GROUND WATER RESOURCES ESTIMATION USING GEC-1997 METHODOLOGY

By
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GROUND WATER RESOURCES ESTIMATION USING GEC-1997 METHODOLOGY
GROUND WATER RESOURCES ESTIMATION

USING GEC-1997 METHODOLOGY

- Evaporation
- Transpiration
- Water Stored in Atmosphere
- Precipitation
- Water Stored in Ice & Snow
- Snow melt Runoff
- Surface Runoff
- Infiltration
- Fresh Water Storage
- Ground Water Discharge to Surface Water Bodies
- Infiltration from surface water bodies
GROUND WATER RESOURCES ESTIMATION USING GEC-1997 METHODOLOGY

\[ I = P - R \]
\[ I = P - R - E \]
\[ I = P - R - E - T \]
\[ I = P - R - E - T - ICE \]
\[ I = P - R - E - T - ICE + SNOWR \]
\[ I = P - R - E - T - ICE + SNOWR - FWST \]
\[ I = P - R - E - T - ICE + SNOWR - FWST + GWD \]
\[ I = P - R - E - T - ICE + SNOWR - FWST + GWD + ISW \]

Is This Feasible for a Regional Scale Assessment
GROUND WATER RESOURCES ESTIMATION

USING GEC-1997 METHODOLOGY

\[ I = P - R - E - T - ICE + SNOWR - FWST + GWD + ISW \]

I = Infiltration
P = Precipitation
R = Surface Runoff
E = Evaporation
T = Transpiration
ICE = Water Stored in Ice & Snow
SNOWR = Snow melt Runoff
FWST = Fresh Water Storage
GWD = Ground Water Discharge to Surface Water Bodies
ISW = Infiltration from surface water bodies
GROUND WATER RESOURCES ESTIMATION
USING GEC-1997 METHODOLOGY

\[ I = P - R - E - T - ICE + SNOWR - FWST + GWD + ISW \]

If We Consider Rainfall is the only form of Precipitation

ICE = Water Stored in Ice & Snow **can be ignored**

If We Consider an area not in the region of Himalayan rivers

SNOWR = Snow melt Runoff **can be ignored**
GROUND WATER RESOURCES ESTIMATION
USING GEC-1997 METHODOLOGY

Then the Infiltration Can Be Estimated By

\[ I = P - R - E - T - FWST + GWD + ISW \]
Availability of Data

P - Available one set per Block
R - Not Available even one per an Assessment Unit
E & T – One Set Per District
FWST – Design Storage is available not the actual.
GWD - Except For small Project Areas, not even idea to measure at present
ISW – Indirect Measurement
GROUND WATER RESOURCES ESTIMATION
USING GEC-1997 METHODOLOGY

Reliable Parameters In This Method:

P is reliable.
ISW is reliable provided there is a proper method to compute.
Modeling Approach:
Certainly It gives better result provided
One can develop a fully validated model for each assessment unit.

Is It Feasible (Possible) Today?
In Last 60 years after Independence we have flow models in India not more than 30 or 40.
Whether can they be used for parameter estimation?
Modeling Approach:

We don’t have sufficient data for the lumped parameter model.
How can we manage data hungry discrete parameter modeling?
Approach

Lumped Parameter Model
Basic Equation

Inflow - Outflow = Change in Storage
GROUND WATER RESOURCES ESTIMATION

USING GEC-1997 METHODOLOGY

Inflow Components

- Rainfall Recharge
- Recharge From canals
- Recharge From Surface Water Irrigation
- Recharge From Ground Water irrigation
- Recharge From Tanks & Ponds
- Recharge From Water Conservation Structures
Inflow Components (not included in GEC)

- Lateral Inflow across Boundaries
- Sub surface inflow from hydraulically connected streams
- Vertical inter aquifer inflow
Outflow Components

- Gross Draft
Ground Water Resources Estimation

Using GEC-1997 Methodology

Outflow Components (not included in GEC)

- Lateral Outflow across Boundaries
- Sub surface Outflow from hydraulically connected streams
- Vertical inter aquifer Outflow
- Evapotranspiration
The parameters not included in GEC are mainly very difficult to compute in the assessment at regional scale.

Lateral flows are zero when hydrological boundary is selected.

In other components it is assumed inflow=outflow.

For Base flow and Evapo-transpiration provision for 5 –10 % as unaccounted discharges is made.
<table>
<thead>
<tr>
<th>Type of Rock Areas</th>
<th>Type of Boundaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard Rock Areas</td>
<td>Hydrological Boundaries</td>
</tr>
<tr>
<td>Soft Rock Areas</td>
<td>Administrative Boundaries</td>
</tr>
</tbody>
</table>
# Ground Water Assessment Sub-Units

<table>
<thead>
<tr>
<th>Area</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hilly Areas</td>
<td>Recharge is Not Possible</td>
</tr>
<tr>
<td>Ground Water Worthy Areas</td>
<td>Recharge is Possible</td>
</tr>
<tr>
<td>Poor Ground Water Quality Areas</td>
<td>Quality is Beyond Permissible Limits</td>
</tr>
<tr>
<td>Good Ground Water Quality Areas</td>
<td>Quality is Within Permissible Limits</td>
</tr>
<tr>
<td>Command Areas</td>
<td>Command of any Major or Medium Irrigation Project</td>
</tr>
<tr>
<td>Non-Command Areas</td>
<td>Not in the Command of any Major or Medium Irrigation Project</td>
</tr>
</tbody>
</table>
ESSENTIAL DATA ELEMENTS
- AREA OF ASSESSMENT UNIT
- HILLY AREA
- COMMAND AREA
- POOR GROUND WATER QUALITY AREA

OPTIONAL DATA ELEMENTS
- STARTING AND ENDING LATITUDES & LONGITUDES
## Ground Water Year

<table>
<thead>
<tr>
<th>Predominant Monsoon</th>
<th>South-West Monsoon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>North-East Monsoon</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ground Water Year</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Predominant Monsoon</td>
<td>June To May</td>
</tr>
<tr>
<td></td>
<td>July To June</td>
</tr>
<tr>
<td></td>
<td>October To September</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monsoon Period</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Predominant Monsoon</td>
<td>June To September</td>
</tr>
<tr>
<td></td>
<td>July To October</td>
</tr>
<tr>
<td></td>
<td>October To December</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Non-Monsoon Period</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Predominant Monsoon</td>
<td>October To May</td>
</tr>
<tr>
<td></td>
<td>November To June</td>
</tr>
<tr>
<td></td>
<td>January To September</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pre-Monsoon Monitoring</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Predominant Monsoon</td>
<td>May/June/September</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Post-Monsoon Monitoring</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Predominant Monsoon</td>
<td>October/November/January</td>
</tr>
</tbody>
</table>
GROUND WATER RESOURCES ESTIMATION USING GEC-1997 METHODOLOGY

THE MAIN COMPONENTS ARE

- COMPUTATION OF GROUND WATER DRAFT
- COMPUTATION OF RECHARGE DUE TO OTHER SOURCES
- COMPUTATION OF RAINFALL RECHARGE
- COMPUTATION OF SUMMARY DETAILS
GROUND WATER RESOURCES ESTIMATION

USING GEC-1997 METHODOLOGY

COMPUTATION OF RECHARGE DUE TO OTHER SOURCES

- Recharge Due To Canals
- Recharge Due To Surface Water Irrigation
- Recharge Due To Ground Water Irrigation
- Recharge Due To Tanks & Ponds
- Recharge Due To Water Conservation Structures
GROUND WATER RESOURCES ESTIMATION USING GEC-1997 METHODOLOGY

COMPUTATION OF SUMMARY DETAILS

- Net Annual Ground Water Availability
- Current Stage Of Ground Water Development
- Water Level Trend
- Categorization For Future Ground Water Development
- Ground Water Allocation For Domestic & Industrial Water Supply
- Net Annual Ground Water Availability For Future Irrigation Needs.
- Additional Potential Recharges.
- Static Ground Water Resources.
Draft Can Be Of Three Types

- Domestic draft
- Irrigation draft
- Industrial draft
DOMESTIC DRAFT

WELL CENSUS METHOD
No. of different types of abstraction structures
Unit Draft

REQUIREMENT METHOD
Population Census
Percapita Requirement
Estimation Of Ground Water Draft

IRRIGATION DRAFT
WELL CENSUS METHOD
No. of different types of abstraction structures
Unit Draft

CROPPING PATTERN METHOD
Cropping Pattern
Crop Water Requirement

POWER CONSUMPTION METHOD
Total power consumed
Unit Power Required For Unit Water Lift
Estimation Of Ground Water Draft

INDUSTRIAL DRAFT

WELL CENSUS METHOD
No. of different types of abstraction structures
Unit Draft

POWER CONSUMPTION METHOD
Total power consumed
Unit Power Required For Unit Water Lift
Estimation Of Ground Water Draft

\[ GGWDft = \sum_{i=1}^{\text{types}} \text{No} \times \text{Unit Draft} \]

Where

- **GGWDft** = Gross Ground Water Draft in any season
- **No.** = Number of Abstraction Structures actually in Use.
- **Unit Draft** = Draft For one abstraction structure during the season.
- **Types** = No of Types of Different Structures.
- **Unit Draft** = Draft per day * No of days the structures are in use
Estimation Of Ground Water Draft

Dug wells with Manual Lift : 866
Daily draft during non monsoon = 6m³/day
No of days 100

Dug wells with Electric Pumpset : 49
Daily draft during non monsoon = 30m³/day
No of days 90

What is the Unit Draft During non-monsoon
Gross Ground Water Draft
Estimation Of Ground Water Draft

Dug wells with Manual Lift : 866
Unit draft during non monsoon = 6 *100m3 =600m3
Draft From Dugwells with Manual Lift =866 *600 =
519600 m3 =51.96ham

Dug wells with Electric Pumpset : 49
Unit draft during non monsoon = 30 * 90 m3 =2700
m3
Draft From Dugwells with Pumpset =2700 *49 =
132300 m3 =13.23ham

Gross Ground Water Draft For Irrigation = 51.96 +
13.23 =65.19ham
ESSENTIAL DATA ELEMENTS

- Estimated draft per day per structure during monsoon & non-monsoon
- Estimated no of such days the structure is in operation during monsoon & non-monsoon
- No. of different structures for different types of drafts

OPTIONAL DATA ELEMENTS

- NIL
Estimation Of Recharge Due To Other Sources

COMMAND AREAS

- Seepage from canals
- Return flow from surface water irrigation
- Return flow from ground water irrigation
- Recharge due to tanks/ponds
- Recharge due to water conservation structures
Estimation Of Recharge Due To Other Sources

NON-COMMAND AREAS

- RETURN FLOW FROM GROUND WATER IRRIGATION
- RECHARGE DUE TO TANKS/PONDS
- RECHARGE DUE TO WATER CONSERVATION STRUCTURES
Estimation Of Recharge Due To Canals

\[ Rc = WA \times \text{Days} \times \text{SF} \]

Where

- \( Rc \) = The recharge due to canal segment in ham
- \( WA \) = Wetted Area in Million Sq.m
- \( SF \) = Seepage Factor in ham/Million Sq.m/day
Estimation Of Recharge Due To Canals
Estimation Of Recharge Due To Canals
Estimation Of Recharge Due To Canals

\[ \sin(\theta) = \frac{FSD}{\text{Wetted Side}} \]

\[ \text{Wetted Side} = \frac{FSD}{\sin(\theta)} \]
Estimation Of Recharge Due To Canals
Estimation Of Recharge Due To Canals

\[ \text{Wetted Side} = \frac{ASD}{\sin(\theta)} \]

\( ASD = \text{Average Supply Depth} \)

(Or 0.6*FSD)

\( \theta = \text{Side Angle} \)
Estimation Of Recharge Due To Canals

Where

WP=Wetted perimeter in m
ASD = Average Supply Depth in m
SideAngle = Side slope of the canal in Degrees
BW = Bed width of the canal in m.
Estimation Of Recharge Due To Canals

\[ WA = WP \times L \]

Where

- \( WA \) = Wetted Area in Million Sq.m
- \( WP \) = Wetted perimeter
- \( L \) = Length of Canal Segment in Kms.

\[ Rc = WA \times \text{Days} \times SF \]

Where

- \( Rc \) = The recharge due to canal segment in ham
- \( WA \) = Wetted Area in Million Sq.m
- \( SF \) = Seepage Factor in ham/Million Sq.m/day
Estimation Of Recharge Due To Canals

### NORMS FOR CANAL SEEPAGE

<table>
<thead>
<tr>
<th>Unlined canals in normal soils with some clay content along with sand</th>
<th>1.8 to 2.5 cumeecs per millison sq m of wetted area (or) 15 to 20 ham/day/million sq m of wetted area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unlined canals in sandy soil with some silt content</td>
<td>3.0 to 3.5 cumeecs per million sq m of wetted area (or) 25 to 30 ham/day/million sq m of wetted area</td>
</tr>
<tr>
<td>Lined canals and canals in hard rock area</td>
<td>20% of above values for unlined canals</td>
</tr>
</tbody>
</table>
NORMS FOR CANAL SEEPAGE

- The above values are valid if the water table is relatively deep. In shallow water table and waterlogged areas, the recharge from canal seepage may be suitably reduced.

- Where specific results are available from case studies, the adhoc norms are to be replaced by norms evolved from these studies.
Canal reach Name – Nandgaon Minor
Reach Type – Unlined
Lithology – Hard Rock
Length – 2660m
Full Supply Depth – 5m
Bed Width – 3m
Slope – 45°
Monsoon Running Days – 30
Non-monsoon Running Days -90
Canal Seepage Factor – 3 ham/day/million sq.m during both monsoon & non-monsoon

What is the Recharge Due to The Canal reach?
Estimation Of Recharge Due To Canals

$WA = 11.56 \times 2660 = 30749.6 \text{ sq.m} = 0.3075 \text{ m sq.m}$

$Rc \text{ during monsoon} = 0.3075 \times 30 \times 3 = 27.675 \text{ ham}$

$Rc \text{ during non - monsoon} = 0.3075 \times 90 \times 3 = 83.025 \text{ ham}$
Recharge Due To Canals

ESSENTIAL DATA ELEMENTS

- NAME OF THE CANAL, TYPE AND LENGTH
- NAME OF THE SEGMENT, LENGTH, DESIGN DEPTH, BASE WIDTH, SIDE SLOPE, LINING, TERRAIN, No. OF RUNNING DAYS DURING MONSOON & NON-MONSOON SEASONS.

OPTIONAL DATA ELEMENTS

- STARTING AND ENDING LATITUDES & LONGITUDES
Estimation Of Recharge
Due To Surface Water Irrigation

\[ R_{swi} = IWA \times RFF \]

Where

\( R_{swi} = \) Recharge due to Surface water irrigation in ham
\( IWA = \) Irrigation water applied in ham
\( RFF = \) Return Flow Factor as a fraction

\[ IWA = AD \times \text{days} \]

Where

\( IWA = \) Irrigation water applied in ham
\( AD = \) Average Discharge of the outlet in ham/day
\( \text{Days} = \) No of days the outlet is open.
Estimation Of Recharge
Due To Surface Water Irrigation

**NORMS FOR SURFACE WATER IRRIGATION RETURN FLOW**

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Water Level mbgl</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;10m</td>
</tr>
<tr>
<td>Paddy</td>
<td>50%</td>
</tr>
<tr>
<td>Non-Paddy</td>
<td>30%</td>
</tr>
</tbody>
</table>
Estimation Of Recharge
Due To Surface Water Irrigation

NORMS FOR SURFACE WATER
IRRIGATION RETURN FLOW

1. The recharge is to be estimated based on water released at the outlet.

2. Where continuous supply is used instead of rotational supply, an additional recharge of 5% of application may be used.

3. Where specific results are available from case studies, the adhoc norms are to be replaced by norms evolved from these studies.
Estimation Of Recharge
Due To Surface Water Irrigation

Outlet Name – Nandgaon Minor
OL-1
Canal Reach Name – Nandagaon Minor
Design Discharge – 1.646 ham/day
Monsoon Running Days – 30
Non-monsoon Running Days – 90

Crop Type – Paddy
Area irrigated During Monsoon – 3000 ha
Area irrigated During Non-Monsoon – 3000 ha

Crop Type – Non-Paddy
Area irrigated During Monsoon – 6000 ha
Area irrigated During Non-Monsoon – 6000 ha

RFF for paddy during Monsoon - 0.5
RFF for Non- Paddy during Monsoon – 0.3
RFF for paddy during Non- Monsoon - 0.5
RFF for Non- Paddy during Non-Monsoon – 0.3
Estimation Of Recharge
Due To Surface Water Irrigation

IWA During Monsoon = 1.646* 0.6 * 30 = 29.628ham
IWA During Non-Monsoon = 1.646* 0.6 * 90 = 88.884ham

\[
\text{Weighted Average RFF} = \frac{\text{Paddy Area} \times \text{Paddy RFF} + \text{Non-Paddy Area} \times \text{Non-Paddy RFF}}{\text{Paddy Area} + \text{Non-Paddy Area}}
\]

\[
\text{Weighted Average RFF} = \frac{3000 \times 0.5 + 6000 \times 0.3}{3000 + 6000} = \frac{1500 + 1800}{9000} = \frac{3300}{9000} = 0.3667
\]

Rswi During Monsoon = 29.628 * 0.3667 = 10.86 ham
Rswi During Non-Monsoon = 88.884 * 0.3667 = 32.59 ham
Estimation of Recharge due to Ground Water Irrigation

\[ R_{gwi} = IWA \times RFF \]

Where

- \( R_{gwi} \) = Recharge due to Ground water irrigation in ham
- \( IWA \) = Irrigation water applied i.e. Gross ground Water Draft in ham
- \( RFF \) = Return Flow Factor as a fraction
### NORMS FOR GROUND WATER IRRIGATION RETURN FLOW

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Water Level mbgl</th>
<th>&lt;10m</th>
<th>10m-25m</th>
<th>&gt;25m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy</td>
<td></td>
<td>45%</td>
<td>35%</td>
<td>20%</td>
</tr>
<tr>
<td>Non-Paddy</td>
<td></td>
<td>25%</td>
<td>15%</td>
<td>05%</td>
</tr>
</tbody>
</table>
NORMS FOR GROUND WATER IRRIGATION RETURN FLOW

1. The recharge is to be estimated based on Gross Ground Water Draft.

2. Where continuous supply is used instead of rotational supply, an additional recharge of 5% of application may be used.

3. Where specific results are available from case studies, the adhoc norms are to be replaced by norms evolved from these studies.
Estimation Of Recharge Due To Ground Water Irrigation

Crop Type – Paddy
Area irrigated During Monsoon – 3000 ha
Area irrigated During Non-Monsoon – 3000 ha

Crop Type – Non-Paddy
Area irrigated During Monsoon – 6000 ha
Area irrigated During Non-Monsoon – 6000 ha

RFF for paddy during Monsoon - 0.45
RFF for Non- Paddy during Monsoon – 0.25
RFF for paddy during Non- Monsoon - 0.45
RFF for Non-Paddy during Non-Monsoon – 0.25
Estimation Of Recharge Due To Ground Water Irrigation

Gross Ground Water Draft For Irrigation During Non-Monsoon = 65.19 ham

\[
\text{Weighted Average RFF} = \frac{\text{Paddy Area} \times \text{Paddy RFF} + \text{Non-Paddy Area} \times \text{Non-Paddy RFF}}{\text{Paddy Area} + \text{Non-Paddy Area}}
\]

\[
\text{Weighted Average RFF} = \frac{3000 \times 0.45 + 6000 \times 0.25}{3000 + 6000} = \frac{1350 + 1500}{9000} = \frac{2850}{9000} = 0.2778
\]

\[
\text{Rgwi During Non-Monsoon} = 65.19 \times 0.2778 = 18.11 \text{ ham}
\]
Estimation Of Recharge Due To Tanks & Ponds

RT = AWSA * Days * RFact

Where
RT = Recharge from tanks & Ponds
AWSA = Average Water Spread Area.
(Or 60% of Design Water Spread Area.)
Days = No. of water is actually available in the Tanks & Ponds.
RFact = A recharge Factor in mm/day
Estimation Of Recharge Due To Tanks & Ponds

NORM FOR TANK & POND SEEPAGE

1.4 mm / day
Estimation Of Recharge Due To Tanks & Ponds

Tank Name – Yesamba
Design Water Spread Area – 35ha
Monsoon Running Days – 120
Non-monsoon Running Days – 120
RT During Monsoon = 35 * 0.6 * 120 * 0.0014 = 3.528 ham
RT During Non-Monsoon = 35 * 0.6 * 120 * 0.0014 = 3.528 ham
Estimation Of Recharge Due To Water Conservation Structures

\[ RWCS = GS \times RFact \]

Where

- \( RWCS \): Recharge due to Water Conservation Structures
- \( GS \): Gross Storage
- \( RFact \): Recharge Factor as a Fraction

\[ GS = \text{Storage Capacity} \times \text{No. Of Fillings} \]
Estimation Of Recharge Due To Water Conservation Structures

NORM FOR SEEPAGE FROM WATER CONSERVATION STRUCTURES

50% of Gross Storage during a year means
25% during Monsoon Season
25% During Non-Monsoon Season
Estimation Of Recharge Due To Water Conservation Structures

WCS Name – Nandgaon
Type – Percolation tank
Storage Capacity – 3.2ham
No. of Fillings – 1.5
Estimation Of Recharge Due To Water Conservation Structures

RWCS During Monsoon = 3.2 * 1.5 * 0.25 = 1.20 ham

RWCS During Non-Monsoon = 3.2 * 1.5 * 0.25 = 1.20 ham
1. Rainfall infiltration factor method
2. Water level fluctuation method
Estimation Of Recharge Due To Rainfall

Rainfall Infiltration Factor Method

\[ \text{RRF} = \text{Area} \times \text{NMR} \times \text{RFIF} \]

Where

- \( \text{RRF} \) = Recharge due to rainfall
- \( \text{Area} \) = Total area of the subunit
- \( \text{NMR} \) = Normal Monsoon Rainfall
- \( \text{RFIF} \) = Rainfall infiltration Factor
### Estimation Of Recharge Due To Rainfall

#### Rainfall Infiltration Factor Method

#### NORMS FOR RIF

<table>
<thead>
<tr>
<th>S.No</th>
<th>Geographic Location</th>
<th>Recommended</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Indo-Gangetic &amp; Other Inland</td>
<td>22%</td>
<td>20%</td>
<td>25%</td>
</tr>
<tr>
<td>2</td>
<td>East Coast</td>
<td>16%</td>
<td>14%</td>
<td>18%</td>
</tr>
<tr>
<td>3</td>
<td>West Coast</td>
<td>10%</td>
<td>8%</td>
<td>12%</td>
</tr>
</tbody>
</table>
Estimation Of Recharge Due To Rainfall
Rainfall Infiltration Factor Method

**NORMS FOR RIF**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Rock Formation</th>
<th>Recommended</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Weathered Granite. Gneiss and Schist with low clay content</td>
<td>11%</td>
<td>10%</td>
<td>12%</td>
</tr>
<tr>
<td>2</td>
<td>Weathered Granite. Gneiss and Schist with significant clay content</td>
<td>8%</td>
<td>5%</td>
<td>9%</td>
</tr>
<tr>
<td>3</td>
<td>Rocks belong to Granulite Facies like Chornockite</td>
<td>5%</td>
<td>4%</td>
<td>6%</td>
</tr>
<tr>
<td>4</td>
<td>Vesicular and Jointed Basalt</td>
<td>13%</td>
<td>12%</td>
<td>14%</td>
</tr>
<tr>
<td>5</td>
<td>Weathered basalt</td>
<td>7%</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>6</td>
<td>Laterite</td>
<td>7%</td>
<td>6%</td>
<td>8%</td>
</tr>
</tbody>
</table>
## NORMS FOR RIF

<table>
<thead>
<tr>
<th>S.No</th>
<th>Rock Formation</th>
<th>Recommended</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Semi-Consolidated Sandstone</td>
<td>12%</td>
<td>10%</td>
<td>14%</td>
</tr>
<tr>
<td>8</td>
<td>Consolidated Sandstone, Quartzite, Limestone (except cavernous Limestone)</td>
<td>6%</td>
<td>5%</td>
<td>7%</td>
</tr>
<tr>
<td>9</td>
<td>Phyllites &amp; Shales</td>
<td>4%</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>10</td>
<td>Massive Poorly Fractured Rock</td>
<td>1%</td>
<td>1%</td>
<td>3%</td>
</tr>
</tbody>
</table>
NORMS FOR RIF

- Usually, the recommended values should be used for assessment, unless sufficient information is available to justify the use of minimum, maximum or other intermediate values.

- An additional 2% of rainfall recharge factor may be used in such areas or part of the areas where watershed development with associated soil conservation measures are implemented.
Estimation Of Recharge Due To Rainfall

Rainfall Infiltration Factor Method

- Area 27565 ha
- Rainfall infiltration factor = 0.07
- Normal Monsoon Rainfall = 750mm
Estimation Of Recharge Due To Rainfall
Rainfall Infiltration Factor Method

- Area 27565 ha
- Rainfall infiltration factor = 0.07
- Normal Monsoon Rainfall = 750mm

\[ RRF = 27565 \times 0.750 \times 0.07 = 1447.16 \text{ ham} \]
Estimation Of Recharge Due To Rainfall

Water Table Fluctuation Method

\[ \Delta S = h \times SY \times A \]

Where

\( \Delta S \) = Change in storage

\( h \) = Rise in water level in the monsoon season

\( SY \) = Specified yield

\( A \) = Area of sub unit
## Estimation Of Recharge Due To Rainfall

**Water Table Fluctuation Method**

### NORMS FOR Sy

<table>
<thead>
<tr>
<th>S.No</th>
<th>Formation</th>
<th>Recommended</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sandy Alluvium</td>
<td>16%</td>
<td>12%</td>
<td>20%</td>
</tr>
<tr>
<td>2</td>
<td>Silty Alluvium</td>
<td>10%</td>
<td>8%</td>
<td>12%</td>
</tr>
<tr>
<td>3</td>
<td>Clayey Alluvium</td>
<td>6%</td>
<td>4%</td>
<td>8%</td>
</tr>
</tbody>
</table>
Estimation Of Recharge Due To Rainfall
Water Table Fluctuation Method

NORMS FOR Sy

<table>
<thead>
<tr>
<th>S.No</th>
<th>Rock Formation</th>
<th>Recommended</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Weathered Granite. Gneiss and Schist with low clay content</td>
<td>3%</td>
<td>2%</td>
<td>4%</td>
</tr>
<tr>
<td>2</td>
<td>Weathered Granite. Gneiss and Schist with significant clay content</td>
<td>1.5%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>3</td>
<td>Weathered or Vesicular or Jointed Basalt</td>
<td>2%</td>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>4</td>
<td>Laterite</td>
<td>2.5%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>5</td>
<td>Sandstone</td>
<td>3%</td>
<td>1%</td>
<td>5%</td>
</tr>
<tr>
<td>6</td>
<td>Quartzite</td>
<td>1.5%</td>
<td>1%</td>
<td>2%</td>
</tr>
</tbody>
</table>
## Estimation Of Recharge Due To Rainfall

### Water Table Fluctuation Method

## NORMS FOR $Sy$

<table>
<thead>
<tr>
<th>S.No</th>
<th>Rock Formation</th>
<th>Recommended</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Limestone</td>
<td>2%</td>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>8</td>
<td>Karstified Limestone</td>
<td>8%</td>
<td>5%</td>
<td>13%</td>
</tr>
<tr>
<td>9</td>
<td>Phyllites &amp; Shales</td>
<td>1.5%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>10</td>
<td>Massive Poorly Fractured Rock</td>
<td>0.3%</td>
<td>0.2%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>
NORMS FOR Sy

Usually, the recommended values should be used for assessment, unless sufficient information is available to justify the use of minimum, maximum or other intermediate values.
Estimation Of Recharge Due To Rainfall

Water Table Fluctuation Method

Area 27565 ha
Specific yield – 0.02
Pre-Monsoon WL = 9.00
Post-Monsoon WL = 4.00
Estimation Of Recharge Due To Rainfall

Water Table Fluctuation Method

Area 27565 ha
Specific yield – 0.02
Pre-Monsoon WL = 9.00
Post-Monsoon WL = 4.00

\[ \Delta S = (9.00 - 4.00) \times 0.02 \times 27565 = 2756.5 \text{ham} \]
Determination of Sy Using Dry Season Ground Water Balance Method
Specific Yield Estimation Using Dry Season Ground Water Balance Method

\[ S_y \times h \times A = D_G - R_{gw} + B \]

Where

- \( h \) = decline in water level during dry season
- \( S_Y \) = Specific yield
- \( A \) = Area of the micro watershed
- \( R_{gw} \) = Recharge due to Ground Water Irrigation
- \( D_G \) = Gross Ground Water Draft
- \( B \) = Base flow in any
Specific Yield Estimation Using Dry Season Ground Water Balance Method

\[ S_y = \frac{D_G - R_{gw} + B}{hxA} \]
Estimation Of Recharge Due To Rainfall
Water Table Fluctuation Method

\[ \Delta S = h \cdot SY \cdot A = RF + RC + RSW + RGW + RT + RWCS - DG \]

Where

- \( \Delta S \) = Change in storage
- \( h \) = Rise in water level during monsoon season
- \( SY \) = Specific yield in the zone of fluctuation
- \( A \) = Area of the sub unit
- \( RRF \) = Recharge due to Rainfall
- \( RC \) = Recharge due to Canals
- \( RSW \) = Recharge due to Surface Water Irrigation
- \( RGW \) = Recharge due to Ground Water Irrigation
- \( RT \) = Recharge due to Tanks & Ponds
- \( RWCS \) = Recharge due to Water Conservation Structures
- \( DG \) = Gross Ground Water Draft
Estimation Of Recharge Due To Rainfall
Water Table Fluctuation Method

Hence

\[ RRF = \Delta S - RC - RSW - RGW - RT - RWCS + DG \]

Or

\[ RRF = (h \times SY \times A) + DG - RC - RSW - RGW - RT - RWCS \]
Normalization of Recharge Due To Rainfall During Monsoon Season

Two Methods Can Be Employed

- As proposed by the GEC-1984 i.e. $y=mx$
- Using $y=mx+c$ equation
Normalization of Recharge Due To Rainfall During Monsoon Season

\[ Y = mX \]

\[ y = mx \]

\[ \text{Rech} = mRf \]

\[ m = \frac{\text{Rech}}{Rf} \]
Normalization of Recharge Due To Rainfall During Monsoon Season

\[ Y = mX \]

<table>
<thead>
<tr>
<th>Rainfall</th>
<th>Recharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>1434.80</td>
<td>1329.78</td>
</tr>
<tr>
<td>936.10</td>
<td>956.50</td>
</tr>
<tr>
<td>767.00</td>
<td>833.29</td>
</tr>
<tr>
<td>1164.00</td>
<td>1204.44</td>
</tr>
<tr>
<td>1016.18</td>
<td>1060.40</td>
</tr>
</tbody>
</table>
Normalization of Recharge Due To Rainfall During Monsoon Season

\[ Y = mX \]

<table>
<thead>
<tr>
<th>Rainfall</th>
<th>Recharge</th>
<th>Recharge/Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>y</td>
<td>m = y/x</td>
</tr>
<tr>
<td>1434.80</td>
<td>1329.78</td>
<td>0.927</td>
</tr>
<tr>
<td>936.10</td>
<td>956.50</td>
<td>1.022</td>
</tr>
<tr>
<td>767.00</td>
<td>833.29</td>
<td>1.086</td>
</tr>
<tr>
<td>1164.00</td>
<td>1204.44</td>
<td>1.035</td>
</tr>
<tr>
<td>1016.18</td>
<td>1060.40</td>
<td>1.044</td>
</tr>
</tbody>
</table>
Normalization of Recharge Due To Rainfall During Monsoon Season

\[ Y = mX \]

<table>
<thead>
<tr>
<th>( m )</th>
<th>( NMR )</th>
<th>( m \times NMR )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.927</td>
<td>1016.18</td>
<td>942.00</td>
</tr>
<tr>
<td>1.022</td>
<td>1016.18</td>
<td>1038.54</td>
</tr>
<tr>
<td>0.975</td>
<td></td>
<td>990.27</td>
</tr>
<tr>
<td>1.035</td>
<td>1016.18</td>
<td>1051.75</td>
</tr>
<tr>
<td>1.044</td>
<td>1016.18</td>
<td>1060.89</td>
</tr>
<tr>
<td>0.927</td>
<td>1016.18</td>
<td>942.00</td>
</tr>
<tr>
<td>0.991</td>
<td>1016.18</td>
<td>1007.03</td>
</tr>
</tbody>
</table>
Normalization of Recharge Due To Rainfall During Monsoon Season

\[ Y = mX + c \]

\[ 10 = m \times 3 + c \]
\[ 16 = m \times 5 + c \]
\[ 10 = 3m + c \]
\[ 16 = 5m + c \]
Normalization of Recharge Due To Rainfall During Monsoon Season

\[ Y = mX + c \]

\[ 10 = 3m + c \]
\[ 16 = 5m + c \]

\[ -6 = -2m \]

\[ m = \frac{6}{2} = 3 \]

\[ 10 = 3 \times 3 + c \]
\[ 10 = 9 + c \]
\[ c = 10 - 9 = 1 \]
Normalization of Recharge Due To Rainfall During Monsoon Season

\[ Y = mx + c \]

\[ 1329.78 = m \times 1434.8 + c \]
\[ 956.50 = m \times 936.10 + c \]

\[ 1329.78 = 1434.8m + c \]
\[ 956.50 = 936.10m + c \]
Normalization of Recharge Due To Rainfall During Monsoon Season

\[ Y = mX + c \]

\[
\begin{align*}
1329.78 &= 1434.8m + c \\
956.50 &= 936.10m + c \\
373.28 &= 498.7m \\
m &= \frac{373.28}{498.7} = 0.749 \\
1329.78 &= 1434.80 \times 0.749 + c \\
1329.78 &= 1074.67 + c \\
C &= 1329.78 - 1074.67 = 255.11
\end{align*}
\]
Normalization of Recharge Due To Rainfall During Monsoon Season

\[ Y = mX + c \]

\[ \begin{align*}
    m &= 0.749 \\
    C &= 255.11 \\
    NMR &= 1016.18 \\
    \text{Rech} &= 0.749 \times 1016.18 + 255.11 = 1016.23
\end{align*} \]
For normalizing the rainfall recharge at least 5 years data of rainfall and the corresponding rainfall recharge is used. Fitting a linear regression curve for this data set will give an equation in $y=ax+b$ form.

Where:
- $r_i =$ Rainfall
- $R_i =$ Recharge due to rainfall
Normalization of Recharge Due To Rainfall During Monsoon Season

\[ Y = mX + c \]

<table>
<thead>
<tr>
<th>S.No</th>
<th>RF</th>
<th>Rech</th>
<th>RF^2</th>
<th>RF*Rech</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.4348</td>
<td>1.3298</td>
<td>2.0587</td>
<td>1.9080</td>
</tr>
<tr>
<td>2</td>
<td>0.9361</td>
<td>0.9565</td>
<td>0.8763</td>
<td>0.8954</td>
</tr>
<tr>
<td>3</td>
<td>0.7670</td>
<td>0.8333</td>
<td>0.5883</td>
<td>0.6391</td>
</tr>
<tr>
<td>4</td>
<td>1.1640</td>
<td>1.2044</td>
<td>1.3549</td>
<td>1.4019</td>
</tr>
<tr>
<td>5</td>
<td>1.0162</td>
<td>1.0604</td>
<td>1.0327</td>
<td>1.0778</td>
</tr>
<tr>
<td>5</td>
<td>5.3181</td>
<td>5.3844</td>
<td>5.9109</td>
<td>5.9222</td>
</tr>
<tr>
<td>N</td>
<td>S1</td>
<td>S2</td>
<td>S3</td>
<td>S4</td>
</tr>
</tbody>
</table>
Normalization of Recharge Due To Rainfall During Monsoon Season

\[ Y = \frac{a}{m} X + c \]

\[ a = \frac{5 \times 5.9222 - 5.3181 \times 5.3844}{5 \times 5.9109 - 5.3181 \times 5.3181} \]

\[ a = \frac{29.611 - 28.6348}{29.5545 - 28.2822} = \frac{0.9762}{1.2723} = 0.7673 \]
Normalization of Recharge Due To Rainfall During Monsoon Season

\[ Y = mX + c \]

\[ b = \frac{5.3844 - 0.7673 \times 5.3181}{5} \]

\[ b = \frac{5.3844 - 4.0806}{5} = \frac{1.3038}{5} = 0.26076 \]
Normalization of Recharge Due To Rainfall During Monsoon Season

\[ Y = mX + c \]

\[ R_{rf} = 0.7673 \times 1.0162 + 0.26076 \]

\[ = 0.7797 + 0.26076 = 1.04046 \]

\[ = 1040.46 \text{ ham} \]
Estimation Of Recharge Due To Rainfall
Water Table Fluctuation Method

PERCENT DIFFERENCE

\[ PD = \frac{RRf(wtfm) - RRf(rifm)}{RRf(rifm)} \times 100 \]

Where

- \( PD \) = Percent Difference
- \( RRf(wtfm) \) = Rainfall Recharge for normal monsoon season rainfall estimated using Water Table Fluctuation Method
- \( RRf(rifm) \) = Rainfall Recharge for normal monsoon season rainfall estimated using Rainfall Infiltration Factor Method
The rainfall recharge for Normal Monsoon Season Rainfall is finally adopted as per the following criteria.

If $-20\% < PD < +20\%$

Final Rainfall Recharge = $RR_f(wtfm)$

If $PD < -20\%$

Final Rainfall Recharge = $RR_f(rifm)* 0.8$

If $PD > +20\%$

Final Rainfall Recharge = $RR_f(rifm)* 1.2$
Total Ground Water Recharge

\[ TGWR = R_{Rf} + R_{C} + R_{SW} + R_{GW} + R_{T} + R_{WCS} \]

Where

- TGWR = Total Ground Water Recharge
- \( R_{Rf} \) = Recharge due to Rainfall
- \( R_{C} \) = Recharge due to Canals
- \( R_{SW} \) = Recharge due to Surface Water Irrigation
- \( R_{GW} \) = Recharge due to Ground Water Irrigation
- \( R_{T} \) = Recharge due to Tanks & Ponds
- \( R_{WCS} \) = Recharge due to Water Conservation Structures
Total Ground Water Recharge During Monsoon Season

$$TGWR_m = R_{Rf} + R_C + R_{SW} + R_{GW} + R_T + R_{WCS}$$

Where

$TGWR_m =$ Total Ground Water Recharge During Monsoon

$R_{Rf} =$ Recharge due to Rainfall

$R_C =$ Recharge due to Canals

$R_{SW} =$ Recharge due to Surface Water Irrigation

$R_{GW} =$ Recharge due to Ground Water Irrigation

$R_T =$ Recharge due to Tanks & Ponds

$R_{WCS} =$ Recharge due to Water Conservation Structures
Total Ground Water Recharge During Non-Monsoon Season

$$\text{TGWR}_n = R_{\text{Rf}} + R_{\text{C}} + R_{\text{SW}} + R_{\text{GW}} + R_{\text{T}} + R_{\text{WCS}}$$

Where

$$\text{TGWR}_n = \text{Total Ground Water Recharge During Monsoon}$$

$$R_{\text{RF}} = \text{Recharge due to Rainfall}$$

$$R_{\text{C}} = \text{Recharge due to Canals}$$

$$R_{\text{SW}} = \text{Recharge due to Surface Water Irrigation}$$

$$R_{\text{GW}} = \text{Recharge due to Ground Water Irrigation}$$

$$R_{\text{T}} = \text{Recharge due to Tanks & Ponds}$$

$$R_{\text{WCS}} = \text{Recharge due to Water Conservation Structures}$$
The sum of recharge during Monsoon and Non-Monsoon seasons will be the Total Annual Ground Water Recharge.
Net Annual Ground Water Availability

\[ \text{NAGWA} = \text{TAGWR} - \text{UND} \]

Where

\begin{align*}
\text{NAGWA} & = \text{Net Annual Ground Water Availability} \\
\text{TAGWR} & = \text{Total Annual Ground Water Recharge} \\
\text{UND} & = \text{Unavoidable Natural Discharges} \\
& \quad (5\% - 10\% \text{ of Total Annual Ground Water Recharge})
\end{align*}
Stage Of Ground Water Development
GEC-1997 has recommended to categorize the assessment sub unit based on the stage of ground water development and the long term ground water level trend.
## Categorization Of The Sub-Unit

<table>
<thead>
<tr>
<th>Stage Of Ground Water Development (%)</th>
<th>Ground Water Level trend</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=70</td>
<td>Either Pre-monsoon or Post Monsoon Water levels does not show a Falling Trend</td>
<td>Safe</td>
</tr>
<tr>
<td>70-90</td>
<td>Both the trends during Pre and Post Monsoon Seasons do not show a Falling Trend</td>
<td>Safe</td>
</tr>
<tr>
<td>70-90</td>
<td>Either Pre-monsoon or Post Monsoon Water levels Shows a Falling Trend</td>
<td>Semi-critical</td>
</tr>
<tr>
<td>&gt;90</td>
<td>Either Pre-monsoon or Post Monsoon Water levels Shows a Falling Trend</td>
<td>Critical</td>
</tr>
<tr>
<td>&lt;100</td>
<td>Both the trends during Pre and Post Monsoon Seasons show a Falling Trend</td>
<td>Critical</td>
</tr>
<tr>
<td>&gt;100</td>
<td>Both the trends during Pre and Post Monsoon Seasons show a Falling Trend</td>
<td>Over exploited</td>
</tr>
</tbody>
</table>
# Categorization Of The Sub-Unit

**Based On GEC-2004**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Declining Pre-Monsoon Trend</th>
<th>Declining Post-Monsoon Trend</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=70%</td>
<td>No</td>
<td>No</td>
<td>Safe</td>
</tr>
<tr>
<td>&lt;=70%</td>
<td>No</td>
<td>Yes</td>
<td>To Be Reassessed</td>
</tr>
<tr>
<td>&lt;=70%</td>
<td>Yes</td>
<td>No</td>
<td>To Be Reassessed</td>
</tr>
<tr>
<td>&lt;=70%</td>
<td>Yes</td>
<td>Yes</td>
<td>To Be Reassessed</td>
</tr>
<tr>
<td>&gt;70% and &lt;=90%</td>
<td>No</td>
<td>No</td>
<td>Safe</td>
</tr>
<tr>
<td>&gt;70% and &lt;=90%</td>
<td>No</td>
<td>Yes</td>
<td>Semi-Critical</td>
</tr>
<tr>
<td>&gt;70% and &lt;=90%</td>
<td>Yes</td>
<td>No</td>
<td>Semi-Critical</td>
</tr>
<tr>
<td>&gt;70% and &lt;=90%</td>
<td>Yes</td>
<td>Yes</td>
<td>To Be Reassessed</td>
</tr>
<tr>
<td>&gt;90% and &lt;=100%</td>
<td>No</td>
<td>No</td>
<td>To Be Reassessed</td>
</tr>
<tr>
<td>&gt;90% and &lt;=100%</td>
<td>No</td>
<td>Yes</td>
<td>Semi-Critical</td>
</tr>
<tr>
<td>&gt;90% and &lt;=100%</td>
<td>Yes</td>
<td>No</td>
<td>Semi-Critical</td>
</tr>
<tr>
<td>&gt;90% and &lt;=100%</td>
<td>Yes</td>
<td>Yes</td>
<td>Critical</td>
</tr>
<tr>
<td>&gt;100%</td>
<td>No</td>
<td>No</td>
<td>To Be Reassessed</td>
</tr>
<tr>
<td>&gt;100%</td>
<td>No</td>
<td>Yes</td>
<td>Over-Exploited</td>
</tr>
<tr>
<td>&gt;100%</td>
<td>Yes</td>
<td>No</td>
<td>Over-Exploited</td>
</tr>
<tr>
<td>&gt;100%</td>
<td>Yes</td>
<td>Yes</td>
<td>Over-Exploited</td>
</tr>
</tbody>
</table>
Allocation Of Ground Water For Domestic And Industrial Needs

\[ A = 22 \times N \times L_g \]

Where
- \( A \) = Allocation for domestic and Industrial water Requirement in mm/year.
- \( N \) = Projected Population density in the sub unit in thousands per square kilometer.
- \( L_g \) = Fractional Load on ground water for domestic and industrial water supply (\( \leq 1.0 \))

\[ 365 \times 60 \text{lpcd} = 21900 \text{l/year} = 22 \text{ m}^3/\text{year} \]
Net Annual Ground Water Availability For Irrigation

\[ \text{NAGWAFI} = \text{NAGWA} - \text{AFDIWR} \]

Where

- \( \text{NAGWAFI} \) = Net Annual Ground Water Availability For Irrigation Use
- \( \text{NAGWA} \) = Net Annual Ground Water Availability
- \( \text{AFDIWR} \) = Allocation For Domestic and Industrial Water Requirement.
Net Annual Ground Water Availability For Future Irrigation Development

\[
\text{NAGWAFFID} = \text{NAGWAFI} - \text{CGGWDFI}
\]

Where

\[
\text{NAGWAFFID} = \text{Net Annual Ground Water Availability For Future Irrigation Use}
\]

\[
\text{NAGWAFI} = \text{Net Annual Ground Water Availability For Irrigation Use}
\]

\[
\text{CGGWDFI} = \text{Current Gross Ground Water Draft For Irrigation}
\]
Additional Potential Recharges

1. Water logged and Shallow Water Table Areas.

2. Flood Prone Areas.
Potential Recharge In Water Logged And Shallow Water Table Areas

\[ PRWL = (5-D_TW) \times A \times S_Y \]

Where

- **PRWL** = Potential Recharge in Water Logged and Shallow Water Table Areas
- **DTW** = Average Depth To Water Level
- **A** = Area of the Water logged Zone
- **S_Y** = Specific Yield in the zone upto 5.0m bgl.
PRFL = $1.4 \times N \times \frac{A}{1000}$

Where

PRFL = Potential Recharge in Flood Prone Areas

N = No of Days Water is Retained in the Area

A = Flood Prone Area
Static Ground Water Resources

\[ SGWR = A \times (Z_2 - Z_1) \times S_Y \]

Where

- \( SGWR = \) Static Ground Water Resources
- \( A = \) Area of the Assessment Unit
- \( Z_2 = \) Maximum depth up to which saturated formation extends
- \( Z_1 = \) Maximum extension of Zone of Water Table Fluctuation
- \( S_Y = \) Specific Yield in the Zone of Static Water Resources.
There are two types of situations of occurrence of confined aquifers.

In hard rock areas,

the upper water table aquifer in the weathered zone is connected to the deeper fracture zone, which is semi-confined.

no separate assessment is to be made for the confined aquifer.
There are two types of situations of occurrence of confined aquifers.

In specific alluvial areas,

If the confined aquifer is hydraulically connected to the overlying shallow water table aquifer, it is a semi confined aquifer. No separate assessment is to be made for the confined aquifer.

If there is no hydraulic connection to the overlying water table aquifer, the resource may have to be estimated taking care to avoid duplication of resource assessment from the upper unconfined aquifers.
Where the assessment unit is a watershed, there is a need to convert the ground water assessment in terms of an administrative unit such as block/ taluka/ mandal.

- The ground water assessment in the sub units, non-command and command areas of the watershed may be converted into depth unit (mm), by dividing the annual recharge by the respective area.

- The contribution of this sub units of the watershed to the block, is now calculated by multiplying this depth with the area in the block occupied by this sub unit.

- The total ground water resource of the block should be presented separately for each type of sub unit, namely for non-command areas, command areas and poor ground water quality areas, as in the case of the individual watersheds.
GROUND WATER RESOURCES
ESTIMATION
USING GEC-1997 METHODOLOGY

Thank You