recharge projects.

### 2.5. Agency wise Water Conservation Programme.

Measures	Types of Measures	Agency
1) Soil Conservation	Forestation	Forest Department & Social Forestry.
	Continuos Contour Trench (C.C.T.)	-do-
	Contour Trench	Soil Conservation
	Contour Bunding	-“-
	Farm Ponds	-“-
	Check dam	-“-
2) Water Conservation	Vanrai, Kaccha earthen Bund, Nala Bandhara, Nala Plugs, check dam, Percolation tank,	Soil Conservation Department.

	Underground bandhara.	
3) Strengthening of drinking water sources (Unconventional)	F.S.C. – Fracture Seal Cementation., Jacket well, Stream blasting, Bore Blast Technique, Borewell flooding.	Groundwater Surveys & Development Agency

## 2.6. Master key for success of Water Conservation Programme.

- Co-ordination and participation of the programme implementing agencies.
- Exchange of technical matters.
- Plan of work.
- People's participation from the beginning of the programme. People's awareness and training.

## 3. The Concept of Integrated Watershed Development.- Through Water Conservation.

### 3.1. Essential factors –

The important factors for planning 30 to 35% of the total rainfall run-off water of the watershed to be recharged to the maximum possible extent in the same watershed are –

- Available run off in the watershed.
  - Land slope.
  - Nature of land.
  - Land use pattern.
  - Geological formation.
  - Storage capacity of the formation.
- Essential maps for watershed development plan.
- Contour map.
  - Geological map.
  - Geohydrological map.
  - Map showing the rainfall.
  - Map showing the land use.
- Essential points for preparing recharge project in the watershed.
- Availability of surface run-off water.
  - Site selection and selection of proper measures to arrest run-off water .
  - Availability of water bearing formation for recharge of arrested (rain fall) run-off water.
  - Sufficient number of wells nearby the project, proper cropping pattern, irrigation system etc. for effective withdrawal of the water which is recharged through the project.

### 3.2. Calculation of run-off water –

#### 3.2.1 The use of the chart suggested by the scientist- W.N. Strange –

- Applicable to the areas having annual rainfall up to 1500 mm.
- Three groups of the watershed.
  - a) Excellent watershed –
    - ❖ More than 20% slope.
    - ❖ Maximum run-off of water.
    - ❖ Less vegetation cover.
    - ❖ Adverse geological conditions for recharge.
  - b) Medium watershed –
    - ❖ 5 to 20% slope.

- ❖ Moderate vegetation cover.
- ❖ Moderate recharge capacity.
- ❖ c) Poor watershed.
- ❖ Less than 5% slope.
- ❖ Minimum run-off.
- ❖ Excellent vegetation cover.
- ❖ Good recharge process.

Strange's Chart.

Annual Rainfall (mm)	Percentage of run off to rainfall		
	Excellent watershed	Moderate watershed	Poor watershed
250	4.30	3.20	2.10
375	9.40	7.00	4.60
500	15.00	11.25	7.50
625	20.30	15.40	10.80
750	26.30	19.70	13.10
875	31.90	23.90	15.90
1000	37.50	28.10	18.70
1125	43.10	32.30	21.50
1250	48.80	34.40	24.40
1375	54.40	40.80	27.20
1500	60.00	45.00	30.30

### 3.2.2. Formula suggested by the Scientist – Eagles –

More than 1500 mm. Annual rainfall –

Formula for Ghat region –

$$\text{Annual run-off(cm)} = (0.85 \times \text{Annual rainfall in cm}) - 30.5$$

$$\text{Formula for other region} = \text{Annual runoff (cm)} =$$

$$(\text{Annual rainfall in cm} - 17.8) / 254 - \text{Annual rainfall(cm)}$$

### 3.3 – Site selection for various measures of Water Conservation. Points to be considered before proposing the measure.

- Rainfall – Last 50 years study of type, intensity, period, rainy days etc. is essential.

- Land form –

The useful information about nature of desection & depth of desection is obtained from mud cones, plains in the flood areas, Hilly terrain, Ridges and valleys etc.

- Land topography –

Through the distribution of rainfall water –

- ❖ . Percolation places.
- ❖ . Recharge and withdrawal zones.
- ❖ . Water flow direction and flow rate.

- . Drainage Pattern –

Useful information is obtained from the pattern and density of drainage –

- ❖ . Nature of available rocks.
- ❖ . Rock structure.
- ❖ . Rock jointing.
- ❖ . Rock porosity.
- ❖ . Water carrying capacity.
- ❖ . Water supply capacity.
- ❖ . Water Flow.
- ❖ . Geological & Geohydrological pattern.
- ❖ Various formations in the watershed –
- ❖ . Water storage capacity.
- ❖ . Groundwater level in summer.
- ❖ . Groundwater quality.



### **3.4. Study of Satellite Imageries and Aerial Photographs for fixing up watershed area and planning of water conservation measures (Fig. 1).**

#### **A- Class – (Highly desected plateau)**

The area in the vicinity of ridge line, hilly terrain and run off zone is included in this class. The following measures are implemented – Forestation for water conservation, Nilgiri, Sadaphuli, Ghaipat etc. trees, contour trenches, drainage check dams, borewell recharge schemes.

#### **B - class (Moderately desected plateau)**

This area consists of moderate slope, moderately desected rocks and moderate soil cover. In this area following measures are implemented.

- 1) Cross contour pits on the down slopes.
- 2) Drainage check dams, contour dam.
- 3) Deep ploughing.
- 4) Percolation Tanks.
- 5) Nala Bunding.
- 6) Nala straightening.
- 7) Chain of check dams etc.

#### **C - Class (Undesected plateau)**

Recharge zone = Lower most portion of the watershed. Soil cover is 1 to 3 Mt. And depth of desection is 10 to 15 Mt. The following structures are take up.

- Under Ground Bandhara.
- Village Tank.
- Farm ponds.
- Sub surface run off grouting.
- Borewell in Nala Bed, cut of wall by grouting.

#### **4.0. Brief information of the measures under water conservation programme–**

##### **4.1. Conventional measures.**

###### **4.1.1. Majagi Works.(Paddy pits.)**

Essential geographical conditions

- Foot hill.
- 4 to 8 % Land slope.
- Area of more rainfall i.e. western ghat & Vidarbha region in Maharashtra.

Construction (Fig. No. 2)

- Step by step leveling of the slopping land in stages of 10 to 20 Mt. distance.
- Construction of bund.
- Provision of Weir.
- Wherever necessary, excavation of trenches for bringing the outside water into the majagi field.

Expenditure (As per revised norms)

- Rs. 27762 to 33482 per Hectare.

###### **4.1.2. Earthen Nala Bund –**

Essential geographical conditions -

- Protective bund on the drains having depth less than 1 Mt.
- Nala having watershed area from 10 to 1000 Hectares.
- Nala with both the banks – distinct & visible.
- Width of Nala – less than 15 Mt.
- Bottom slope – less than 3%.
- No waste(chibad) land nearby.
- Availability of pakka murrum or rock at the spot of the weir.

Construction work of Nala bund (Fig. No. 3)

- 1.5 TCM to 4 TCM water storage.

Benefits of Nala bund –

- Control on soil erosion.
- Increase in irrigation areas through increase in the groundwater storage in the wells within 1 to 2 km areas.
- The silt from the drainage is used as fertilizer.

Expenditure on Nala bund (Temp. norms)

- Rs. 25462 to Rs. 28009 per thousand cubic Mt. Water storage.

#### 4.1.3. Continuous contour Trenching (CCT).

- Continuous contour trenching is an experiment in the forest areas since 1993.
- Essential factors –
- The area unsuitable for agriculture in the hilly terrain of the watershed having undulating topography.
- Construction and work procedure (Fig 4a, 4b)
- Starting the works from hill top.
- Drawing of continuous contour lines with the help of contour marker firstly on the hill top and on the slopes.
- Excavating continuous trenches (60 cm wide x 30 cm. deep) on continuous contour lines.
- The distance between two continuous trenches depends upon the slope of the area.
- Excavated soil from the trenches is deposited on the down slope side of the trench for making the bunds of 30 cm height.
- On the top of the bund fertile soil and at the bottom of the bund poor quality soil is filled.
- Seeds of trees and plants is sewn on the bund. Near the trench bush belts are produced.
- There is heavy rainfall in Konkan and Western ghat region. In such situation. Stone pitching of raw stones is done on the down slope side and continuous trenches are cut at some places to provide water outlets.

Purpose –

- To stop the soil erosion.
  - To absorb each and every drop of rain fall water in the ground.
  - Rainfall water between two trenches to be arrested in the same trench only.
  - Increase in groundwater storage due to percolation of surface water.
  - Availability of employment and water for drinking & irrigation to the local people.
  - Forestation and biological fertility on continuous contour trench.
  - Guaranteed clean environment and acceleration of environment cycle.
- Expenditure (Temporary revised norms).

1. Rs. 7072 to Rs. 7559 per hectare.

2. Rs. 8157 to Rs. 8734 -“-

3. Rs.9111 to Rs. 9652 -“-

4. Rs. 12859 to Rs. 13670 -“-

5. Rs. 5071 to Rs. 5920 -“-

6. Rs. 5864 to Rs. 6858 -“-

7. Rs. 7321 to Rs. 8536 -“-

8. Rs. 10,222 to Rs. 11449 -“-

Success history of the programme implemented by the Forest Department.

1) Village Dolasane Tal. Sangamner, Dist. Ahmednagar.

- Increase in water level of the well.
- Increase for more than 2 times in the irrigation area.
- Increase in the period of storage of the percolation tank for 3 times.

2) Village Shinde, Taluka- Karjat, Dist. Ahmednagar.

- There was no water in the well for drinking to the cattle in the summer of 1995, now the same well is irrigating 2 hectare groundnut crops.
- Increase in groundwater availability in 6 -7 nearby wells.

3) Village Suregam, Taluka- Shrigonda, Dist. Ahmednagar.

- 11 Mt. deep well was supplying water for 2 hrs in the morning and 1 hour in the evening earlier. After completion of CCT work the same well was filled up to the top on 9<sup>th</sup> day and started overflowing.
- The same benefit to other wells in the village.

#### **4.1.4- Live Check Dam.**

- To control the drain and stop the soil on the spot, which was carried along with the rainwater from the small drains.
- Live check dam is ready by planting 1 or 2 rows of special or local grass.
- Norms – Rs. 100 per bund.

#### **4.1.5. Brush wood Dam.**

- Just on the down side of the gradient area of the watershed the width & depth of drainage increased. This is the spot for construction of Brush wood Dam.
- On the length side of the drain, and having length equal to width of the drain and at a spacing of 20 cm , 2 rows of 5 cm diameter, 60-65 cm. Height dried or wet wood in sticks are fixed and grass, fodder or branches of thorny trees are placed between the wooden sticks and stones, soils etc. placed on them.
- Expenditure norms – Rs. 150 per dam.

#### **4.1.6. Loose Boulder Structure –**

- Measure for arresting soil in large drain.
- Use of local stones.
- Slope on both the sides of the dam if required
- The width of the dam is equal to the width of the drain
- Sanctioned norms – Rs. 500 to 750 for small and Rs. 2000 to 3000 for big dams.

#### **4.1.7. Vegetative filter stripes in place of diversion dam –**

- The measures in place of diversion dam for arresting water in the non-agriculture areas of the upper portion of the watershed so as to avoid the entry of water in the lower portion of the agriculture fields.
- Norms – Rs. 15 per Mt

#### **4.1.8. Contour bunding.**

Essential factors.

- Area of irregular and average rainfall.
- Area suitable for cultivation having slope less than 3%.
- Poor to moderate quality soil up to 45 cm depth.

Expenditure as per revised norms.

- Rs. 2551 to 2807 per hectare.
- Very much effective for soil conservation

#### **4.1.9. Sloping bunds.**

Essential points.

- Areas of regular and good rainfall.
- Moderate to rich soil.

Work procedure –

- The soil erosion is stopped by constructing slopping dams and trenches at 0.2% slopes for draining out excess water.

Expenditure as per temporary revised norms.

Rs. 2459 to 2691 per hectare.

#### **4.1.10 Nala Trenching-**

Essential factors –

- Distinct out fall of water.
- To see, the water is not stagnated in the Nala

Work procedure.

- To remove obstacles in the Nala.
- Remove curves of the Nala.

Benefits –

- Due to spreading of flood water in the nearby fields, they become unfertile and irregular nala bends. If proper direction is given by removing bends water is cleared out of the fields and the land is safe.

Expenditure.

- Rs. 22033 to 25435 per km.

#### 4.1.11 Diversion Bundhara –

Essential factors.

- Nalas flowing up to end of December at 150 Lt./second.
- Width of nala should be less than 30 Mt.
- Exposed rock at nala bed.
- Depth of Nala should not be more than 3 Mt.

Construction & work procedure (Fig. No. 5a, 5b)

- Top of the bundhara 0.60 Mt and height – 1.10 Mt.
- Upper side of bundhara should be vertical and slope of 1:0.5 on the lower side.
- 0.5 m x 0.5 m size collapsible gate, at the mid point of the dam should be provided. .
- For diverting the stored water in the nearby fields 0.60 thick stone masonry wall should be constructed on the downside. From this point water is diverted to the fields by digging both the nala banks.
- For construction dubber should be used. Cement mortar 1:5 ratio, pointing to exposed portion of the wall, and 10 cm thick 1;2:4 cement concrete coping on the top side.

Utility – Konkan, Vidarbha & regular rainfall areas.

#### 4.1.12 Cement Nala Bund (Fig. No. 6).

Essential factors.

- Nala having rich and deep black soil.
- More beneficial on 'U' type nala.
- Nearby fields should not be water retaining

Benefits –

- 40 to 50% improvement in water storage in the nearby wells.
- 25% increase in irrigation area.
- As the water storage retention period is more, useful for the crops, after monsoon.

Expenditure –

- Rs. 20,000 to Rs. 26,000 per thousand cubic Mt. of water storage.

#### 4.1.13.- Gabian Bundhara (Structure)

- The structure made from the dubber and wire mesh, across the nala bed.
- Suitable, simple and less expensive for the sites where, it is not possible to provide soil bunds due to non availability of proper location for the weir and cement bunds due to pukka foundation problem.
- Recharge to nearby well though percolation of stored water in the nala bed.

Essential factors –

- Average 10-15 Mt. Nala bed width.
- Hard & exposed rock should not be available any where in the nala bed.

Construction (Fig No.7).

- Bundhara makes right angle (90°) to the Nala flow.
- Excavation which is extended to 1 Mt. In both the nala banks.
- The pattern of laying dubber in the wire mesh should be as under.
  - a- Top - 60 cm.
  - b- Height - 120 cm.
  - c- Side slope - 1:0.5
  - d- Width of foundation - 180 cm.
- 10 gauge (3 mm) thick wire mesh should be spread over the nala bed.
- In the middle of the mesh dubber bundhara should be constructed on the entire width of nala.
- After construction, the wire mesh, alongside of the bundhara should be pulled to the top of the structure and joined together.



Expenditure –

- If the work of collection of dubber, filling, fastening of wire mesh etc. is done voluntarily then wire mesh expenditure per sq.m. is Rs. 20. The wire mesh is supplied free of cost if the bundhara is constructed through 'Vanrai Institute.' 45 sq.m. wire mesh is required for above mentioned bundhara. The cost of wire mesh including fastening charges say Rs. 100, comes to Rs. 1000 (i.e. 45 sq.m. x Rs. 20 per sq.m. + 100). As per revised temporary norms the expenditure per cubic Mt. Comes to Rs. 211 to 217.

#### 4.1.14 – 'Vanrai Bundhara' (Fig No. 8)

After September the water flow is retarded, therefore temporary Vanrai Bundharas can be constructed by using empty cement bags and arresting flow water from the nala, stream etc. By erecting such structures and retarding the flow rate it is possible to percolate more water in the ground and increase the water level in the irrigation wells and drinking water wells. If the farmers, villagers, cultivators and student participate voluntarily in this work, the drinking water problem can be solved within minimum time and expenditure.

On an average Rs. 1000 expenditure for construction of bundhara of 1000 cement bags (empty) is incurred if the villagers contribute their labour voluntarily. On both the sides of bundhara, 10-15 hectares land is irrigated from the dug wells or directly from the water in the nala. Suitable crops such as sunflower, Jowar, wheat, vegetables etc. can be taken up. Also due to water storage, water levels in the nearby wells increase by about 1.5 to 2 Mt. Which can be sufficient to solve the drinking water problem. The above facts have been disclosed during the survey conducted by the 'Vanrai Institute'

Work procedure for Vanrai Bundhara.

1. Selection of site – Nala slope between two bundharas should be up to 3%. The height of both the nala banks should be 1 to 1.5 Mt.
2. Construction material – Empty cement bags, sand or sand mixed soil, plastic thread for stitching and stitching poker.

Construction method,

After selecting the site for the bundhara by considering nala slope and the watershed generally excavation for foundation of 1.5 to 2 Mt wide and 0.30 Mt. deep is done on the entire width of nala, then empty cement bags should be filled with sand or sand mixed soil and mouth of the bag should be stitched by the plastic thread. All such stitched bags should be placed on after another across the entire width of nala as shown in the figure and first layer should be completed. (Fig. No. 8) . Second layer of bags should be arranged in such a way that the bag in the second layer comes on the joint of two bags in the first layer. One layer of soil should be placed after completion of 2-3 layers of the bags, on the entire length of bags. Water is arrested due to soil layer on the top of bags and soil between the joints. This makes the structure strong and sturdy.

Generally, the expenditure is Rs. 1000, for the bundhara having 1 Mt. height & 1000 empty cement bags (Rs. 2500 for 20 Mt. Length). This expenditure is only on account of 1000 empty cement bags. This cost of empty cement bags, considering the increasing work volume, may increase in the future.

Such Vanrai Bundharas are mainly constructed in the water scarcity affected areas, as a temporary measures.

#### 4.1.15. Under Ground Bundhara (Fig No. 9)

Essential factors –

- Nala having more than 1 Mt. sand layer construction –
- Excavation of sand up to hard rock of nala bed.
- Soil filling at the bottom in the excavated portion, wetting the soil, consolidation by pressing and ramming the soil to obtain desired density.
- Filling the soil up to the height of the nala bed.

Benefits –

- Recharge of water in the surrounding areas of Nala. This gives permanent benefit to the nearby wells. Water being in the sand layers and soft rocks below the ground, evaporation does not take place and entire water is completely available for use.

#### 4.1.16. Farm Ponds (Fig. No. 10).

Essential factors –

- The areas receiving rainfall generally 700 mm or more (District of Bandhara, Gadchiroli & Chandrapur).
- Land slope up to 3%.
- Average size – 20m x 20 m x 3 m. The farmer has to bear addition expenditure on account of bigger size.
- Required land has to be donated by the farmer willingly and free of cost.
- Maintenance is entrusted to the farmer.
- Can not be implemented in irrigation projects areas.
- If the project is of individual one, 20% amount of the project has to be borne by the farmer.
- If the farmer does the labour work voluntarily amounting to 20% of the project cost, remaining work is done through the Government.

Expenditure (revised temporary norms)

Rs. 30,118 to Rs. 35957 per thousand cubic Mt.

#### 4.1.17. Recharge Trench (Fig No. 11)

Maximum areas in Vidharbha, Marathwada and Khandesh are occupied by rich black soil. In such area suitable site for the weir of earthen bund is not available and also hard rock for the foundation of cement plug is not available. Shenolikar Committee has suggested the measure of recharge trench as one of the various measures for orange growing areas in Vidarbha. If there is no rainfall during the monsoon, then this structure is useful for irrigation.

Technical aspects of Recharge Trench –

1) Nala bed should have at least 4 to 5 Mt. Strata of Kuccha murrum. This can be verified from the Nala bank and surrounding land.

2) Small & big dubber (rubble) is required for refilling. This facility should be available within 2 km. from the site. If the distance is more than 2 km. Then such structure should not be taken up.

3) Nala width should be minimum 10 Mt. A trench of Nala width of 4 to 5 Mt. vertically down should be excavated. Length of the trench may 20 to 30 Mt. As required. Excavated soil should be deposited at Nala banks in such a manner that measurement can be done easily. If murrum is struck while excavating then it should be stored separately. Trench of 4 to 5 Mt. uniform depth is essential. Dubber or stones should be filled in the trench in such a way that maximum cavity remains between the stones. If possible round shaped stones should be used, so that 40 to 50% cavity is available. Last layer should be taken up with a great care and minimum cavity should exist so that it will not be harmful to the cattle and other animals.

4) Recharge Trench should be located at maximum 100 Mt. Distance from the water source. The size of stones required for refilling the trench is given below.

1. Big stone - 0.50 Mt. dia.
2. Medium stone - 0.30 Mt. dia.
3. Small stone - 0.20 Mt. dia.
4. Very small - 0.10 Mt. dia.

5) On the both sides of the Nala bank where recharge trench lines are going parallel, 4 stones should be fixed and painted by oil paint to indicate the location of the trench. Recharges trenches should be constructed in the tanker fed villages near the water source if found technically feasible. These trenches should not be constructed in any other villages or water sheds. For selection of site, the matter should be referred to Groundwater Surveys & Development Agency and necessary feasibility certificate should be obtained from Groundwater Surveys & Development Agency

Essential things to be complied before starting the work and during execution.

- 1) The soil of the recharge trench where the trench is to be constructed should be spread over on the both sides of the Nala bank. If the land is private then necessary consent should be obtained from the land owner for spreading the soil
- 2) While the work is in progress, it is necessary to have formation wise height sketch on a separate paper.
- 3) If the rock is struck at the bottom, then the depth of the trench should not be blasted in any case for further deepening.
- 4) The length of the trench is more along the flow direction while excavating the soil from the trench, the hard rock may strike at different depths and it should be left as it is and in no case blasting should be carried out.

#### **4.1.18. Work progress of conventional measures of water conservation.**

The progress of work of conventional water conservation measures in Maharashtra by the end of 1983 under Individual method from 1983 to end of May 1992 under comprehensive watershed development programme (COWDEP) and from May 1992 to end of 1999 measure wise work progress of soil and water conservation under integrated area development programme is shown in the statement No. 1.

#### **4.2. Unconventional measures for strengthening of drinking water sources.**

- Measures for groundwater conservation and development under the integrated watershed area development programme, and for strengthening of drinking water sources under scarcity and tanker free programme.
- Implementing agency – Groundwater Surveys & Development Agency.

##### **4.2.1. Fracture Seal Cementation (cut off wall fig. No. 12).**

- Drilling of shallow depth (10-15 Mt) bores having 1-2 Mt. Spacing in two rows across the nala bed covering entire width.
- Cement slurry is injected into the drilled bores with the help of grouting pump.
- Cement slurry under pressure, enters into the water bearing fractures, joints etc. and seal them.

Benefits –

Water bearing fractures generally available in the depth range of 6 to 15 Mt. And these are responsible for sub-surface run-off and due to this the well does not store sufficient water. By cement grouting these fractures are sealed thereby arresting sub-surface run-off by way of cut-off wall. Due to this well storage is improved and it can supply water for more period.

#### **4.2.2. Jacket well \_ (Fig. No. 13).**

This technique is to artificially create the fractures, joints etc. by carrying out blasting – Operations in the drilled bores. The new fractures are created in the vicinity of the source well and also existing fractures are interconnected. Due to this water storage and supply capacity of the well is improved

Construction and work procedure –

- Drilling of shallow depth bores around the source well in circular or semi circular patten depending upon geological conditions so as to form a jacket around the well.
- Depth of bores is slightly less than the depth of well.
- The bores are charged with explosives and blasted.
- Due to blasting, artificial fractures are created and connected to the well.
- The groundwater available around the well is percolated into the well and supply capacity of the well is increased.

#### **4.2.3 Bore Blast Technique (BBT) (Fig No. 14)**

The purpose of this technique is to artificially create fractures and improve storage capacity of the source well. This method is suitable for the areas where there is assured and heavy rainfall but the sources become dry because of the non porous or less porous formation.

Construction and work procedure.

- The bores are drilled to a required depth in the upper side of the source area and blasted by charging them with dynamites.
- Groundwater storage during the monsoon is created in the artificially created fractures and joints.
- This storage is made available to the source well or borewell on the down side thereby strengthening the source.
- This measure is useful and beneficial for small hamlets i.e. wadi/vasti/pada/tanda etc. having population less than 150 and having acute drinking water scarcity of drinking water. .

#### 4.2.4 Stream Blasting (Fig No. 15)

This technique is useful for channeling the sub surface water flow artificially below the nala bed, and connecting it to the source well situated on the nala bank

Construction & work procedure –

- Required number of bores depending upon geological formation are drilled in the nala bed.
- Blasting of these bores is carried out by charging them with dynamites.
- Artificial fractures and joints are created and also existing fractures & joints are extended and interconnected.
- The groundwater flow below the nala bed is connected to the source well thereby increasing the groundwater availability in the well.

#### 4.2.5 Unconventional measures implemented under the “Ideal Village Project” (Adarsh village concept).

This is a programme for the development of the village and to be implemented by the villagers as a peoples programme. The aim of the Government is to recreate natural resources of the ruined villages and achieve guaranteed development of drought prone affected villages. For this purpose the Government have started a scheme “ Adarsh village Project” from 1995. Family planning, prohibition on liquor, cutting of the trees, fodder and “Shramdan”, are the 5 main points of this programme.

The Groundwater Surveys & Development Agency has tackled 111 Adarsh villages from the beginning to end of March 99 under this programme for strengthening of drinking water sources and implemented 205 unconventional measures costing Rs. 44.45 lakh (Statement No.2)

The region wise information of the uncoventional measures implemented in the 90 Adarsh villages is shown in the statement no 3.

#### 4.2.6 Utility of unconventional measures.

Though the possibility of implementing the unconventional measures for developing irrigation capacity on large scale is less, but it has been observed that these measures are very much useful for strengthening of drinking water sources. The details of work done from the beginning to March 1999 under various unconventional measures are shown in the statement No. 4.

Utility of unconventional measures – points to make it more clear.

1. unconventional measures are very efficient, useful and effective for the limited area.
2. Unconventional project is a permanent measure (except artificial recharge through borewell project).

3. Due to excessive withdrawal of the groundwater, the groundwater level is depleted in some areas. The groundwater level in such areas can be raised to some extent by additional recharge through the unconventional recharge projects so as to help in maintaining Geohydrological balance.

4. Water loss due to evaporation is avoided, as the recharged water is stored underground.

5. As compared to surface water storage, the groundwater is safe from various types of contamination's.

6. In the unconventional projects mainly the portion of the skilled work and mechanized work is more and therefore if mechanized equipment is available, then the unconventional project as compared to conventional projects can be completed within short time and less expenditure.

7. The cost of unconventional project except bore blast technique as compared to conventional projects is very less.

#### 4.2.7 Average period and expenditure for completing unconventional projects.

Name of the measure	Average expenditure Rs. In lakh.	Approximate time to complete the project.
1) Fracture seal cementation (FSC)	0.4015	15 days.
2) Jacket well (JW)	0.40	15 days.
3) Bore blast technique (BBT)	2.00	50 days.
4) Stream blasting (SB)	0.30	10 days.
5) Hydrofracturing (HF)	0.13	1 day.
6) Recharge through borewell (siphon method)	0.10	Every year regularly during the monsoon.
7) Recharge storage pit	3.00	90 days.

#### 4.2.8 Success history of unconventional measures.

Due to the implementation of unconventional measures from the beginning i.e. from 1990 to March 1999 the problem of drinking water has been completely solved in 837 villages and 489 wadies, and partially solved in 1120 villages and 763 wadies (Statement No. 5). The region wise history in brief of some of the projects, out of the total implemented projects is given below –

#### **4.2.8.1 Konkan region.**

1. Village - Kondmala (Shirkewadi)
2. Taluka - Chiplun.
3. District - Ratnagiri.
4. Village code no. - 84
5. Population - 307.
6. Watershed - WF-62
7. Beneficial source of the project – Pipe Water Supply well.
8. Geological formation - Hard jointed rock.
- 9 Project implemented – Bore Blast Technique and Fracture Seal Cementation.
- 10 Date of completion of project – 2.5.1993.
- 11 Total expenditure of the project – Rs. 40698
- 12 Status of water supply before the project – Well was dried up in March 1993.
- 13 . Status of water supply after the project – The project has been successful. During the summer of May 1994 there was water column of 2.10 Mt. This water was available to the village @ 20 Lt./day/capita, during the summer

#### **4.2.8.2 Nashik Region (Fig No. 16 a)**

- 1) Name of the village - Nimgaon Sinnar.
- 2) Taluka - Sinnar.
- 3) District - Nashik.
- 4) Village code No. - 23
- 5) Population - 2700
- 6) Watershed - GV-20
- 7) Morpho index - MDP (B)
- 8) Drinking water sources
  - 1) Water supply well situated at 300 Mt. on the south of the village
  - 2) 5 Hand pumps, 1 Power pump.



9) Status of drinking water before the project and the geological formation-

Before implementing the project geographical, geological and hydrogeological conditions of the village were taken into account and were studied in detail.

Status of drinking water before the project.

- 1) Scarcity of drinking water after April.
- 2) No flow in nala due to less rainfall.

3) Well was dried in April. At the bottom of the well there is medium hard, fractured and jointed rock. depth of the well = 8.20 Mt., dia. = 4.20 Mt. Well is situated on nala bank. width of nala bed = 22.Mt

10) Unconventional measures implemented – Jacket well, stream blasting and hydrofracturing.

10.1 Jacket well - Project cost – Rs. 38000

Date of starting – 16.10.1994.

Date of completion – 8.11.1994.

10.2. Stream blasting - Project cost – Rs. 16000

Date of starting – 28.10.94.

Date of completion – 8.11.94.

10.3 Hydrofracturing. :Out of the 5 borewells hydrofractured improvement in water was noticed in 4 borewells.

Project cost – Rs. 65000

Date of starting – 21.9.94.

Date of completion – 27.9.94.

11 Water bearing formation : After completion of the project

Before and after the project : groundwater level

Change in groundwater level. : was increased by 0.30 Mt and it was the same after one month.

12 Experience about the increase in water. - Due to hydrofracturing, additional Water @ 19000 Lt./hour is made available and due to increase in water level by 0.30 Mt. additional 3600 Lt. of water is available in the well.

13, Per capita expenditure of the project – Rs. 45

14 Assessment of the success of the project. : Geohydrological survey of this area was done before and after the project  
From the survey it is observed that  
– 1) Drinking water will be available even if there is severe summer.

2) Water storage capacity was increased by 22600 lt. per day. Due to this increase, scarcity of water will not be felt during the summer also.

**Remarks of the Administrator and the Gramsevak of village Nimgaon – Sinnar, about unconventional measures.**

Village Panchayat Office, Nimgaon Sinnar (Sinnar)

No.-Grapan/12/1994      Date-10-12-1994.

**To,**

**The Senior Geologist,**

**Groundwater Surveys & Development Agency,**

**Nashik.**

Subject – Measures implemented at village Nimgaon-Sinnar for setting aside the drinking water scarcity.

Respected Sir,

In connection with the above mentioned subject, it is submitted that the following unconventional measures have been implemented by your office in the village. This has certainly helped in setting aside the drinking water scarcity.

Details of unconventional measures implemented.

1. Borewells - 5 borewells hydrofractured out of this, the borewells at Khalwadi, near the house of Mr. Sanap and near the school are successful and plenty of water is available from these borewells.

2. Well jacketing- The well situated in the Harijan-Vasti has struck plenty of water and water storing capacity of the well is increased.

3. Stream blasting – The drinking water problem will be solved if 2 power pumps are installed.

The unconventional measures implemented through the Government are certainly beneficial to the villagers. Under this scheme the work of underground bundhara on the down side of the well has been started by the Sub Divisional Soil Conservation Officer. After completion of the work, the water level in the well will certainly increase.

This is for your information.

Sd/-

Sd/-

Gramsevak  
Grampanchayat Nimgaon-Sinnar

Administrator.  
Grampanchayat Nimgaon-Sinnar.

#### **4.2.8.3 Pune Region.**

1. Village - Karanjgaon
2. Taluka - Bhore
3. District - Pune
4. Village code No. - 115
5. Population - 330
6. Watershed - BM-81
7. Beneficial source of the project – Pipe Water Supply Well.
8. Geological formation of the source – Weathered, vesicular rock.
9. Project implemented – Fracture Seal Cementation.
10. Date of starting the project - 13.2.1995.
11. Date of completion - 15.2.1995.
12. Cost of project - Rs. 38619
13. Status of water supply before the project = Tanker was deployed to supply drinking water during the summer since the source well was not having sufficient

water. About 13 Lt./capita/day,  
water was available.

14. Status after completion = The project was successful and water  
of the project. Was supplied in the summer @ 40  
Lt./capita/day.

#### **4.2.8.4 Aurangabad Region.**

1. Village - Dekari
2. Taluka - Tulajapur
3. District - Usmanabad.
4. Village code No. - 1
5. Population - 1443
6. Beneficial source of the - Pipe Water Supply Well  
project.
7. Geological formation- : Weathered, black, fractured and  
of the source jointed rock is available in the  
source well.
8. Projects implemented - Fracture seal cementation and bore blast  
technique.
9. Date of starting - 9.12.1994.
10. Date of completion - 12.2.1995.
11. Total expenditure - Rs. 44000
12. Status of water supply Tanker water was supplied since the well .  
before the project water supply was inadequate. There was  
daily short supply of 30720 Lt. of water to  
the village as compared to the requirement.

13 Status after completion of project. =The project was successful. Sufficient water was supplied through the well Tanker was discontinued. 66000 Lt. of water was made available daily to the village and was supplied @ 46 Lt./capita/day to the people.

#### **4.2.8.5 Amravati Region-**

1. Village : Kharadgaon.  
2. Taluka : Ner  
3. District : Yeotmal.  
4. Village code No. : 2  
5. Population : 1502  
6. Watershed : WRB-1  
7. Beneficial source : Pipe Water Supply well.  
8. Geological formation : Black & fractured rock at the bottom of the well.  
9. Project implemented : Jacket well.  
10. Date of starting : 4.3.1995.  
11. Date of completion : 7.3.1995.  
12. Total expenditure - Rs. 40258  
13. Status of water supply before the project. About 20,000 Lts of water was available per day. Therefore water supplied was only 13 Lt./day/capita

14 Status of water supply after the project. = The project has been successful giving @ 47 Lt./capita/day and about 70,000 ltrs. per day was made available to the village.

#### **4.2.8.6. Nagpur Region.**

1. Village : Durgawada.  
2. Taluka : Asti

3. District : Wardha.
4. Village code No. : 10
5. Population : 1129
6. Watershed : WRJ-1
7. Beneficial source of water : Pipe Water Supply well.
8. Geological formation : Blackish, fractured rock at the bottom of the well.
9. Project implemented : Bore Blast Technique.
10. Date of starting : 4.3.1995.
11. Date of completion : 24.3.1995.
12. Total Expenditure : Rs. 26,031
13. Status of water supply before the project = The well was having inadequate water supply during the summer. i.e. only 4 Lt./capita/day or total 5000 Lt./day water was available. Therefore water was supplied by tankers
14. Status after the completion of the project. : Water was available @ 40 Lt./capita /day and therefore tanker was discontinued. About 45000 Ltrs. was daily available to the village.

#### **4.2.9 Use of Dyke and Lineament of Basalt for Strengthening of water source.**

The problem of the drinking water supply of some of the villages in the state of Maharashtra, was solved by the experienced Geologists of Groundwater Surveys & Development by involving dykes and lineaments available in Basalt (Deccan Trap) for deciding the type of the unconventional measures. For example:

##### **4.2.9.1 Village Sarole Pathar Tal. Sangamner, Dist. Ahmednagar.**

Intrusive type of rocks i.e. dykes (available in igneous rocks – Basalt or Deccan trap) are available in many areas of the state of Maharashtra, specially dykes are more in the Western Maharashtra. If the dyke, available near the village, has the property of water storing, then it is used for storing the recharged water and to increase the groundwater storage. For this purpose in the upper parts of the dyke, village tank should be constructed and rain

water should be stored in it. If the dyke is a carrier of groundwater, then on the dyke, in plain area of the village, cut off wall by cement grouting through the drilled bores is constructed and due to this, available groundwater storage is arrested by cut off wall and prevented from going out as a leakage and the well constructed on the dyke, receives adequate recharge thereby improving water supply capacity of the well. Such type of project has been implemented with the help of the World Bank at village Sarole Pathar Tal. Sangamner, District. Ahmednagar and this village is permanently freed from tanker. (Fig No. 16b)

#### 4.2.9.2 .Village Jambhali,Taluka-Bhor, Dist. Pune.

Since the village was not having adequate water supply through conventional measures, the problem was solved by unconventional measures through Groundwater Surveys & Development Agency (Fig. No. 16 c).

Geological formation – The geological formation is basalt 5 different flows were marked during groundwater survey. The average thickness of each flow is 12 to 15 Mt. This area was studied by aerial photographs and satellite imageries and was found that the surrounding area of the pipe water supply well is suitable for implementing the technique of bore blast and fracture seal cementation.

Bore Blast Technique – In the upper parts of the well, it was noticed that lineament is available in the direction of south-east and north-west. This was confirmed by geophysical survey and with the help of aerial photographs. In the upper side of the well 28 bores of average depth of 9 meters were drilled (The depth of the bore was less than the depth of the well) up to the lineament. The spacing between two bores was 5 Mt. These bores were charged by dynamites and then blasted. Due to blasting, the artificial fractures were created and connected to the well and also to the lineament. This blasting effect also created additional storage of groundwater in the well surrounding areas and the additional water was stored in the well. The recharge process is expected during each monsoon.

Fracture Seal Cementation – This technique was implemented to arrest the stored water in the well. On the down side of the well at a distance of 25 mts. 11 bores of 115 mm dia., 12 Mt. depth were drilled in the nala bed and cement slurry was injected in these holes. By this method all the fractures which were present in the formation were sealed by cement grout and cut-off wall was created to arrest the sub surface run off of groundwater from the down side of the well .

The expenditure incurred on the project –

1) Bore blast technique	- Rs. 53070
2) Fracture seal cementation	- Rs. 23839 .
	-----
	Total Rs. 76909

The expenditure per capita =  $76909/990=77.68$

Evaluation –

Above mentioned works were completed by 15.2.1993. On 17.2.1993 it was noticed that the groundwater level in the well was increased by two meters. The water level on 15.2.1993 before blasting = 5.50 m below the ground level. The water level on 17.2.1993 after blasting = 3.50 M. below the ground level.

Water supply was started from this well by the end of February, due to this the process of recharge was improved and groundwater level was raised to 2.5 m, then the tanker was completely discontinued.

From the above experiments, the conclusion can be drawn that, due to blasting artificial fractures were developed and connected to each other and the water from the lineament was made available to the well through an additional recharge, which has resulted into the increase of water level in the well and due to fracture seal cementation, the sub surface water flow was arrested, thereby stopping the leakage – and increasing water storage capacity of the well. The tanker was completely discontinued thereby saving the expenditure on tanker water for the period of 2-3 months and it will be also seen that the expenditure incurred on the projects was quite negligible.

#### **4.2.9.3 Village Horti, Tal. Tulajapur, Dist. Usmanabad.**

- a) Problem of the village – This village has been identified as an Adarsh village. With an aim to have all facilities available in this village unconventional projects for strengthening of drinking water sources were implemented in the year 1997.

The population of the village is 1400. Drinking water scarcity is felt mainly in April. 7 borewells have been drilled in the village by Groundwater Surveys & Development Agency to solve the drinking water problem. Out of 7 borewells 3 are high yielding. In addition to this there is one water supply well in the village and the water was available up to the end of February only and thereafter the village was fully dependent on the borewell water supply. Some time water was supplied by the tanker.

The daily drinking water requirement of the village is 103 kilo liters. Due to less availability of the groundwater the water supply is inadequate even though the rainfall is sometimes good. Therefore it was decided to solve the drinking water problem of the village by implementing the unconventional measures.

- b) Project Survey - In the first instance, detail groundwater survey was carried out and then with the help of aerial photographs and satellite imageries, study was done to know the nature of fractures in this area . From the studies it was seen that the water supply well is situated in the moderately slopping zone i.e. recharge zone. It was observed that there is a lineament towards the nala which is flowing in the direction of the well and there was no influence of the lineament on the well as it was situated at a distance.



There is one Percolation Tank on the upside of the well, water from the tank is percolated in the lineament and therefore though the big groundwater storage is available in nala, the water supply well did not receive the recharge as the formation between the well and nala is jointed but hard rock. Therefore it was decided to do the blasting so that the existing fractures can be widen and also new fractures can be developed so as to interconnect them and the nala and the well, so that nala water can be recharged into the water supply well.

#### Projects implemented –

In most of the villages, drinking water supply wells are constructed on the nala banks with a view, that the water from the nala can be recharged by way of percolation to the well, but some times due to the absence of the fracture networks between the nala and the well or the fractures are closed and not interconnected then the well does not get recharge from the nala. In such formation, bores are drilled to a depth of the well and then blasted. Due to blasting effect artificial fractures are created and extended, also existing fractures are widen, developed and interconnected to the nala and the well thereby causing percolation of nala water into the well. This process is called as stream blasting. Such type of project has been implemented in this Horti village.

- a) Stream blasting – 25 bores were drilled in the nala bed, the depth of the bores was more but less than the depth of the well near the well and less at the upside of the well, so as to establish hydraulic gradient to carry the water from the nala to the well, by gravity. Drilled bores were charged by the dynamites and then blasted.
- b) Fracture seal cementation – The water which is made available through the process of stream blasting is to be prevented from running out of the well. Therefore to arrest the sub surface flow, the project of fracture seal cementation was implemented . Due to this the water is available in the well till the summer.

Since the groundwater is arrested, it remains in the vicinity of the well and percolates in the well so as to match the withdrawal from the well, maintaining the permanent storage in the well.

In this particular project bores were drilled in nala bed on the down side of the well, at a predetermined distance to the depth of hard rock and cement grouting was done to seal the water carrying fractures and create cut off wall. Due to this groundwater storage is increased. The total expenditure of both the projects was Rs. 92,880 and per capita expenditure was Rs. 41.

#### Changes observed in the well after completion of the project –

1)Artificially created fractures were having width of 10 to 20 cm and orientation was in the direction of the well.

2)After blasting the water in the well became dark due to the entry of soil from the formation along with incoming water.

3)Bubbles appeared in the water of the well due to the gases of blasting process.

4)15cm.rise of water level in the well within 20 minutes.

5)At the time of the work water level in the well, on 28.3.1997 was 7.50 Mt and it was 5.30 Mt on 6.5.1997 . This shows the increase of water level by 2.20 Mt. in the summer. Also it was noticed that, after the first rainfall in June, the increase in the level was by 3 Mt.

From the above unconventional measures, it has been established that it is possible to increase the water level artificially and drinking water problem of such villages can be tackled successfully.

## **5.0. Artificial Groundwater Recharge.**

### **5.1 Borewell flooding.**

#### **5.1.1. Technique of borewell flooding.**

- 12 to 15% recharge is done to the shallow depth water bearing formations by implementing the conventional measures such as Percolation Tanks, Under Ground Bundharas, Cement Nala Dam. etc.
- Out of this recharge very less storage due to geological pattern is percolated to the deeper formations (aquifers).
- Instead of conventional measures, if borewell flooding technique is adopted, then 100% groundwater can be percolated in the deeper aquifers.

#### **5.1.2. Benefits of the technique.**

During the period of monsoon, if the water from the rivers, nalas etc. or the water from the shallow depth dugwells is injected with the help of the pump or siphon into the borewell, it goes to deeper zones and can be stored there in the cavities created due to withdrawal of groundwater. The water to be injected, has to be silt free (Fig. No. 17,18,19)

- It is possible to store the additional water from the shallow aquifer which is going as run-off, for the future provision.
- Evaporation is avoided, therefore 100% water is available for the use.
- Bacterial contamination can be avoided.
- Stored water is useful for managing the drinking water scarcity in the summer.

- Depletion of groundwater level and due to this, the adverse effects on the environment and human life etc. can be avoided.

#### **5.1.3. Essential geological formation for the technique –**

- The borewell proposed to be flooded should be high yielding and should have deeper static water level.
- Borewell should be from the highly fractured zone.
- Borewell should have good capacity for acceptance of water.
- If the borewell is dry due to the over withdrawal of groundwater it is good for the recharge.

#### **5.1.4. Quality of water for the recharge.**

- Clean and free from any contamination..
- Silt free.
- Use of bleaching powder as required.

(As per necessity filter pit or trench gallery may be provided and the bleaching powder should be used in it).

#### **5.1.5. Use of the available water for the technique –**

- For siphon method – 1.50 m to 20 m long pipe as required (Fig No. 17)
- If the well or the filter point is shallow, then excavation of trench with the pipe in it is to be provided (Fig No. 18)
- Direct pumping by the use of the pump (Fig No. 19)

#### **5.1.6. The projects implemented through Groundwater Surveys & Development Agency.**

The details of the projects implemented through Groundwater Surveys & Development Agency are given in the statement No. 6

#### **5.2. Artificial groundwater recharge in the overdeveloped river basin through the non use well(Fig. No. 20)**

- The groundwater level due to excessive withdrawal, in the river basin areas, has gone down to the depth of 35-40 Mt. Therefore the wells which are having depth of 20-25 Mt. have dried up and such wells can be used for groundwater recharge.
- Such types of dried up wells are available in Yawal taluka of Jalgaon District.

- Geological formation of such wells is favorable for groundwater recharge and therefore these wells are suitable for recharge.
- The water required for the recharge is available from the Hatnur canal.
- The water from the Hatnur canal has to be treated. This is essential for maintaining the water storing capacity of the water bearing formation.
- Groundwater Surveys & Development Agency is implementing this project on the large scale through 50 dried up wells. The evaluation of this work is being carried out through the research and development technique under hydrology project.

### **5.3. Artificial groundwater recharge in the rock areas through the well.**

- Village Watwada Tal. Kalamb, Dist. Usmanabad.
- Population – 1850 (As per 1991 census)
- Total 6 borewells, 2 hand pumps and 1 power pump functioning throughout the year, and 3 hand pumps are seasonal.
- 2 simple dug wells, and seasonal pipe water supply.
- Acute drinking water scarcity and water supply through tankers.

#### Technique for Artificial groundwater recharge (GSDA)

- The pipe water supply well is situated at a distance of 10 m from the base nala.
- Filter bed of size 3m x 2m x 2 m is provided between the well and base nala.

Filter bed consists of fine sand, coarse sand, boulders and perforated cement pipes of 200 mm dia and 6 m length.

- The water from the base nala is carried to the filter bed.
- From the filter bed, the water is transported to the well at the rate of 3382 Ltrs per hour.
- About 81 kilo-liters water is recharged daily.
- The water which is percolated through the percolation tank in the base nala and going waste in the form of run off is completely used by proper planning.
- If this process is continued for 5 months then total 12175 kilo Lt. water is made available which is sufficient to manage the water scarcity.
- Due to this project villagers have been supplied with, an additional 40 Ltrs water/capita/day and therefore there is no need of tanker.

#### **5.4. The projects implemented for artificial recharge of groundwater.**

##### **5.4.1. Groundwater recharge in the catchment area of the tank through borewell (National Geophysical & Research Institute – Hyderabad).**

The groundwater recharge is affected to great extent in the area of percolation or simple tank because of the silting problem. In some cases, desilting is very costly, therefore expected benefits from the tank are not gained.

Measure to avoid above situation (Fig. No. 21)

- The borewell is drilled in the catchment area of the tank.
- The rectangular mild steel box having perforations is installed around the perforated casing pipe of the borewell to prepare filter bed.
- Filter bed is prepared by filling stones, boulders etc in the M.S.box.
- Therefore water is filtered before entering into the perforated casing pipe.
- The height of the casing pipe is generally above the water level. The air valve is provided at the top for removing the air.
- Flow meter is used for measuring the groundwater recharge.
- If such projects are implemented on large scale then there is no need of M.S. box and the flow meter. This has been suggested by the said institute (NGRI)

##### **5.4.2. Groundwater recharge experiment in the hard rock area through the borewell (National Geophysical and Research Institute – Hyderabad)**

- Village – Nandora, Taluka – Katol, Dist. Nagpur.
- Yield testing, Electrical logging, Packer test and pumping test etc. of 9 borewells.
- Evaluation of hydrofracturing process of some of the borewells.
- Use of the tracer – Potassium Iodide (K.T.)
- Monitoring of groundwater level electrical conductivity of water and hardness of water etc. during the period of experiment.
- One recharge borewell of 150 mm dia and 30 m depth.
- 7 observation wells of the same depth.
- Groundwater recharge was done through the borewell for 53 days by using treated surface water.

The process of groundwater withdrawal from the main recharge well was continued for 98 days continuously after 70 days from the recharge process.

In this way, recharge of 35 lakh Ltrs of water was done at the rate of 48 LPM. 75% of recharged water was pumped out at the rate of 103 LPM from the same main recharge well.

Conclusion–

- It was observed that the weathered zone of the borewell has 75 to 90% water intake capacity.
- No specific improvement in the groundwater storage by the hydrofracturing process but due to flushing of borewell, improvement in the water storing capacity was observed.
- It was observed that 40% of recharged water was withdrawn.

In this way it is possible to recharge the surplus rain water or surface water which is going as a waste through the borewell and use the same during the period of summer when there is scarcity of water. This has been brought to the notice by the said institute. The institute has also recommended to select large dia borewells and apply more pressure, for the groundwater recharge.

#### **5.4.3. Experiment of groundwater recharge of the water of Minor Irrigation Tank by Siphon Technique and through the dry well.**

- Village – Kandukurumanna, Dist. Anantpur – Andhra Pradesh.
- Saving of water due to evaporation loss and using the same for additional irrigation.
- The water from the tank was continuously transported to the dry well by 2.5 cm dia siphon pipe at the rate of 30 to 40 LPM (Liters per minute) from 16.7.1986 to 21.1.87 . The siphon stopped functioning due to the water level in the tank, which went down in the month of January . Even though during this period about 10,000 cubic meters of water was recharged in the dry well. (Fig. No. 22)

#### **5.5 Trench cum filter borewell ((GSDA).**

- On the upstream side of the source well, ‘V’ type trench is excavated and sand is filled in it.
- The rain water during the monsoon is stored in trench due to the sand.
- This helps in getting withdrawal for a longer period from the wells.
- If cut off wall is constructed on the down side of the well, the sub surface flow is arrested, and the water is made available in the well during summer.

## 5.6 Hydrofracturing.

In rural areas, the villages are supplied drinking water through borewells and large number of villages are tackled by this way. However at some places the borewells are not successful or they are poor yielding, therefore cannot be fitted with hand pump for water supply. The reasons for poor yielding or less yielding are that these borewells receive inadequate recharge of groundwater, fractures and joints are not interconnected to water bodies, clogged or choked up fractures, joints etc.

The poor yielding borewells can be rejuvenated by the technique called as hydraulic fracturing (commonly known as hydrofracturing). Due to hydrofracturing (1) new fractures are created artificially (2) existing clogged/choked up fractures are cleaned and extended (3) closed fractures are opened and interconnected to the surrounding water bodies.

By adopting this technique, the borewell yield is increased substantially and these borewells start supplying water after installation of hand pump.

### 5.6.1 Process of Hydrofracturing

1) Borewell is completely filled with water so as to remove any air in the formation.

2) Hydraulic packers are installed (single or double as the case may be) into borewell at specified depth to create confined conditions. The packer assembly has to be always below the depth of casing pipe and in the hard formation.

3) Water under pressure from the water pump is injected into borewell. Due to this additional injected water, the water pressure in the borewell goes on rising till the new fractures are created or existing fractures are opened. Once the fracture is created or opened, it is further propagated and connected to the net work of water bearing fractures. At least this process should be continued for 15 to 20 minutes.

4) The quality of water to be injected must be good and suitable for drinking. It should be totally free from any type of contamination. The water for hydrofracturing is collected in the truck mounted tanker having capacity of 10,000 lt.

5) Hydrofracturing operations should be carried out in a borewell at different packer setting depths, in case of single packer. Packer setting is always done from top to bottom in 2 or 3 stages.

6) During hydrofracturing process, following things are recorded.

- Maximum or break down pressure in bar. (1 bar = 1 kg/cm approx.)
- Propagation pressure in bar.
- Shut in pressure in bar.
- Total time required.

- Packer setting depths in Mt.
- Quantity of water injected in Lt.
- Type of packer (Single or double)

7) Pre fracturing and post fracturing yield of borewells are recorded and Improvement Ratio (I.R.) is worked out as below.

$$\text{I.R.} = \text{Final yield} / \text{Initial yield.}$$

8) Hydrofracturing operations are carried out under tremendous water pressure and may be hazardous if any thing goes wrong. Therefore this equipment should be handled by well qualified and experienced person. Also readings of various parameters etc. are required to be recorded for preparation of pressure Vs time curves.

### 5.6.2 Rejuvenation of the poor yielding borewells.

Minimum 700 LPH yield is required from the borewell for installation of hand pump. The yield less than this 700 LPH is considered as less or poor yield and hand pump is not installed. By using hydrofracturing technique for these poor yielding borewells, the yield can be substantially improved so that hand pump can be fitted for water supply.

81% of geological formation of the state of Maharashtra is Basalt or Deccan trap. The improvement ratio of pre and post fracturing yield of borewells observed is 1:3.25. This means to get final yield of 700 LPH, initial yield should be  $700/3.25 = 215$  LPH. Therefore for selection of borewells for hydrofracturing, minimum yield should be 200 Lt.

If the village is having number of dry borewells and 1 poor yielding borewell of 200 LPH, then such borewells should not be considered for hydrofracturing because water bodies are absent in this area. Therefore even though hydrofracturing is done, it will not be successful, though sufficient net work of fractures is created by this process, unless these fractures are connected to local water bodies.

Before carrying out hydrofracturing of a particular borewell, its details such as depth, diameter, depth of casing, yield, depth of water struck zones, static water level etc. are studied in detail and borewell verticality is physically checked by dummy tool of 140 mm dia. for 150 mm dia. Borewells, so as to confirm verticality and clear depth of borewell. From this studies packer setting depths are decided.

### 5.6.3 Hydrofracturing work progress in the State of Maharashtra.

Groundwater Surveys & Development Agency, (the State Government Department) has 14 Hydrofracturing units up to 31.3.1999, hydrofracturing of 6752 borewells is completed and 68% i.e. 4659 borewells are successful. Region wise progress is shown in statement No. 7.

### 5.7. Groundwater recharge through the dry well –



- If rainfall is average or more, then the surface water from the tributary rivers is used for the groundwater recharge through the dried up dugwells.
- The water is transported to the dry well through 25 cm. Dia cement pipe.
- After completion of recharge process, the wells are full of water up to ground level.
- The stored water in the well was percolated into the ground within 2 days.
- Addition benefit of 1 acre irrigation and yield in ground nut crop (Fig 23a)

The measure for the areas where tributary rivers are not available nearby.

- The water from the natural pits which are available in the dried up river bed is transported to the cement pit of 2m x 2 m size through the trench (canal).
- By settling process, sediments which are present in the water are settled to the bottom of the cement tank.
- Clean water from the upper side of the tank is transported through pipe line to the nearby dry wells.

Such type of technique is implemented at village Gudsara in the 'Saurashtra' Region. Out of total 277 dugwells, 210 wells were recharged on a large scale thereby helping in increasing the yield of 'groundnut' crops.

- The above mentioned experiments are economically viable and suitable for maintaining ecological balance.
- Boon to the people in scarcity areas of Saurashtra.
- The credit of this experiments goes to Mr. Shamji Antala who is a pioneer of this experiment.

#### **6.0 The "Tanker Free" programme through the measures of water conservation –**

- Due to the irregular rainfall and increasing pollution, the demand for water for the purpose of drinking, irrigation, and the industries is increased.
- The adverse condition of groundwater recharge and the withdrawal has created imbalance, resulting into depleted ground water levels, due to which drinking water and irrigation wells are dried up.
- Consequently the water has to be supplied by the tankers to many villages/wadies etc. in Maharashtra.
- The Government of Maharashtra have decided to implement the "Tanker free" programme and make Maharashtra "Tanker free" by the year 2000 through the measures of water conservation and unconventional measures for strengthening of drinking water sources.

- 10 districts are freed from the tanker by March 1998 and remaining districts are proposed to be tanker free by March 2000.
- As shown in the fig. No. 24 , various conventional and also unconventional measures, on the upside of the source up to 500 Mt. and on the down side up to 200 Mt distance should be implemented by adopting the scientific methods and the technical feasibility of the site proposed for the measures.

## **7.0 Conventional and modified conventional methods for improving the water availability and to solve the drinking water problem**

### **7.1 Recent modifications in the methods of storing the drinking water in the rural areas.**

#### **7.1.1. Roof Top Rainwater Harvesting.**

- Though the rainfall is more, the drinking water scarcity is felt in the summer , due to the adverse, geographical and geological conditions.
  - Modern technique, of Roof top rain water harvesting is implemented to store the rainwater and to solve the drinking water problem of such villages/wadies etc.
  - The channel is provided below the roof at the slopping edge of the roof to collect the water.
  - The channel is gently slopping towards the vertical pipe which is connected to the storage tank kept on the ground. The pipe is made out, from the material such as G.I. sheets, Bamboo wood, or local available material.
1. At the bottom of the pipe or tube 20 gauge wire mesh is fitted so as to avoid the entry of unwanted materials such as dried up leaves of the trees etc.
- The vertical pipe, connected to the tank is temporary removed and kept aside so that the entry of the first rainfall water along with dirt, dust, bird shit etc. into the storage tank is prevented.
  - Storage tank can be constructed on the ground or below the ground. Handpump is provided to lift the water from the underground tank.
  - The water in the storage tank is kept clean and free from the contamination by the frequent application of bleaching powder or the disinfectants.

#### **7.1.1.1. Roof Top Rain Water Harvesting – Success History – (Dist. Chandrapur)**

1. Village : Lendiguda u/v Nagzala.
2. Taluka : Korpana

3. Village code No. : 253
4. Population (1991) : 200
5. Watershed : PG-1
6. Morpho zone : Ab.
7. Geological formation : Basalt.
8. Existing drinking water schemes : 2 simple wells, 1 BBT project.
9. Reasons for tanker deployment: Hilly terrain, source goes dry  
in the summer
10. Measures implemented Roof top structure and deepening  
of the existing well
11. Implementing agency GSDA, ZP, Chadrapur. (Unicef  
assisted)
12. Month of completion. Deepening of well-May 1998  
Roof top structure-June 1998
13. Remarks. : The scheme was successfully implemented with the active participation of the villagers. The village is in hilly terrain having high rainfall but the groundwater formation is not suitable for the recharge.

**7.1.1.2. Roof Top Rainwater Harvesting Project (Taluka- Amalner, Dist. Jalgaon)**

- 1) Name of the project : Roof top rainwater harvesting technique.
2. Project Financial Assistance : UNICEF
3. Purpose of the project =To provide clean and hygienic drinking  
water to the scarcity affected (difficult)  
village by collecting the roof top rain  
water and storing it into the cement  
tanks with the peoples participation (Women).
4. Project implementing authority: Sane Guruji Foundation For Education  
Cultural and Rural Development  
Research, Amalner, Dist. Jalgaon.

5. Villages included : Dangar, Shirud, Chopdai and Kondhwal  
Tal. Amalner, Dist. Jalgaon.
6. Monitoring & Guidance : 1) Chief Executive Officer, District  
Rural Development Agency,  
Zilla Parishad Jalgaon.  
2) Programme Officer, Drought Prone  
Division, Zilla Parishad, Jalgaon.
7. Object of the Project
- a) By participation of women, female masons training to be imparted so as to make them self dependent and create self employment.
  - b) Storing additional water and provide it in the scarcity period.
  - c) Storing water at village habitation.
  - d) To relieve the stress on the local water supply scheme.
  - e) To train women for water supply management, technical & financial matters.
  - f) To develop the skill of the local workers.
  - g) Construction of very less expensive tank (Rs 1/- per hectare)
- 8) Project in brief : To collect the rainfall water from the roof top through the channel provided below the roof, filter it through natural sand filter, construct with the help of women masons, the cement tank based on the Ferro-cement technology and store the water in the tanks and use the same during the scarcity period.
- 9) Capacity of storage tank : 2500 Ltrs, 5000 Ltrs and 10,000 Ltrs.

10) Special help for the project– a) Block Development Officer cum President, Taluka level Co-ordination committee

Panchayat Samiti Amalner.

b) Area Co-ordinator, Tata Social Science Institute, Amalner.

c) Area Technical (Women) Area co-ordination (Women), Sane Guruji Foundation, Amalner.

11) Water management under the project. Daily 5 Lt./capita/day water is required for drinking, 25 Lt. will be required daily for the family of 5 members. For this family the water having 10000 Lt. storing capacity will be sufficient for 400 days.

12) Participating agencies for achieving the goals of the project.

a) UNICEF

b) Govt. of Maharashtra.

c) Zilla Parishad, Jalgaon.

d) Panchayat Samiti Amalner.

e) Gram Panchayats, Dangar, Shirud, Chopdai and Kondhwal, Tal. Amalner, Dist. Jalgaon.

f) Sane Guruji Foundation for Education, Cultural and Rural Development Research, Amalner.

Special efforts are being made to have peoples participation in this project.

### **7.1.2 Khadin method of storing the rain water –**

- Land must have gentle slope.
- The rainfall water in the storage zone of the small nalas (streamlets) is arrested by constructing the soil or masonry dams.
- This water from the dam is transported via pipe line to the well, constructed on the down side of the dam.
- To avoid the loss due to the percolation, the rubber or plastic sheets are spread over the bottom of the tank.
- Such type of Khadin dams are existing in Jaiselmer division in Rajasthan (Fig. No. 26).

### **7.1.3 Hill top collection –**

- Prevailing in the areas such as Konkan, having hilly terrain, high rain fall and scarcity of water.
- The water is stored on the hill top during the monsoon and carried to the village/wadi situated at the foot hill through the pipe line by gravity drainage and distributed further through house to house tap connections.
- This water supply period is restricted to the period of water supplied by tanker.

### **7.1.4 Recharge Trench /Storage Pit for the remote areas having high rainfall, excessive run off, hard rocks and hilly terrain.**

- The technique is developed by Groundwater Surveys & Development Agency.
- The problem of drinking water of Jammamal u/v. Hatti Tal. Surgana, Dist. Nashik having 150 population was permanently solved with the assistance of UNICEF.

#### **Storage Pit/Trench Technique**

- Excavation of the trench considering 20 Ltrs/capita/day, water requirement for 100 days, in the village/wadi having acute drinking water scarcity during the summer.
- Excavated pit is refilled by the river boulders so as to avoid evaporation loss and keep the water in clean and pollution free condition.
- The size of the storage pit is three times of the water requirement of the village, because due to refilling of trench generally 70% area is occupied by the stones, boulders etc. and only 30% area is available for water storage.
- The Handpump is installed to withdraw the water from the storage pit which is situated at a distance of 30 Mt. From the pit, the environment of

the pit is kept clean and the villagers receive assured supply of clean and hygienic drinking water (fig. 27)

- The peoples participation, of course from the beginning to the distribution stage is very much essential.

## **7.2 Rainwater planning in the urban area.**

- The water supplied by Pipe Water Supply Scheme to the cities is very less due to excessive increasing urban population, industrial development and uncontrolled civilization
- Large number of borewells are drilled in the cities, to support the water supply and meet the additional requirement on account of drinking, industrial development etc.
- Large number of buildings and tar roads have restricted the groundwater recharge.
- Due to the imbalance in the groundwater recharge and the withdrawal, the groundwater levels are going down and down.
- The quality of groundwater is also affected by the pollution.
- The solution on above mentioned conditions is to adopt the method of Roof top rain water harvesting to raise the groundwater levels to the safe level and improve the quality of groundwater too. Therefore it has become quite essential to implement this measure.
- This technique has been implemented on the large scale in the cities of– Hyderabad and Chennai in India. The methodology is described below.

### **a) For Independent Bungalows –**

- 1) Excavation of percolation pits of 3 m dia and 3 m depth having 3 m spacing should be done alongside of the plinth. These should be filled in by the small pieces of bricks and 0.15 Mt top portion of the pit should be filled in by the sand. The wall of 0.75 Mt height should be constructed for the groundwater recharge from the percolation pit (Fig. No. 28)
- 2) In addition to this the rain water stored on the terrace of the bungalow should be collected through the drain pipe and stored into the filter of the size 0.60m x 0.60 m x 0.60 m, filled with the small pieces of the bricks and further transported into the well, situated in the bungalow surrounding.

### **b) For the buildings**

- 1) The well of 1.2 m dia and 6 m depth should be constructed on the back side of the building.
- 2) The layer of 3m x 3 m x 1 m size should be given.

3) In addition, a trench of 0.23 m width should be excavated near the compound wall. The depth of trench should be 0.23 m at the beginning, near the entrance gate of the building and it should be 0.45 m near the well. The trench should be connected to the sand layer, around the well. (Fig. No. 29)

c) Groundwater recharge through the defunct borewell –

- 1) Excavation of the pit of size 1 m dia, 0.6 m deep around the borewell.
- 2) The borewell should be filled in by the small pieces of the bricks and the pit around the borewell up to 0.3 m from the bottom. Upper 0.3 m portion of the pit should be filled in, by the sand. The circular pit should be covered by the perforated cement slab. The holes in the slab should be frequently cleaned so as to enter the water into the borewell easily (Fig. No. 30)

d) Water conservation of the rain water through the service well and the recharge well –

- 1) The rain water stored on the terrace of the building should be collected through the drain pipe and diverted to the service well having size of 1.2 m dia and 10 m depth.
- 2) The rain water stored in the open space of the building should be diverted to the recharge well of 0.8 m width, 1 m length and 10 m depth (Fig. No. 31).

e) Collection & recharge of water, flowing on the city roads.

- 1) Instead of allowing the rain water, flowing on the roads, to enter into the drainage line, it should be diverted for recharge to the recharging sites at the places such as public garden, play grounds of the schools or colleges etc.
- 2) The trench of size 0.5 m wide x 1.5 m long x 1.5 m deep and filled with the sand should be used for the recharge. To have, quick distribution of the water, perforated pipe is useful. On the road side, near the open space, if percolation pits of 1 m dia and 2-3 m depth are excavated and further connected to the percolation, then the rain water can be recharged on the large scale.

### **Proposal of “Roof top rain water harvesting” for the office building – “Bhujal-Bhawan” of Groundwater Surveys & Development Agency.**

- The first, proposal for planning the rain water in the Pune city by implementing this modern technique.



- The area of the roof top is 1200 sq.m, average annual rain fall is 672 mm, after deducting evaporation loss and the dirty water at the beginning, total 575 cu.m water is available for artificial recharge and can be used for gardening or other purposes either in summer or during the monsoon when there is no rainfall for the long time.
- As shown in the Fig. No. 32, 33, 34 & 35, the rain water collected on the terrace will be transported to the side by nala and the nala, clean water will be filtered in the filter unit and then measured water will be stored in the storage tank. 500 cu.m of water, after filling the storage tank completely, will be transported through the recharge pipe to the nearby well of hand made paper factory . The factory has a shortage of 2000 cum of water in the summer , out of this shortage at least 500 cum. of water will be available for the use of the factory.
- Such type of experiment will be implemented in Pune city by the Groundwater Surveys & Development Agency. If the peoples awareness is created for this technique and if they start implementing this technique on the large scale then it will help in minimizing the water shortage in the summer. Other than this 75 cu.m of drinking water will be saved.
- If this method is adopted from the technical and economical aspects, the rain water planning will be useful and beneficial

#### **. 8.0 Water Conservation Programme – New Direction –**

More than 70% irrigation is depending on rainfall and 80% population of the state of Maharashtra i.e. rural population (20% urban) is dependant on groundwater at least for 3 months (April to June) in a year. Therefore , considering this background it is essential to increase groundwater storage by arresting rainfall water. Up till now, groundwater development has taken place by the various measures undertaken by Government agencies, private people and institutes etc. Also utilization is increased but there is no much addition by way of recharge to the groundwater reservoirs. Due to irregular and untimely rainfall, the groundwater level goes deep in summer in the particular areas of the state, resulting into drying of irrigation and drinking water wells. Agriculture production reduced and drinking water problem become severe.

Consequently these villages were supplied drinking water by tankers and Government have to incur crores of rupees expenditure every year. It has become very important to implement water conservation programme in the time to come and do the groundwater development from the scientific view. From this point of view it is very important to give new direction and acceleration to water conservation programme. To make this programme successful, it is essential to discuss the following issues.

- a) Salient features of water conservation programme.
- b) Co-ordination of various agencies.
- c) Planning and implementing the programme on priority.

- d) Implementation of groundwater act for the success of tanker free programme through water conservation.
- e) Plan for time bound programme and budget provision.
- f) Implementation of programme.
- g) Particular agency for evaluation and separate budget provision.
- h) People's awareness, participation, motivational camps and training.

### **8.1 Salient features of water conservation programme –**

- 1) Integrated planning should be done for water conservation and proper land use work by considering “mini watershed” as a unit. To decide measures of the programme in the watershed, study of geological formation, morphological analysis, ridge to valley etc. conceptual issues should be done and guidelines to be followed.
- 2) The watersheds where in water conservation works are required to be completed on priority should be selected and works should be completed within 2 years.
- 3) To make existing drinking water supply sustainable.
- 4) To prepare protective irrigation apparatuses so that at least one crop can be obtained in the scarcity condition and to motivate for proper and efficient use of water.
- 5) To have integrated planning and execution by bringing all agencies under one effective monitoring dept.
- 6) To involve voluntary organizations which are related to the implementation of such programme.
- 7) Various types of all the works which are undertaken earlier should be properly adjusted and accounted for in the new programme so as to obtain immediate benefits from such works.
- 8) To emphasis on the rural people, the concept of water planning and water budgeting so as to make them feel self sufficient about water resources.
- 9) Before implementing the programme the watershed map showing distinctly the water conservation measures should be prepared and blue-print copy is put up on Village Panchayat Office and villagers are contacted through the discussions.

### **8.2 . Effective co-ordination of various agencies –**

There is a need to have an effective co-ordination of various agencies which are implementing various water conservation measures under integrated watershed development programme. While implementing the measures in every village, it becomes necessary to see how much additional quantity of recharge can be accumulated or absorbed in the formation by calculating the porosity of the formation and planning the recharge accordingly. If such type of formation is not available then where such type of formation is available recharge project should be implemented there only.

In this regard Groundwater Surveys & Development Agency being a expert technical agency should be contacted for further guidance and technical opinion. For water conservation works, the village is considered as an administrative unit and the mini watershed selected within the area of the villages is treated as a unit of water conservation programme. Such villages are the part of major watershed which is numbered and named by Groundwater Surveys & Development Agency. While preparing plan for water conservation work in the village, entire mini watershed area is plotted on the village map prepared by Groundwater Surveys & Development Agency. This village map shows contour levels.

Watershed assessment is done by Groundwater Surveys & Development Agency every 5 years therefore, how much scope is there for recharge in the future is certainly known, from this planning of the water conservation programme can be done or priority can be given to a particular watershed for implementing the programme. Today, only 10 to 15% area of the watershed is tacked by water conservation works, considering drainage line and other things but planning for the rain fall on the remaining area depends on cultivation and the cropping pattern. Therefore participation of extension division of agriculture department along with water conservation works is equally important. Also, other departments such as M.S.E.B. , Irrigation department to Social Welfare department have to jointly work together and complete the works concerning with them. To have accurate information about flow etc. of the drainage line on which bundharas are proposed for construction, participation, of rain gauging depts. at state level and national level is important.

### **8.3 . Priorities for implementing water conservation programme.**

The selection of villages for the programme, should be done on the following priority norms.

- 1) The villages where scarcity was prevailing continuously for last three years and drinking water was supplied by tankers or bullock carts.
- 2) The villages where in water conservation works in the watershed were taken on 25.5.1992 under crash programme.
- 3) The villages identified by Central Groundwater Board & Groundwater Surveys & Development Agency where in there is less recharge capacity watershed.

- 4) The villages classified by Groundwater Surveys & Development Agency as Dark, Grey or over exploited.
- 5) The villages wherein the works undertaken by Agriculture Department are in progress and more than 50% works have been completed.

The villages falling under command areas of the major and medium projects should not be included in this programme.

#### **8.4. Implementation of Groundwater Act for tanker free programme through water conservation –**

It has been observed that even though the tanker free programme was implemented through water conservation for strengthening of drinking water sources, the capacity of sources have been reduced in the summer in many wadies due to non implementation of Groundwater Act 1993.

As per clause 3 of the 'Maharashtra Groundwater Act' the construction of new well within 500 Mt radius of the public drinking water source can not be done without prior permission. With the provision of clause no. 3,4 & 5 , the restrictions can be imposed on the wells falling within 1 km. Radius, under scarcity conditions or these wells are kept non-functioning during the period of scarcity, also as per clause 6 and 7 – new well cannot be taken in the overdeveloped watersheds. If the provisions of clauses 3,4,5,6,7 are exercised then the drinking water sources can be protected and the success of the water conservation works can be raised. If this act is implemented for overdeveloped watersheds and drinking water sources in the areas of tanker fed villages then many villages can be freed from tanker.

In this matter special attention has to be paid to the villages in the talukas of Katol, Kalameshwar, Savner in Nagpur region, Niphad in Nashik dist. Varud and Morshi in Amrawati dist. Karanja in Wardha dist. Umarga in Latur dist. Yawal, Bhusawal, Chalisgaon and Edalabad in Jalgaon dist. Sangamner, Shrirampur and Kopergaon in Ahmednagar dist. Junnar, Indapur, Purandar and Baramati in Pune dist. Barshi, Madha and Mohol in Solapur dist. Miraj, Jat and Kavate mahankal in Sangli dist. and Chandgad in Kolhapur dist. As per groundwater assessment of 1990 there are 34 over developed water sheds in these talukas.

#### **8.5. Plan for execution of time bound water conservation programme and essential budget provision.**

If the programme of watershed management and development is accelerated and necessary funds are provided it will be possible to achieve the goals in particular time. Big budget provision is required to implement this programme on large scale to solve drinking water problem permanently and to have agriculture development through groundwater development. This

programme is implemented in the state of Maharashtra but in some areas these works are going on for last 10 years. If such works are completed in time bound period then the groundwater recharge rate can be increased up to 25% from 15% provided Government provide the required budget for these works.

#### **8.6. Implementation of water conservation programme.**

The site selection for various measures of water conservation depends on the surface topography of the watershed, type of drainage, weather conditions and the rainfall. The additionally created groundwater storage mainly depends on the geological formation and the rainfall. Storage of rainfall run-off should not be more than 70%. Before implementing the programme groundwater budget (account) has to be prepared based on the mini watershed. If this is accurate then, proper planning can be done for surface and sub-surface run off. For this purpose it is necessary to pay special attention to the following aspects.

- 1) Rainfall gauges – Modern and automatic rainfall gauges should be used and the number may be increased if required.
- 2) River gauges – Modern system for measurement of water should be made available for measuring the surface water in the river situated at the boundary of the watershed.
- 3) Observation wells – The number of observation wells should be increased for accurate assessment of the recharge from the surface water and there should at least one representative observation well for each zone (runoff, recharge and storage). The site and depth of the observation well should be such that it is possible to obtain water levels accurately throughout the year. Care has to be taken to see that this observation well is not influenced by the withdrawals in nearby wells or borewells. If such type of observation well is not available in the watershed area then Groundwater Surveys & Development Agency should be consulted and 150 mm diameter borewell (Piezometer) can be drilled and installed with automatic water level recorder which will record the water levels at predetermined time interval and from this groundwater fluctuations can be studied. Considering the characteristics and properties of basalt rock in Maharashtra, the quantity of piezometers should be more, for assessing groundwater fluctuation levels accurately.
- 4) This programme can be implemented successfully and effectively if the above mentioned technical information is compiled and computerized and exchanged between the various implementing agencies.

Groundwater Surveys & Development Agency should carry out the works of site selection for underground bundharas and unconventional measures for strengthening the drinking water sources and accord technical sanctions to these measures. A joint team consisting of the representatives of all implementing agencies should visit the villages and see the area of

watershed then propose the measures which are technically feasible for soil and water conservation, prepare the project reports, budget estimates, and also accord budget estimates, and also accord technical and administrative sanction within the powers delegated to them. The project proposal should be submitted to the concerned Chief Executive Officer, Zilla Parishad and his administrative sanction should be obtained. Measure wise survey maps and budget estimates should be prepared and given to the concerned agency. Necessary allocation of grants should be demanded and implementation of the programme should be started.

### **8.7 Present stage of evaluation of water conservation programme.**

At present the evaluation of the measures implemented is done by the same agency. The evaluation of the various programmes implemented by some agencies is done through American International Aid Institute or by the Adviser, appointed by the World Bank. The expenditure incurred on various water conservation measures and accrued benefits can not be separated out. Due to implementation of water conservation measures within the watershed boundary, groundwater development takes place. The evaluation of all the measures implemented jointly by all the concerned agencies, in the watershed through a single agency is felt necessary and seems to be feasible.

Selection of Groundwater Surveys & Development Agency for evaluation –

Water conservation is the subject which is mainly related to the groundwater recharge and depends upon the type of water conservation measure and the site, topographical pattern, groundwater condition and rainfall. Also the work of assessment of groundwater is done by Groundwater Surveys & Development Agency since 1974. Watershed wise evaluation of water conservation programme is necessary. This evaluation will be done accurately under the control of research and development division of Groundwater Surveys & Development Agency and proper planning can be done for the use of groundwater resources. If an accurate assessment is done to work out, increase of recharge to groundwater through implementation of various water conservation measures, and the benefits out of that i.e. increase in groundwater storage of the source to permanently solve the drinking water problem, to support Rabi and summer crops, and the increase in the agriculture production etc. can be certainly and accurately studied or based on this, future planning for groundwater development to maintain the balance of groundwater recharge and withdrawal can be done so that it will be possible to stop depletion of groundwater levels due to excessive withdrawal in the watershed.

To have an accurate evaluation of groundwater and watershed wise various measures of water conservation, special attention has to be paid to the following points, and for that allocation of grants is essential.

1) To set up river gauging station at the outlet of run-off of each watershed so that an accurate assessment of run-off going out of the watershed can be done.

2) To set up an automatic and modern rain gauge station in each watershed so that watershed run off based on geographical pattern can be ascertained by using Thiessen's chart.

3) To have accurate assessment in the increase of groundwater levels, it is suggested to increase the number of observation wells. For this purpose the existing wells may not be used as observation wells and the provision should be made to construct independent piezometer through Groundwater Surveys & Development Agency for monitoring the levels by installing automatic water level recorders on the piezometers. The withdrawal from the nearby wells should not influence the water levels in the piezometers.

4) To have an accurate assessment of withdrawal from the watershed, the inventory of the wells, borewells should be prepared and records of pumps, cropping pattern, land use etc. should be maintained and compiled.

The research and development division of the Groundwater Surveys & Development Agency should be strengthened for accurately assessing the above mentioned things. In every district the posts of 1 Senior Geologist, 1 Assistant Geologist and 1 Junior Geologist should be created and evaluation of water conservation works should be entrusted to them, under the control of research and development division of Groundwater Surveys & Development Agency.

For evaluation purpose, additional river gauging equipment, rain gauges, piezometers and other equipment etc. and additional officials and staff is felt necessary. The offices of Groundwater Surveys & Development as per necessity, may be newly established at sub division levels and the information related to observation wells etc. may be forwarded to them for evaluation of water conservation measures. Also 5% of technical staff from every implementing agency may be reserved for this work.

#### **8.8. Peoples Awareness, peoples active participation and motivation camps – Training.**

Villagers should be informed about the project plan, proposed measures, the benefits that will be received, before implementing the project and after implementing the project, village panchayat will be responsible for its maintenance and repairs. If some change or modification in the measure is suggested by the villagers or village panchayat, it should be studied by the concerned agency from the technical aspects and if found suitable, then necessary changes or modifications should be incorporated in the project plan and then finalized.

Considering village as a unit for development and taking the concept of watershed development to the common public and creating public awareness is very essential. In this way the active participation of the people will make this programme, successful. The measures of water conservation programme are implemented to improve our life style, if such faith is developed in the beneficiaries then their participation will certainly increase.

The success of any scheme for whom it is implemented, entirely depends on the participation of the beneficiaries . The works such as, preparing project plan to completion of the project and maintenance repairs of the project after completion, etc. are possible through peoples participation. The participation of the beneficiaries is essential in the programme like comprehensive watershed development, and the programme which is the out come of the efforts of various agencies and their united thinking. For this purpose all the implementing agencies in the public meeting of the villagers (Gram Sabha) should explain the project plan. Changes suggested by the villagers may be incorporated in the plan if found technically feasible and economical. The benefits of the project should be brought to the notice of the people and their participation during implementation and after completion of the project should be ensured.

Water is very important, natural wealth, it can be increased through water conservation programme to increase the agriculture production, and of course public awareness has to be created to utilize this wealth, in a proper and economical way. For implementing the projects, arranging training camps and seminars etc. it is the duty of the Government to provide necessary financial support.

Also for explaining the importance of water conservation, taking benefits of the programme to the people and creating awareness in the people, if training camps are arranged at district, taluka and village level for officials/employees of all the agencies, public representatives, and the villagers, then water conservation programme will be definitely successful and the beneficiaries in the water shed will be socially and financially elevated.



This booklet is the revised edition of “JALSANDHARAN MARGADARSHIKA”(Marathi version).The work of compilation of this edition is done by Shri.S.P.Bagde,Dy.Director,(R&D Cell) GSDA,Pune, Under the guidance of Hon.Shri.V.Ranganathan(IAS),the then Additional Chief Secretary,Water Conservation and Sanitation Dept. Mantralaya,Mumbai and Shri.M.D.Pathak (IAS), the then Director, GSDA, Pune.

“Water Conservation Guide,” is the English version of the above booklet,and the work of translation into English is done by Shri.J.D.Darade,Chief Drilling Engineer(Rtd.)GSDA,Pune,under the guidance of Hon.Shri. Fattesingrao Jadhav, Director, GSDA,M.S. Pune

Pune/September 2001.

## Statement No. 1

### Details of measure wise works done under Soil and Water Conservation..

Sr.No.	Measures	Unit	Up to 1983	1983 to	1992 to	Total
			Individual			
			Method	End of	end of	
				92 under	1999	
				COWDEP	IWDP	
1.	2.	3.	4.	5.	6.	7.
1.	Contour bunding	Thousand	8726	788	196	9660
		Hectare				
2.	Majaji (Paddy pits)	-“-	182	121	165	460
3.	Land and Horticulture Dev.	-“-	27	23	0	60
4.	Waste Land Development	-“-	20	10	10	40
5.	Land leveling	-“-	11	220	0	231
6.	Contour Terracing	-“-	0	11	152	163
7.	Contour grass, brush bunds					
	Slope bunds etc.	-“-	0	0	182	182
8.	Earthen nala bund	No.	32880	40540	72825	146201
9.	Cement nala bund	“	0	2877	25794	28601
10.	Live check bund	“	0	0	180290	180290
11.	Brush wood bund	“	0	0	207016	207016
12.	Loose boulder structure	“	0	0	959787	959787
13.	Earthen structure	“	0	0	212675	212675
14.	Gabian structure	“	0	0	1575	1575
15.	Underground Bandhara	“	0	0	4964	4964
16.	Diversion Bandhara	“	0	0	1847	1847
17.	Farm ponds Bandhara	“	0	0	5611	5611

## Statement No. 2

### Adarsh Village Project

#### Abstract

**No. of Districts tackled – 28, Total Adarsh villages = 252.**

#### The work done by G.S.D.A.

From the beginning to March 1998	Total No. of tackled villages.	Jacket well	Project						
			BBT	FSC	Hydrofracturing	Other projects	Total No. of projects	Grants allotted	Expenditure incurred in Rs. lakh
1	2	3	4	5	6	7	8	9	10-
Villages from the project	92	12	11	27	104	11	165	36.12	36.12
Villages dropped out from the previous list.	19	2	-	7	31	-	40	8.33	8.33
<b>Total</b>	<b>111</b>	<b>14</b>	<b>11</b>	<b>34</b>	<b>135</b>	<b>11</b>	<b>205</b>	<b>44.45</b>	<b>44.45</b>

**Statement No. 3**  
**Information of Unconventional measures implemented upto 1999 under**  
**Adarsh village Programme.**

Sr.No	District	Adarsh Tackled Measures Implemented.								Expenditure incurred in lakhs.
		village s	villages	Other	Jack et well	BBT	FSC	Hydrofra-cturing	Total Projects	
1	2	3	4	5	6	7	8	9	10	11
1	Thane	3	0	0	0	0	0	0	0	0
2	Raigad	10	4	0	1	1	2	4	8	1.77
3	Ratnagiri	4	0	0	0	0	0	0	0	0
4	Sindhudurg	1	1	0	0	0	1	2	3	0.74
	<b>Total</b>	<b>18</b>	<b>5</b>	<b>0</b>	<b>1</b>	<b>1</b>	<b>3</b>	<b>6</b>	<b>11</b>	<b>2.51</b>
5	Nashik	12	8	0	1	0	1	12	14	2.2
6	Dhule	3	1	0	0	0	1	0	1	0.54
7	Jalgaon	14	2	0	0	0	1	2	3	0.69
8	Ahmednagar	16	11	0	1	0	0	24	25	3.54
	<b>Total</b>	<b>45</b>	<b>22</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>3</b>	<b>38</b>	<b>43</b>	<b>6.97</b>
9	Pune	29	11	3	2	0	5	8	18	5.08
10	Solapur	3	0	0	0	0	0	0	0	0
11	Kolhapur	10	3	2	1	3	0	0	6	1.89
12	Sangali	2	1	0	0	0	0	3	3	0.39
13	Satara	12	5	0	1	0	1	6	8	1.38
	<b>Total</b>	<b>56</b>	<b>20</b>	<b>5</b>	<b>4</b>	<b>3</b>	<b>6</b>	<b>17</b>	<b>35</b>	<b>8.64</b>
14	Aurangabad	9	5	0	0	5	1	6	12	3.02
15	Jalna	5	3	2	1	1	3	0	7	2.69
16	Beed	7	2	0	0	1	2	0	3	1.15
17	Parbhani	7	1	0	0	0	0	3	3	0.39
18	Nanded	12	8	0	2	1	3	5	11	3.1
19	Osmanabad	5	2	0	1	0	1	0	2	0.85
20	Latur	14	4	4	0	0	0	0	4	1.6
	<b>Total</b>	<b>59</b>	<b>25</b>	<b>6</b>	<b>4</b>	<b>8</b>	<b>10</b>	<b>14</b>	<b>42</b>	<b>12.8</b>
21	Amravati	17	5	0	1	0	0	9	10	1.46
22	Yeotmal	11	3	0	0	0	1	3	4	0.73
23	Buldana	6	2	0	0	0	0	5	5	0.65
24	Akola	7	2	0	0	0	0	5	5	0.65
	<b>Total</b>	<b>41</b>	<b>12</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>22</b>	<b>24</b>	<b>3.49</b>
25	Nagpur	3	1	0	0	0	0	1	1	0.13
26	Bhandara	12	4	0	0	0	0	6	6	0.78
27	Wardha	0	0	0	0	0	0	0	0	0
28	Chandrapur	17	3	0	0	2	1	0	3	0.8
29	Gadchiroli	1	0	0	0	0	0	0	0	0
	<b>Total</b>	<b>33</b>	<b>8</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>	<b>7</b>	<b>10</b>	<b>1.71</b>
	<b>Grand Total</b>	<b>252</b>	<b>92</b>	<b>11</b>	<b>12</b>	<b>11</b>	<b>27</b>	<b>104</b>	<b>165</b>	<b>36.12</b>

## StatementNo.4

**Information of Unconventional measures under Tanker fed and regular water conservation programme from the beginning – 1990 to March 1999.**

Sr.No	District	Projects Implemented					Total	Village s	Expr. Rs.in lakhs
		FSC	BBT	Jacket Well	Hydrofr a- cturing.	Other			
1	2	3	4	5	6	7	8	9	10
1	Thane	1	20	97	45	28	191	175	48.05
2	Raigad	14	21	7	64	6	112	109	22.61
3	Ratnagiri	9	8	8	49	55	129	125	17.5
4	Sindhudurg	24	0	0	108	14	146	143	25.86
	<b>Total</b>	<b>48</b>	<b>49</b>	<b>102</b>	<b>266</b>	<b>103</b>	<b>578</b>	<b>540</b>	<b>114.02</b>
5	Nashik	57	12	89	311	9	478	363	96.53
6	Dhule	56	0	19	82	1	158	105	47.03
7	Jalgaon	47	13	20	115	1	196	140	47.51
8	Ahmadnagar	25	10	39	81	18	173	137	36.75
	<b>Total</b>	<b>185</b>	<b>35</b>	<b>167</b>	<b>589</b>	<b>29</b>	<b>1005</b>	<b>745</b>	<b>227.82</b>
9	Pune	91	19	58	75	18	261	155	86.11
10	Solapur	12	4	16	136	2	185	133	34.35
11	Kolhapur	38	12	10	13	12	85	60	36.87
12	Sangali	19	6	17	139	2	183	117	36.43
13	Satara	17	14	28	95	1	155	128	58.47
	<b>Total</b>	<b>177</b>	<b>55</b>	<b>129</b>	<b>458</b>	<b>35</b>	<b>863</b>	<b>593</b>	<b>252.21</b>
14	Aurangabad	37	63	6	110	8	234	153	47.06
15	Jalna	58	40	7	115	1	221	157	53.97
16	Beed	60	29	20	112	5	226	183	51.27
17	Parbhani	61	28	22	119	4	234	178	57.01
18	Nanded	45	18	30	235	8	335	287	61.75
19	Osmanabad	68	48	15	75	9	215	188	58.95
20	Latur	59	33	18	90	6	206	131	56.35
	<b>Total</b>	<b>388</b>	<b>259</b>	<b>118</b>	<b>855</b>	<b>41</b>	<b>1671</b>	<b>1277</b>	<b>386.36</b>
21	Amravati	32	15	19	193	11	270	149	40.74
22	Yeotmal	40	3	12	56	11	122	92	19.56
23	Buldana	30	15	30	133	2	210	155	40.22
24	Akola	25	5	31	7	0	121	90	23.48
	<b>Total</b>	<b>127</b>	<b>58</b>	<b>92</b>	<b>442</b>	<b>24</b>	<b>723</b>	<b>486</b>	<b>124</b>
25	Nagpur	29	17	6	172	9	233	212	40.41
26	Bhandara	3	8	3	58	20	92	79	13.03
27	Wardha	27	23	5	131	20	206	136	35.11
28	Chandrapur	8	57	2	76	9	152	127	29.97
29	Gadchiroli	0	0	0	0	0	0	0	0
	<b>Total</b>	<b>67</b>	<b>105</b>	<b>16</b>	<b>437</b>	<b>58</b>	<b>683</b>	<b>554</b>	<b>118.52</b>
	<b>Grand Total</b>	<b>992</b>	<b>541</b>	<b>634</b>	<b>3056</b>	<b>290</b>	<b>5529</b>	<b>4195</b>	<b>1223</b>

### Statement No. 5

Information of the problem solved villages by the unconventional projects implemented from 1990 (beginning) to March 1999.

Sr.No	District	Total No.of tackled villages/ wadies	No. of projects Implemen t- Ted	No.of successfully tackled villages/wadies					
				Fully Villages	Wadies	Partially Village	Wadies	Total Village	Wadies
1	2	3	4	5	6	7	8	9	10
1	Thane	172	188	20	9	30	8	50	17
2	Raigad	108	118	15	4	27	4	42	8
3	Ratnagiri	117	129	1	23	0	55	1	78
4	Sindhudurg	155	158	7	35	5	49	12	84
	<b>Total</b>	<b>552</b>	<b>593</b>	<b>43</b>	<b>71</b>	<b>62</b>	<b>116</b>	<b>105</b>	<b>187</b>
5	Nashik	371	490	40	21	157	37	197	58
6	Dhule	107	160	36	21	55	79	91	100
7	Jalgaon	136	194	65	12	79	22	144	34
8	Ahmednagar	147	202	9	15	82	19	91	34
	<b>Total</b>	<b>761</b>	<b>1046</b>	<b>150</b>	<b>69</b>	<b>373</b>	<b>157</b>	<b>523</b>	<b>226</b>
9	Pune	166	276	48	26	56	36	104	62
10	Solapur	126	177	29	12	34	17	63	22
11	Kolhapur	90	85	16	109	59	24	75	33
12	Sangali	108	170	21	15	16	15	37	30
13	Satara	133	160	17	21	15	9	32	30
	<b>Total</b>	<b>593</b>	<b>868</b>	<b>131</b>	<b>83</b>	<b>180</b>	<b>101</b>	<b>311</b>	<b>184</b>
14	Aurangabad	99	175	66	17	39	82	105	99
15	Jalna	151	217	33	35	36	18	59	53
16	Beed	171	214	19	36	39	38	58	74
17	Parbhani	151	212	59	34	32	18	91	52
18	Nanded	212	257	39	35	12	29	51	64
19	Osmanabad	113	184	38	19	35	18	73	37
20	Latur	189	219	61	29	49	15	110	44
	<b>Total</b>	<b>1086</b>	<b>1478</b>	<b>315</b>	<b>205</b>	<b>242</b>	<b>218</b>	<b>557</b>	<b>423</b>
21	Amravati	145	273	36	0	19	5	55	5
22	Yeotmal	92	125	25	11	29	12	54	23
23	Buldhana	118	151	0	5	0	85	0	90
24	Akola	92	126	29	12	27	15	56	27
	<b>Total</b>	<b>447</b>	<b>675</b>	<b>90</b>	<b>28</b>	<b>75</b>	<b>117</b>	<b>165</b>	<b>145</b>
25	Nagpur	199	220	0	0	90	0	90	0
26	Bhandhara	94	99	63	9	15	10	78	19
27	Wardha	127	197	27	15	38	19	65	34
28	Chandrapur	127	152	18	9	45	25	63	34
29	Gadchiroli	0	0	0	0	0	0	0	0
	<b>Total</b>	<b>547</b>	<b>668</b>	<b>108</b>	<b>33</b>	<b>188</b>	<b>54</b>	<b>296</b>	<b>87</b>
	<b>Grand Total</b>	<b>3986</b>	<b>5328</b>	<b>837</b>	<b>489</b>	<b>1120</b>	<b>763</b>	<b>1957</b>	<b>1252</b>

**Statement No. 6**  
**Brief Report of the Borewell Flooding Projects Implemented by**  
**Groundwater Surveys & Development Agency,**  
**on the experimental basis.**

Sr.No.	Village	Taluka	District	Date of Starting	Source	Daily Qty. of the injected water (Av.) Ltrs/day	Total Quantity injected in the BW Ltrs.	S.W.L. Before Flooding Mtrs.	S.W.L. after flooding Mtrs.	Method of flooding
1	2	3	4	5	6	7	8	9	10	11
1	Pimpalgaon Wakhaji	Narkhed	Nagpur	14.8.93	PWS well	14000	2480000	72	70	Siphon
2	Sawali Bk.	Katol	"	11.9.93	VP well	10000	140000	21	6	"
3	Budhala	Kalameshwar	"	24.9.93	"	256000	12685000	44.6	25	"
4	Kukadi Panjara	"	"	15.9.93	Pvt.well	40000	1895000	-	-	Pump
5	Pimpulkhuta	Ashti	Wardha	17.8.93	VP well	25900	459300	44	39	"
6	Belgaon Shelu	Shelu	"	22.8.93	PWS well	6000	70200	29	8.1	"
7	Gumgaon	Arwi	"	28.8.93	"	80000	3000100	30.8	5	"
8	Borgaon Dhole-1	Karanja	"	9.9.93	River	20000	300000	30	4.5	Siphon
9	" -2	"	"	3.10.93	"	200000	6753000	34	-	Pump
10	Temburkheda-1	Varud	Amravati	22.8.93	VP well	200000	9378200	90	90	"
11	" -2	"	"	6.9.93	Pvt.well	50000	4080000	24	6.3	"
12	Nerpingalai	Morshi	"	6.9.93	PWS "	300000	25000000	49	12	"
13	Borkhedi	Chandur	"	9.8.93	VP well	60000	2694010	17	17	"
14	Karmal 2 BW	A'bad	A'bad	2.10.93	PWS "	24000	4868640	7	7	"
15	Sarsi	Mangrul	Akola	9.10.93	PWS "	200000	3200000	6	3	"
16	Anji-Naik	Ghatangi	Yeotmal	6.9.93	Pvt.well	40000	8000000	38	12	"
17	Yawati	"	"	7.9.93	VP well	12000	384000	20	20	Siphon
18	Bhabhul-Gaon-3BW	Latur	Latur	9.9.93	Pvt.well	40000	3456000	40	19	Pump
19	Alur tanda	Tuljapur	O'bad	3.9.93	PWS "	24000	47000	55	55	"
20	Kej-1	Kej	Beed	3.9.93	PWS "	10000	228000	49.15	41.15	"
21	Mohol	Mohol	Solapur	25.10.93	PWS "	100000	5300000	32	212	"
22	Triputi	Koregaon	Satara	27.11.93	Well	120000	1730000	29	17.2	"
23	Mane Rajuri	Tasgaon	Sangali	13.10.93	PWS "	70000	580000	14	7	"
24	Dhakambe	Dindori	Nashik	20.11.93	Well	120000	9300000	27	7	"
25	Nandan-	Gadhing-	Kolhapur	9.10.96	Well	50000	2140000	47	21	Siphon

	wad-1	laj								
26	" -2	"	"	7.10.96	Well	75000	6102000	46	23	"
27	" -3	"	"	12.9.96	Well	60000	2602000	47	23	"
28	Panchgaon	Kolhapur	Kolhapur	2.9.96	Well	50000	831940	80	13	"
29	Indurguchi	Gadhing- laj	"	11.9.96	Well	60000	2894000	65	25	"
30	Pendkar	Mohol	Solapur	20.11.96	PWS "	39000	156000	-	-	Pump
31	Koktale	Khatav	Satara	10.9.96	Pvt.well	16000	48000	-	-	Siphon
32	Azadpur	Koregaon	Satara	20.11.96	"	129500	1554000	-	-	Pump
33	Landage- wadi	Kavatha- mahakal	Sangali	14.12.96	Canal	-	531000	-	-	Pump
34	" -2	"	"	14.12.96	Canal	-	422000	-	-	Siphon
35	" - 3	"	"	18.12.96	PWS well	-	1560000	-	-	Pump
36	Langhapur	Murtizapur	Akola	25.8.96	Well	18000	540000	-	-	Siphon
37	Belgaon- Dhaga	Nashik	Nashik	15.11.96	Public well	4020	257400	12.1	-	Pump



## Statement No. 7

### Progress of Hydrofracturing from the beginning to March 1999.

#### Hydrofractured borewells/Successful borewells.

Year	Konkan	Nashik	Pune	Aurangabad	Amravati	Nagpur	Total
1988-89	-	3/2	2/2	-	-	-	5/4
1989-90	-	58/41	98/69	-	-	-	156/110
1990-91	-	72/40	125/80	-	-	-	197/120
1991-92	24/9	58/40	89/50	45/21	-	-	216/120
1992-93	23/18	70/38	86/59	101/75	42/30	11/8	333/228
1993-94	101/68	82/53	170/108	99/73	80/46	101/74	633/423
1994-95	16/11	126/95	150/117	669/382	40/24	41/31	1042/660
1995-96	73/40	131/90	163/117	314/176	123/97	135/102	939/622
1996-97	106/52	193/140	169/121	247/179	166/137	123/92	1004/721
1997-98	107/66	216/206	117/86	396/274	162/143	133/98	1131/873
1998-99	89/46	120/91	151/120	547/382	105/75	84/65	1096/779
Total- (Region wise)	539/ 310	1129/ 836	1320/ 999	2418/ 1562	718/ 552	628/ 470	6752/ 4659 Maharash tra State.

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