Investigating Aquifer Storage and Recovery Technology to Recharge Saline Groundwater at Farmer's Field

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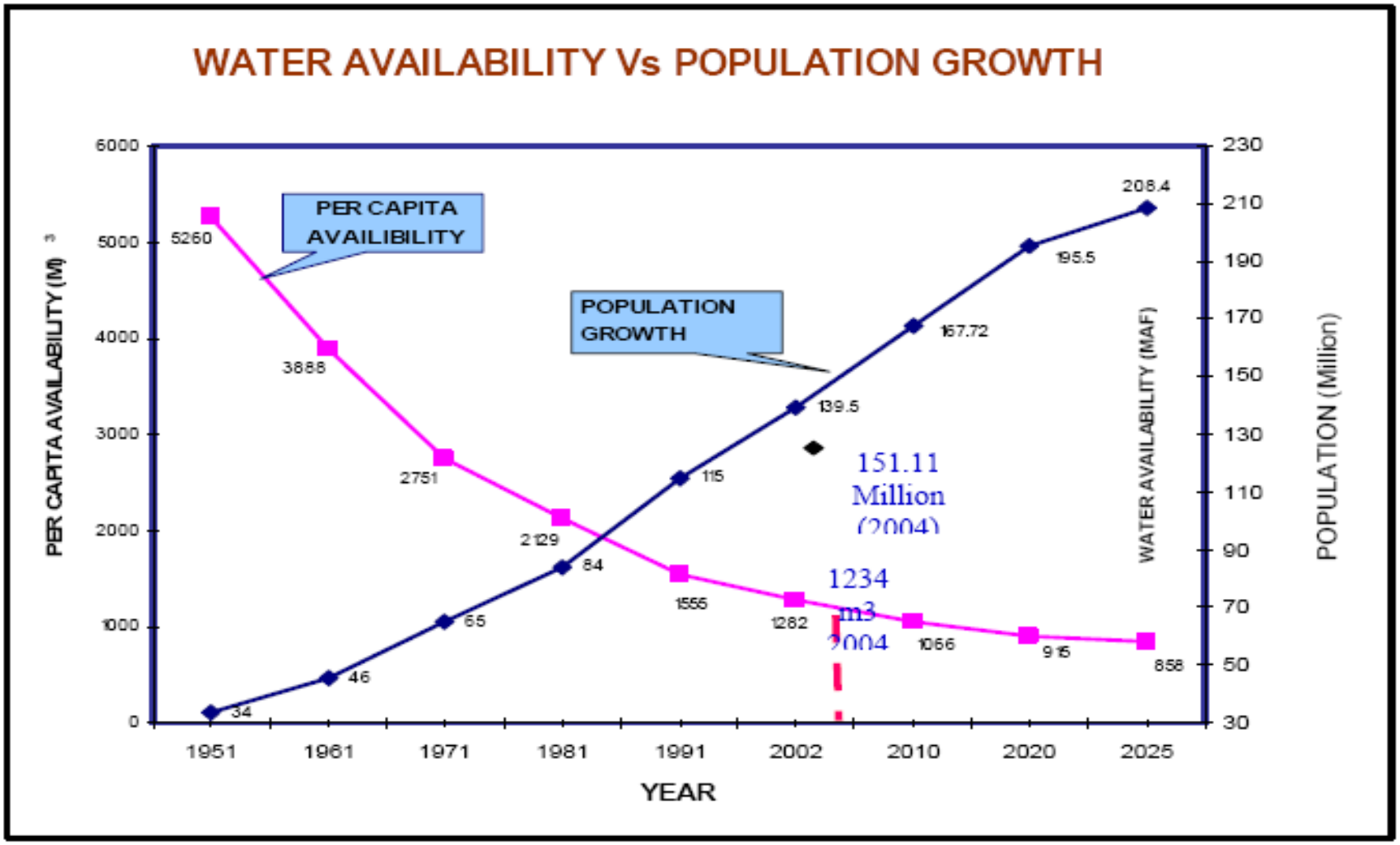
Organization

- Water availability and issues
- ASR Technology: Objectives
- Resistivity Survey
- Water Quality Criteria
- ASR Technology
- Achievements; ASR Design
- Injection and Recovery Time
- Recovery Efficiency
- Conclusions
- Recommendations



Per year. As such in the year 2012, Pakistan will have reached the stage of "acute water shortage", where people flight for every drop of water. Fresh storages, therefore, have to be

Source: Rasul, G. (2008)

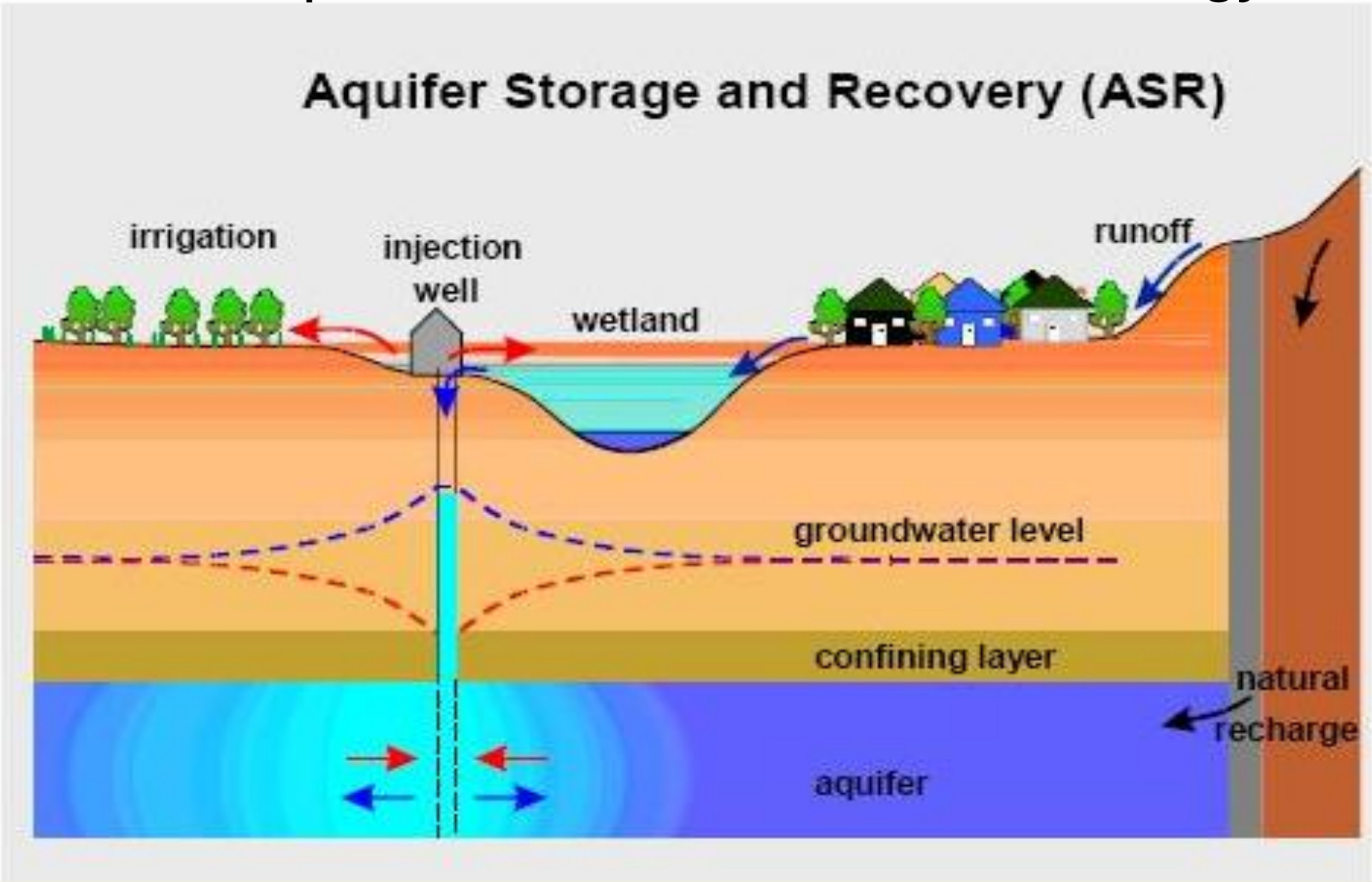
Groundwater Issues

- Growing number of tubewells as groundwater contribution is increasing to about 40-50 MAF to meet crop water requirements (ASP, 2008)
- Falling groundwater levels
- Deteriorating Groundwater quality
- Causing secondary salinization
- Increasing energy cost
- Groundwater recharge is inevitable for its sustainable exploitation through modern technologies such as **ASR**

What is ASR?

- The technique of storing surplus good quality water into the aquifer and pumping the same water during periods of high crop water requirements is called Aquifer Storage and Recovery (ASR).
- ASR techniques are cost effective alternatives aimed at storing surplus water during flood periods and recovering it during times of water shortages.
- These techniques provide an option to the farmer like **water bank deposit** especially where groundwater is brackish.

Conceptual Scenario of ARS Technology



Source: (Dillon et al., 2008)

ASR Benefits

- Subsurface water bank
- Buffers between supply and demand
- Allows storage for irrigation
- No mosquito's
- No evaporation/seepage losses
- On farm subsurface water storage option
- Land saving from surface storage
- Geophysical exploration such as resistivity survey can help design and install ASR components.

Objectives

- To investigate possible changes in quality of the recovered water when injected during aquifer storage and recovery technology.

- To determine the recovery efficiency during different aquifer storage and recovery treatments.

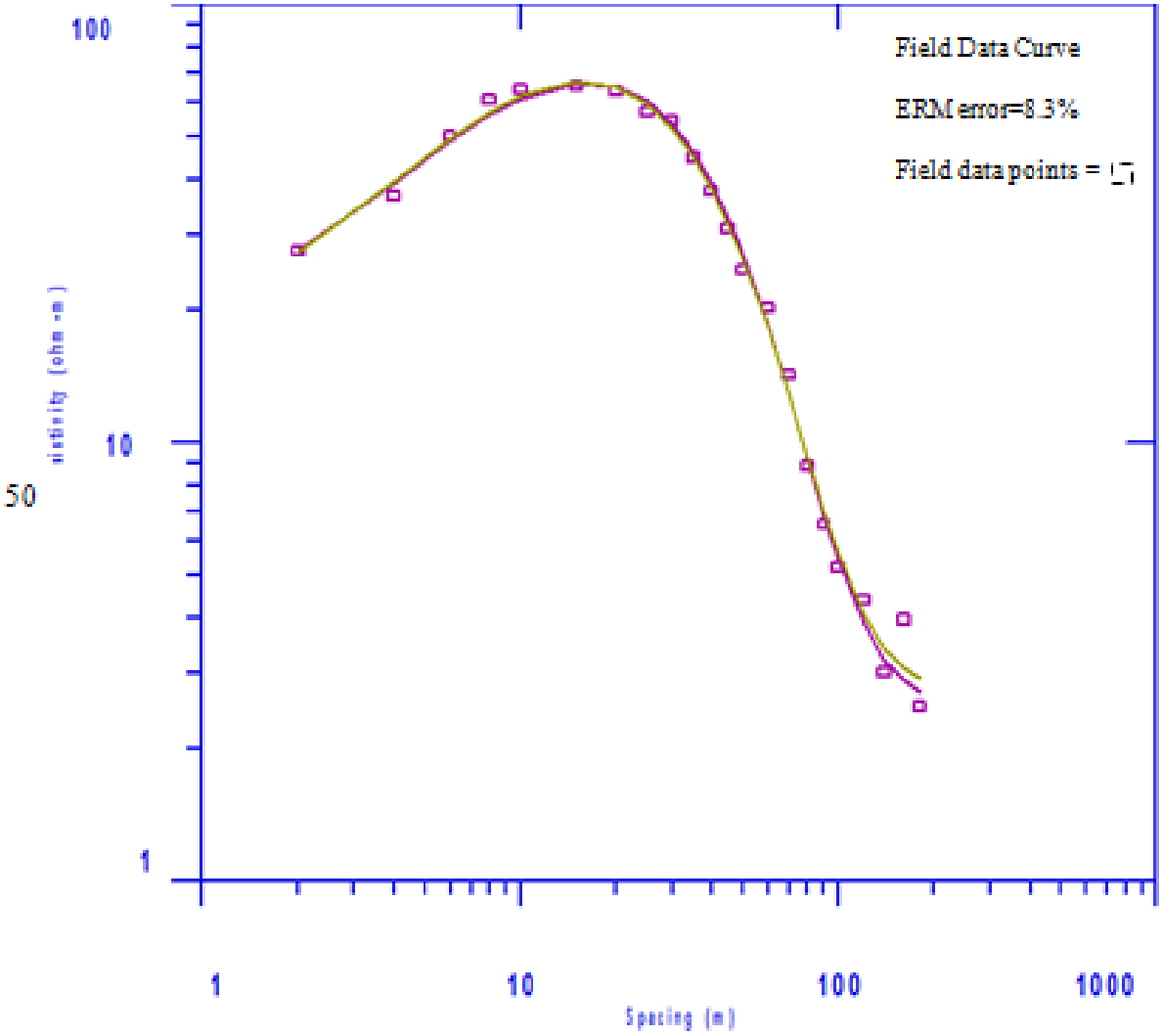
Study Area: 405/J.B., T. T. Singh

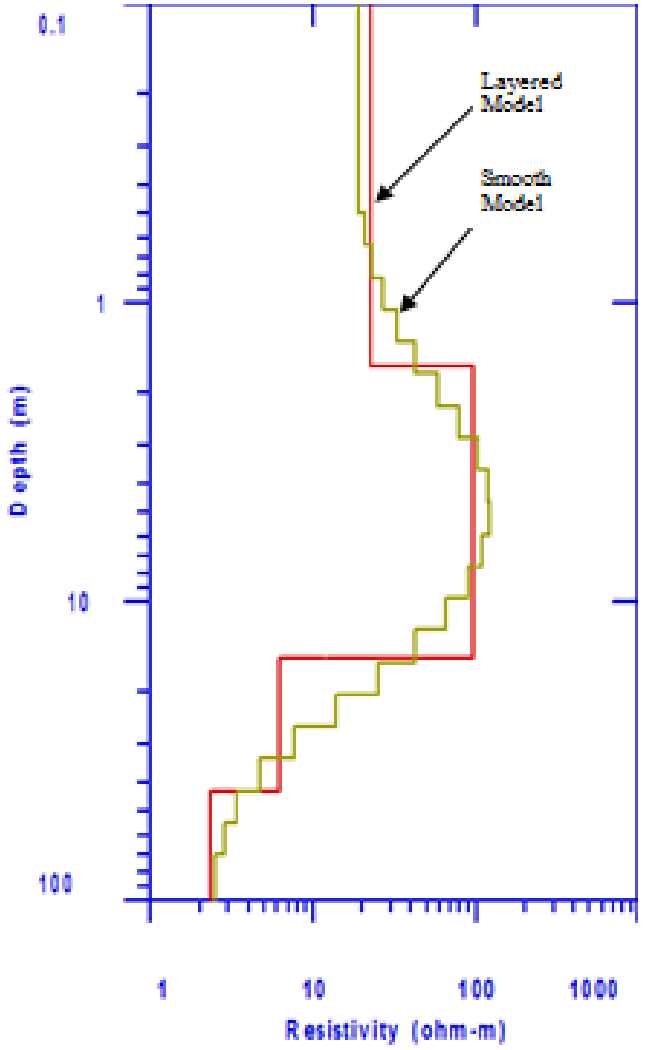

Use of resistivity meter

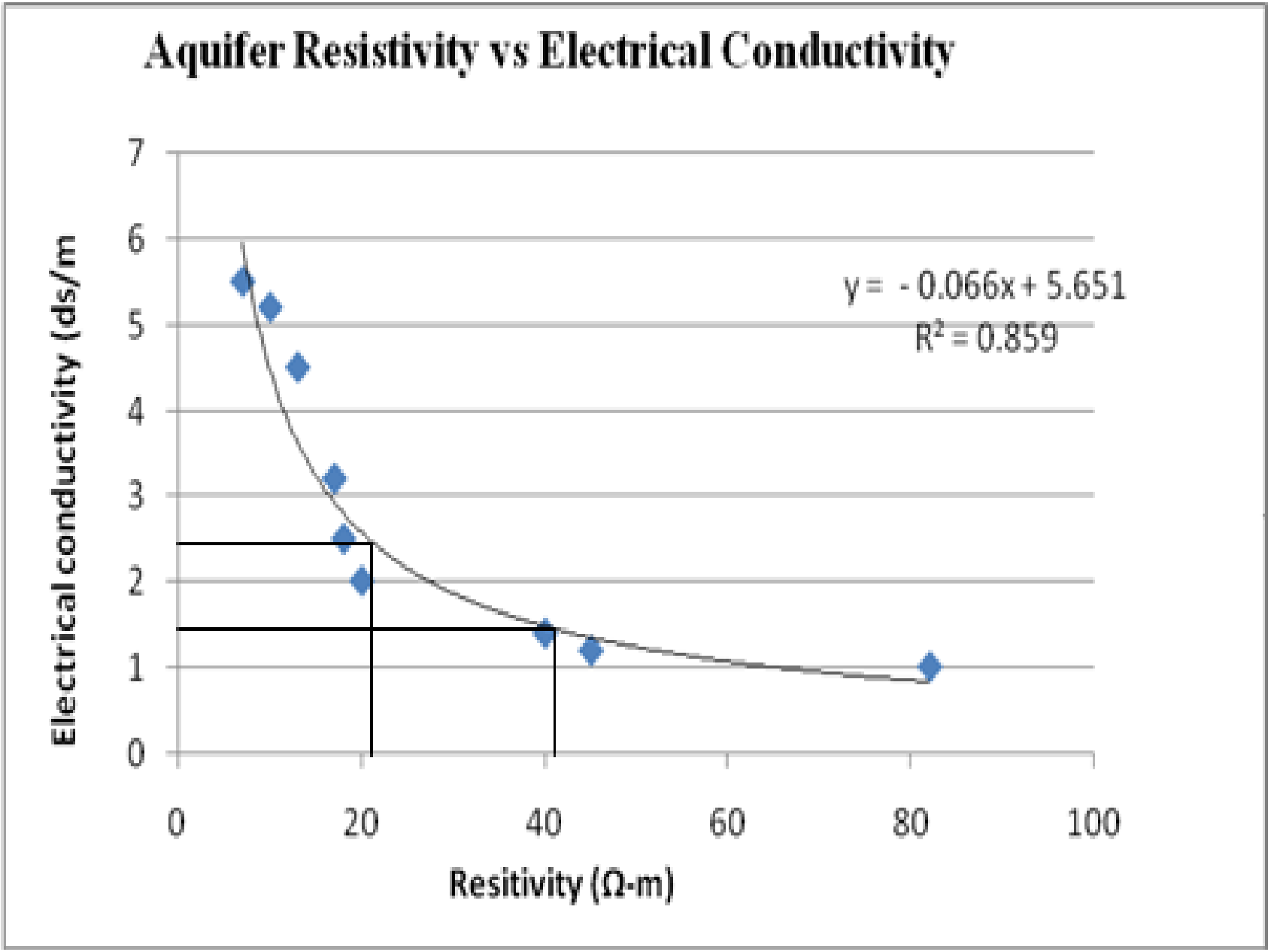
Resistivity Survey

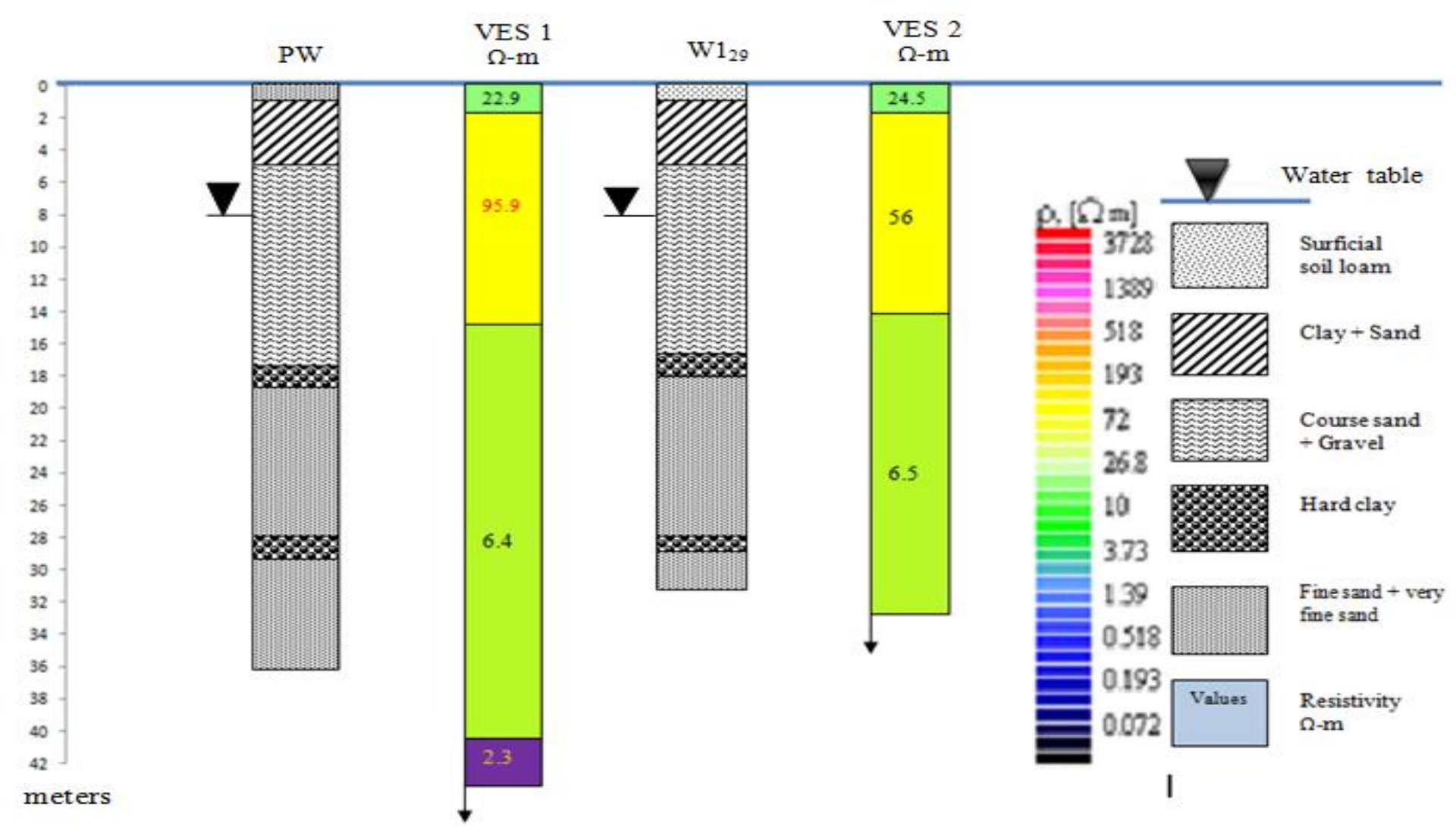
- The resistivity survey meter (ABEM SAS 4000 Terramater) was used to study the aquifer characteristics, water table depth, soil layers below the ground surface and aquifer potential.
- The Schlumberger electrode configuration with current electrode distance (AB/2) was followed with electrode separation of 2, 4, 6, 8, 10, **10**, 15, 20, 25, **25**, 30, 35, 40, 45, 50, **50**, 60, 70, 80, 90, 100, **100**, 120, 140, 160 and 180 meter.
- The potential electrode separation (MN/2) was kept at 0.5, 2, 5, 10 and 20 meter.
- Using 1X1D computer software, field data were analyzed by plotting the resistivity against electrode spacing.

Subsurface Information from 1X1D Software






Aquifer Resistivity vs Electrical Conductivity
Electrical conductivity (ds/m
Resitivity (Ω-m)
y = -0.066x + 5.651
R² = 0.859
0
1
2
3
4
5
6
7
0
20
40
60
80
100



Correlation of VES results with subsurface lithology

PW : Production well

$W1_{29}$: Observation well in west direction in cluster 1with 29 m depth

VES 1 : Vertical Electrical Sounding at position 1

VES 2 : Vertical Electrical Sounding at position

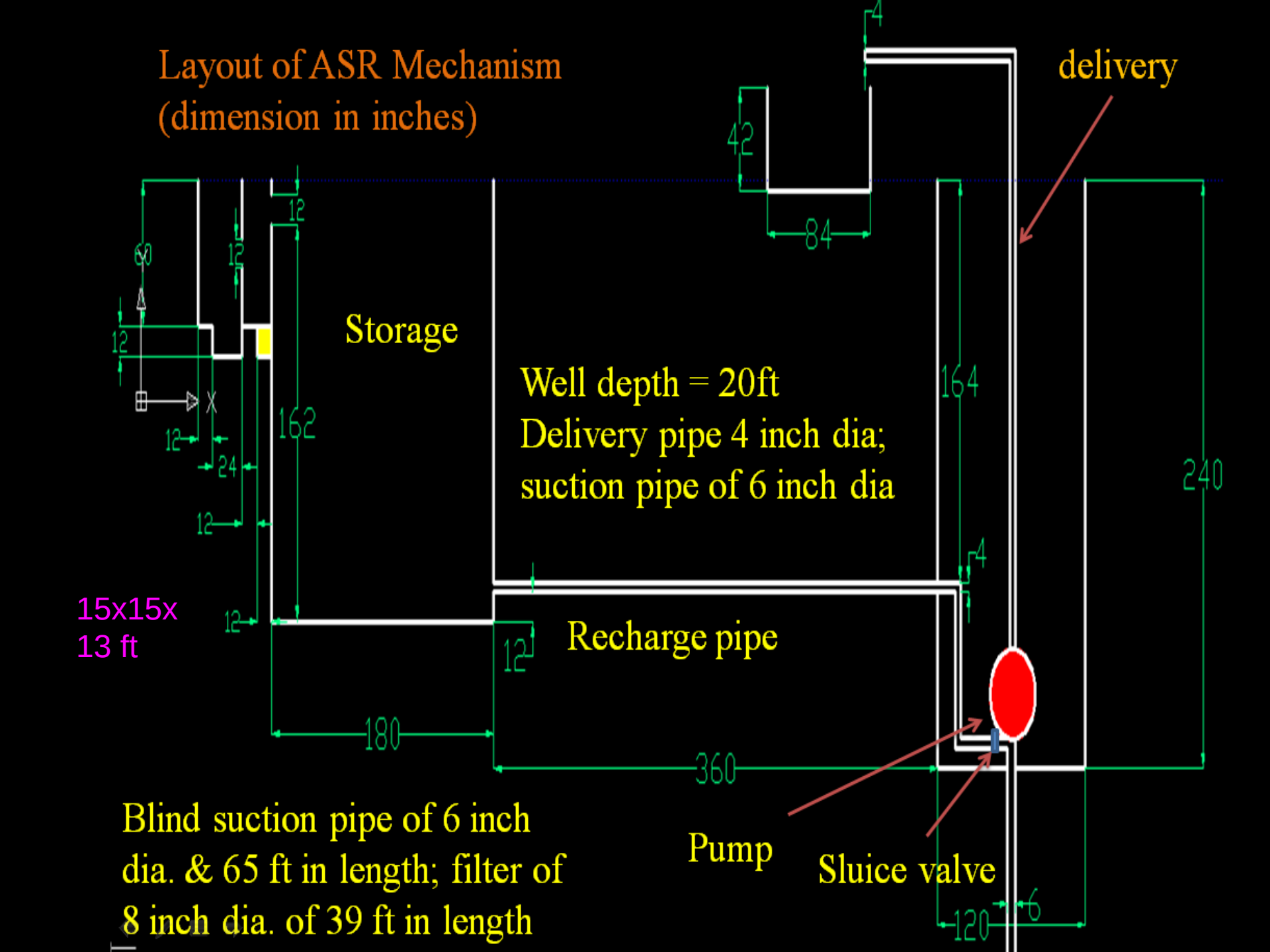
Irrigation water quality criteria

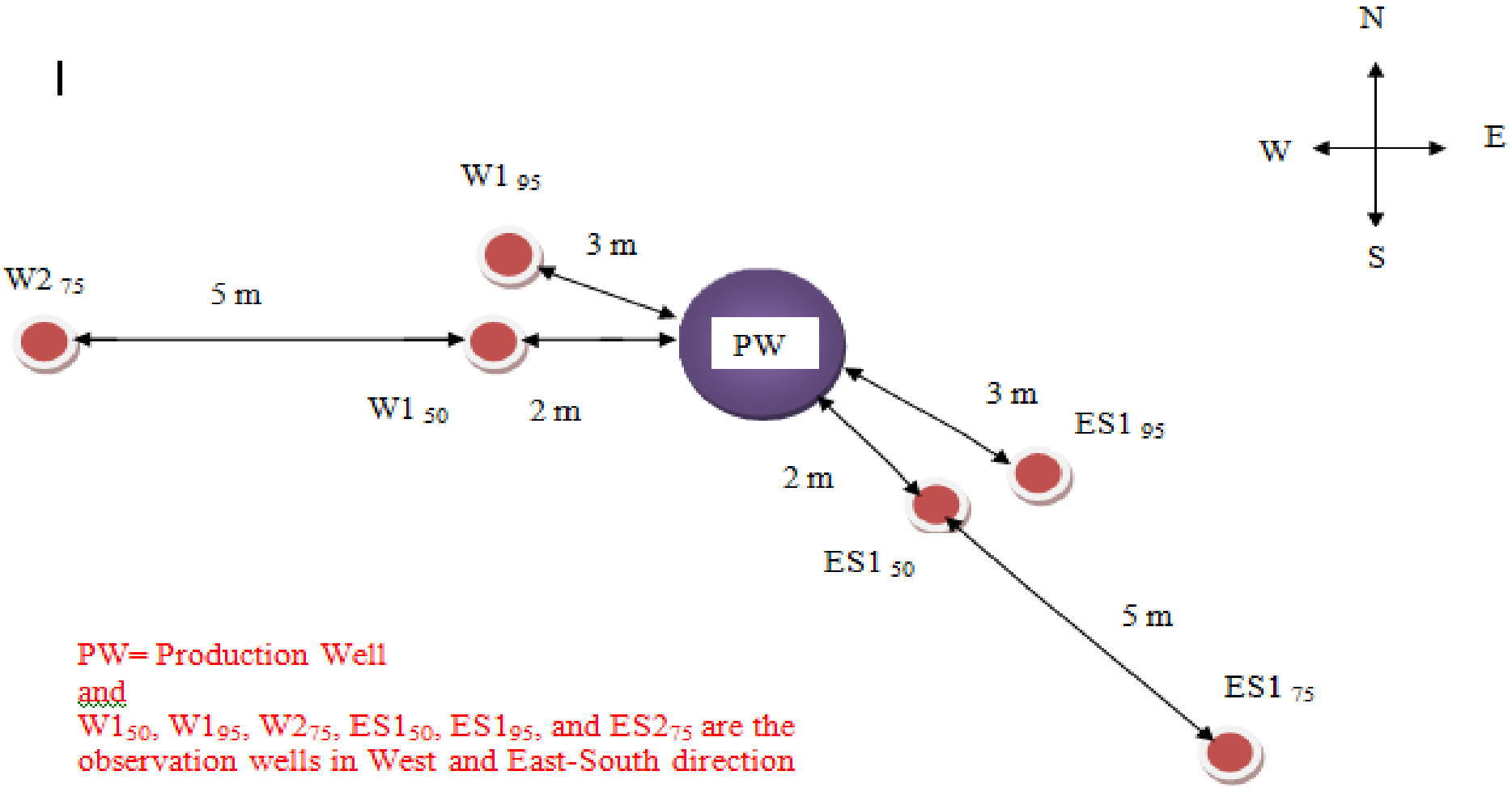
Water parameter	Symbol	Unit	Usual range in irrigation water	Severe
Electrical Conductivity	EC_w	dS/m	0-3	> 3.0
Sodium Adsorption Ratio	SAR		0-5	>15
Residual Sodium carbonate	RSE	meq/l	0-5	> 5

Source: FAO, 1994

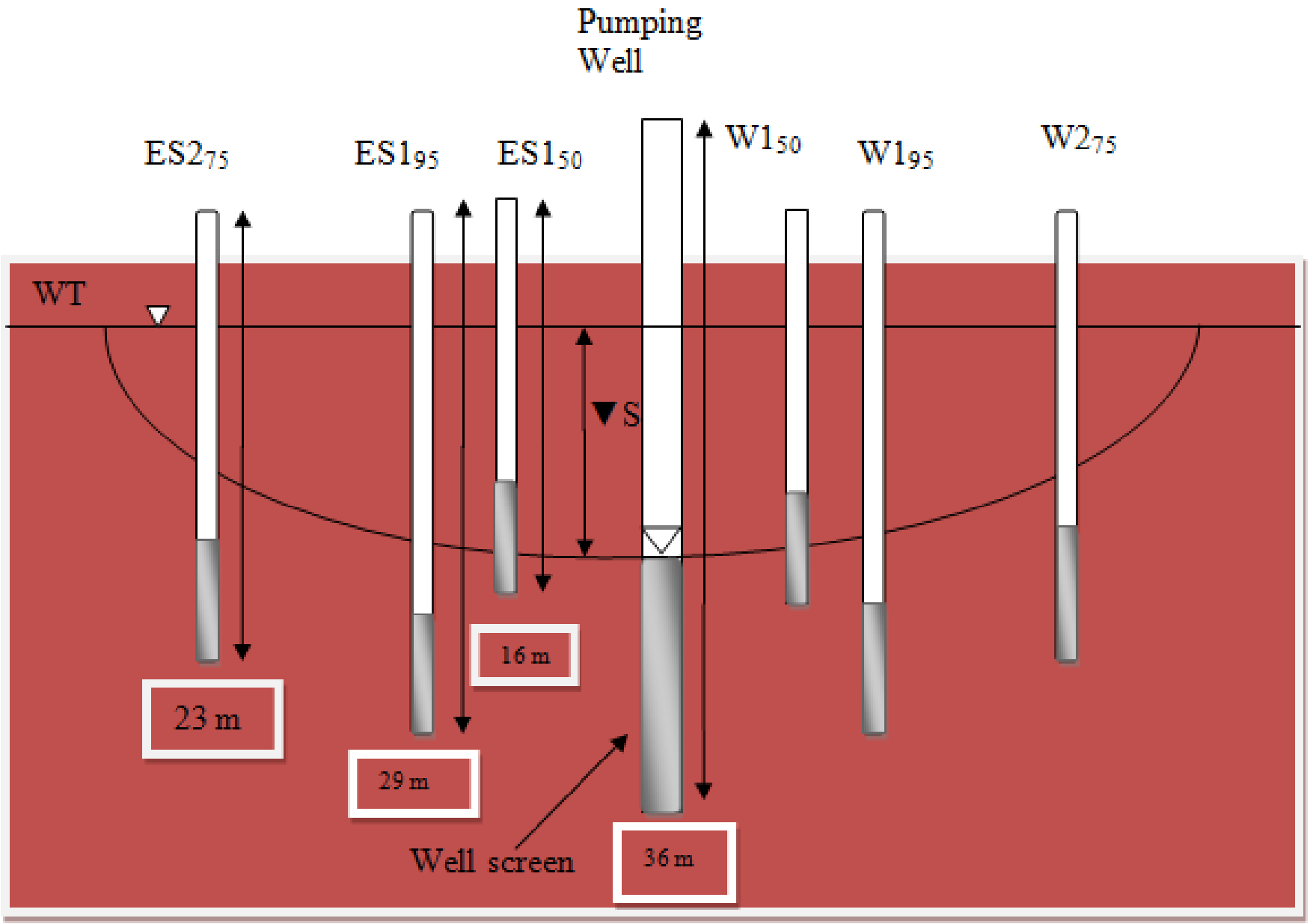
ASR components

- Pump
- Sluice gate valve
- T-section
- Check/ foot valve
- Suction pipe/Delivery pipe
- Nakka
- Canal water entrance pipe into the storage tank
- Recharge pipe
- Flow meter
- Screens/Gravel
- Water storage tank/ Pond
- Observation well


Layout of ASR Mechanism
(dimension in inches)
delivery
42
84
4
12
12
60
12
12
12
24
12
12
162
Storage
Well depth = 20ft
Delivery pipe 4 inch dia;
suction pipe of 6 inch dia
164
240
4
15x15x
13 ft
Recharge pipe
12
180
360
Blind suction pipe of 6 inch
dia. & 65 ft in length; filter of
8 inch dia. of 39 ft in length
Pump
Sluice valve
120
6



PW= Production Well
and
$W1_{50}$, $W1_{95}$, $W2_{75}$, $ES1_{50}$, $ES1_{95}$, and $ES2_{75}$ are the observation wells in West and East-South direction



Depth of the production and observation well


Recharge Connection


Water Storage Section
Water Cleaning Section


Sediment Settling Basin

ASR Technology

Amount of Sediment Removed

Volume of water (m^3)	Total Sediment Present in Canal water (Kg)	Sediment Settling Basin (Kg)	Water Cleaning Section (Kg)	Water Storage Section (Kg)	Sediment Passed (Kg)
100	13	7(54%)	3(23%)	2(15%)	1(8%)

Recovery time, pumping time and injection time

- Recovery time and pumping time both are basically the pumping time but the point which separates these two terms is the quality of water at two different targets.
- **Recovery time** **“**the time required recovering the same volume of water as was injected during injection phase”
- **pumping time** “the time expands to pump the recovered water up to target EC value of 3 dS/m”
- **Injection time** “the time required to inject the measured amount of canal water into the well”

  These all times were measured during all the treatments.

Recovery Efficiency

- Stored water displaces the native water of the aquifer creating a large bubble in the vicinity of the well.
- Monitoring of the groundwater quality was continued to assess the development of freshwater zone during recharge period and its depletion zone during pumping periods to assess the Recovery Efficiency.

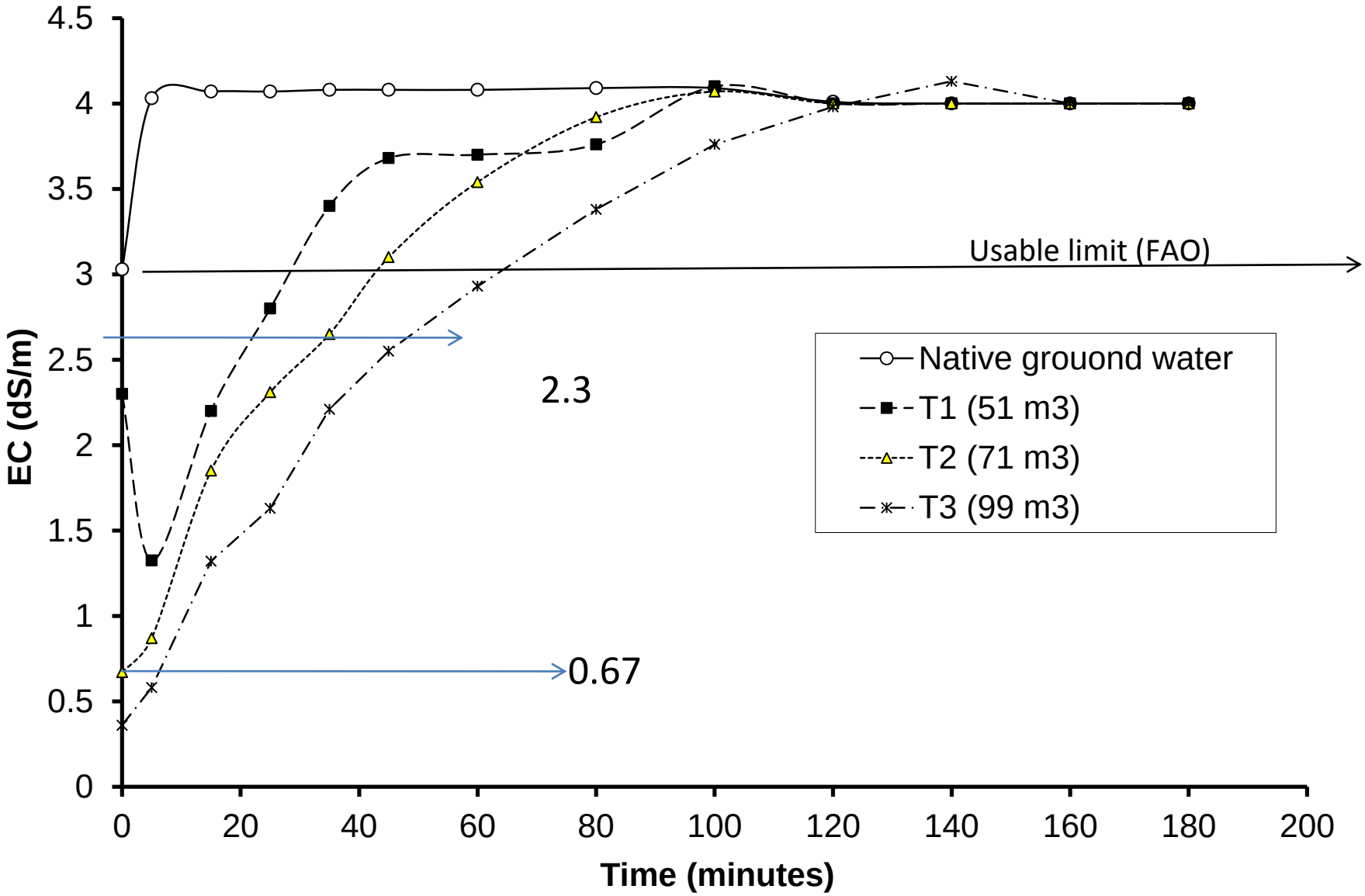
Quality of Native Groundwater

Time (minutes) (Time since pumping)	Electrical conductivity EC (dS/m)	Sodium Adsorption Ratio (SAR)	Residual Sodium Carbonate (RSC)
0	3.03	6.16	Nil
5	4.03	11.5	2.0
15	4.07	11.71	2.0
25	4.07	11.89	2.2
35	4.08	11.75	2.4
45	4.08	11.57	2.2
60	4.08	11.75	2.0
80	4.09	11.7	2.0
100	4.09	12.16	2.4
120	4.01	11.51	2.0
140	4.0	11.45	2.0
160	4.0	11.45	2.0
180	4.0	11.45	2.0

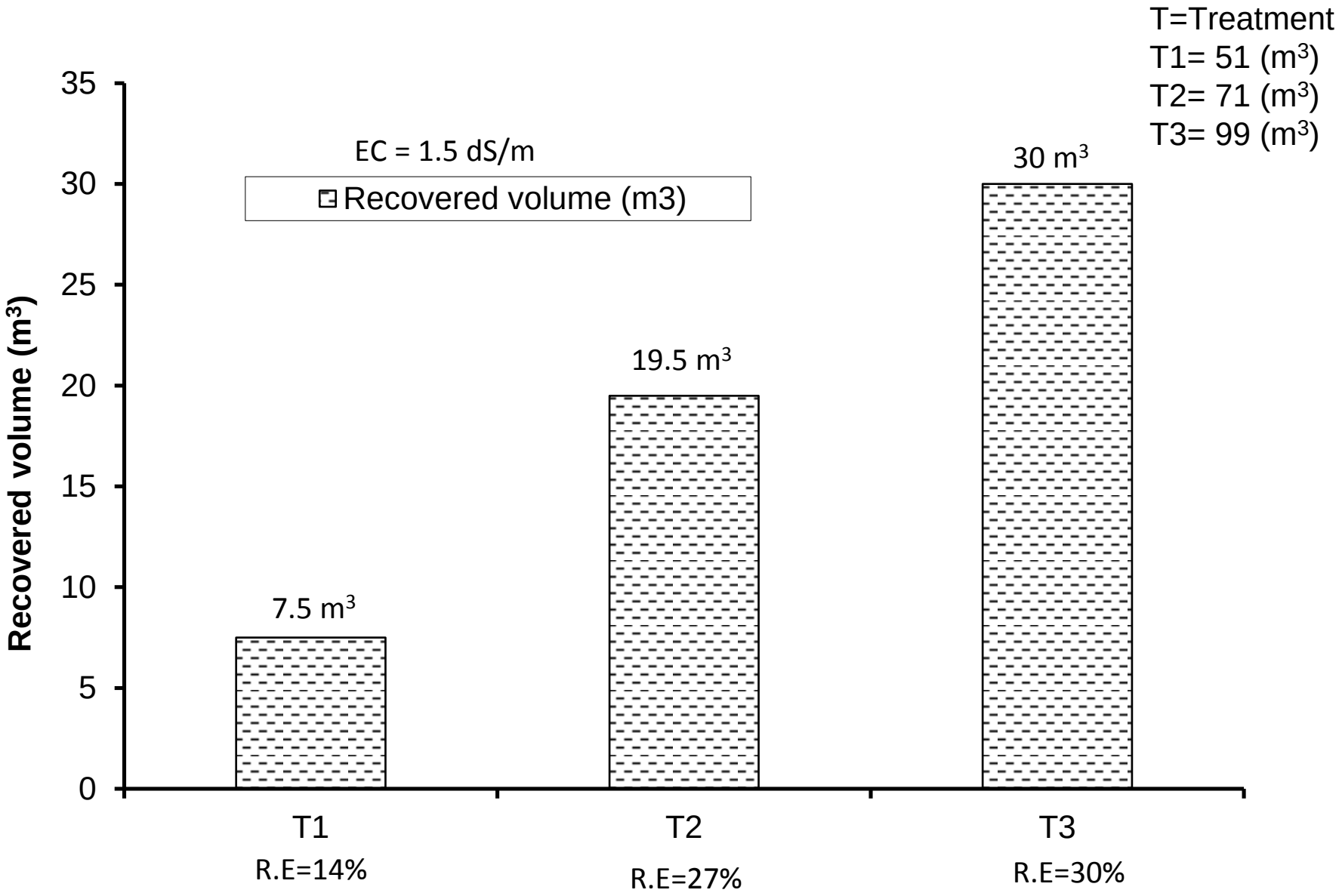
Recovered Water Quality

Time	Treatment 1 51 m^3		Treatment 2 71 m^3		Treatment 3 99 m^3	
(minutes)	EC (dS/m)	SAR	EC (dS/m)	SAR	EC (dS/m)	SAR
0	2.3	9.0	0.67	1.99	0.36	0.4
5	1.5	9.0	0.87	4.39	0.58	0.9
10	1.9	10.1	1.17	5.15	1.06	1.38
15	2.2	10.1	1.85	5.8	1.32	1.30
20	2.4	10.3	2.01	6.40	1.5	2.67
25	2.8	10.5	2.31	7.2	1.63	2.52
30	3.1	10.8	2.5	7.9	1.99	3.53
35	3.4	10.8	2.65	7.9	2.21	3.55
40	3.63	11.1	2.97	8.3	2.33	5.70
45	3.68	11.1	2.98	8.8	2.55	5.70
50	3.68	11.3	3.1	9.6	2.69	6.61
55	3.7	11.3	3.3	9.9	2.8	7.21
60	3.7	11.3	3.4	10.0	2.93	8.02
65	3.74	11.3	3.54	10.3	3.01	8.8
70	3.75	11.5	3.65	10.6	3.26	8.8
75	3.77	11.5	3.72	10.8	3.34	9.6
80	3.76	11.6	3.82	10.8	3.38	9.7
85	3.82	11.6	3.92	11.2	3.46	10.0
90	3.95	11.8	3.98	11.2	3.71	10.7
95	4.0	11.8	4.02	11.2	3.76	10.9
100	4.1	11.9	4.12	11.8	3.85	11.0
110	4.0	12.0	4.0	11.6	3.98	11.0
120	4.0	12.0	4.0	11.6	4	11.1

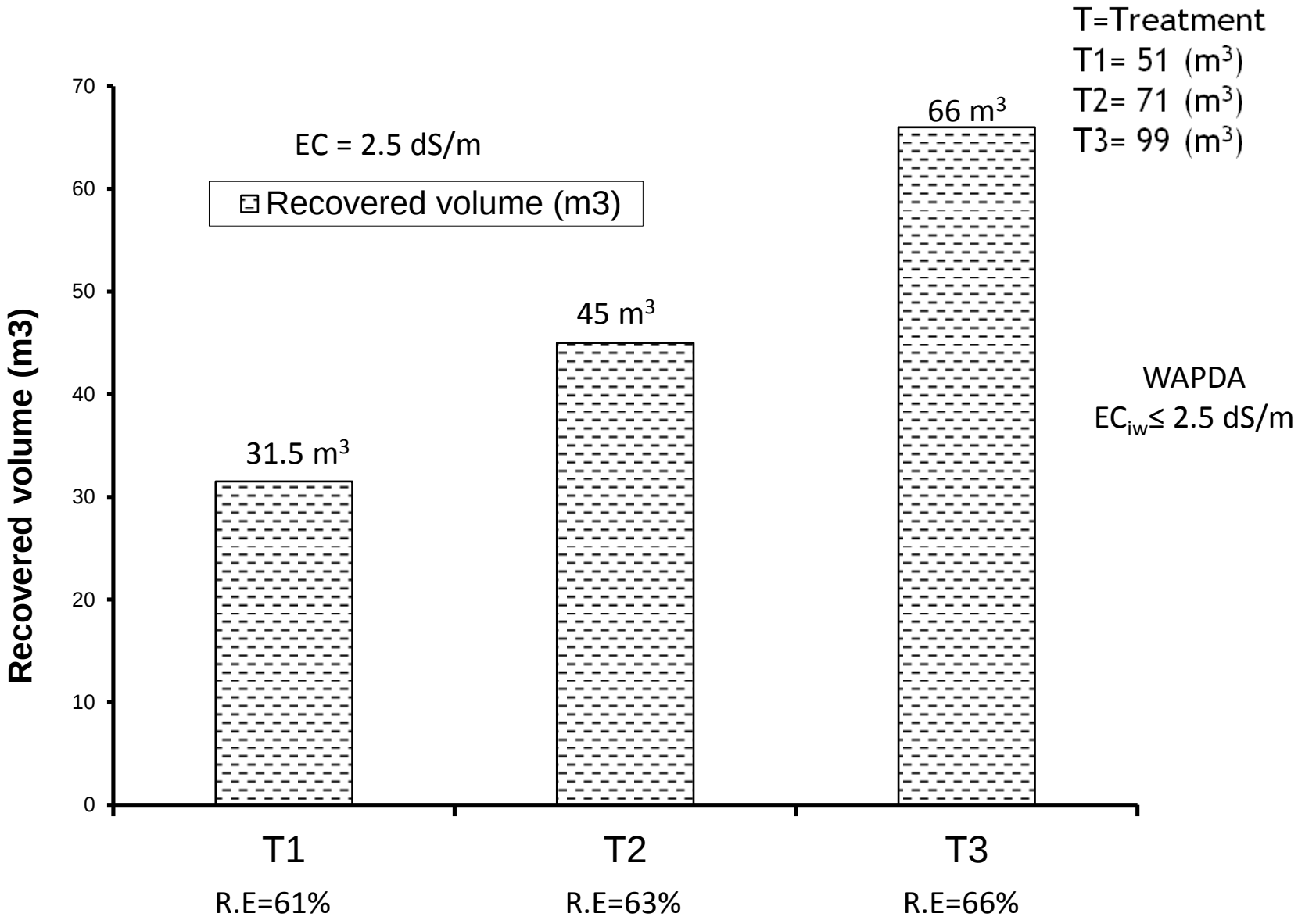
Water Quality Behavior with Pumping



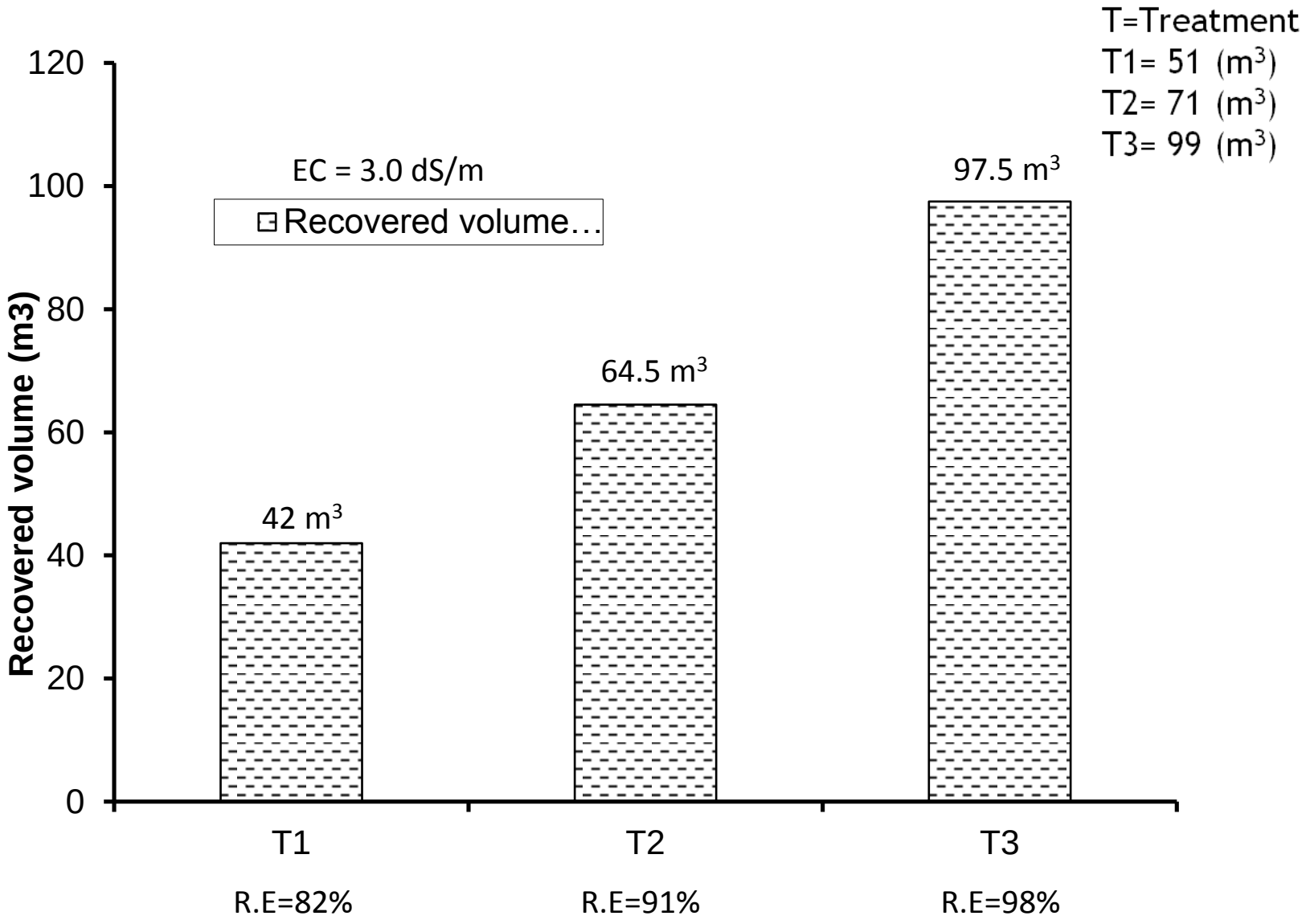
Recovered Volume up to 1.5 dS/m



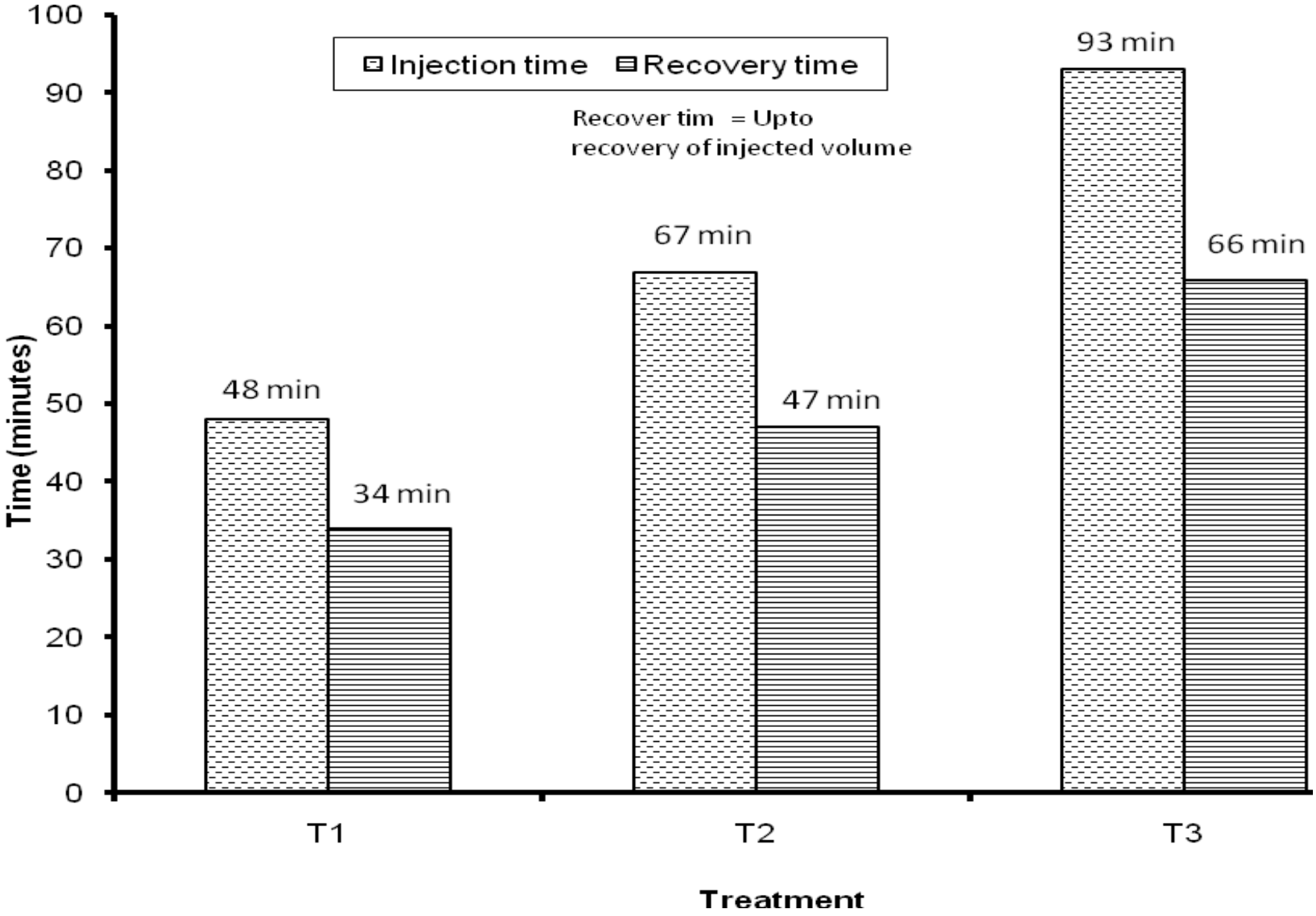
Recovered Volume up to 2.5 dS/m



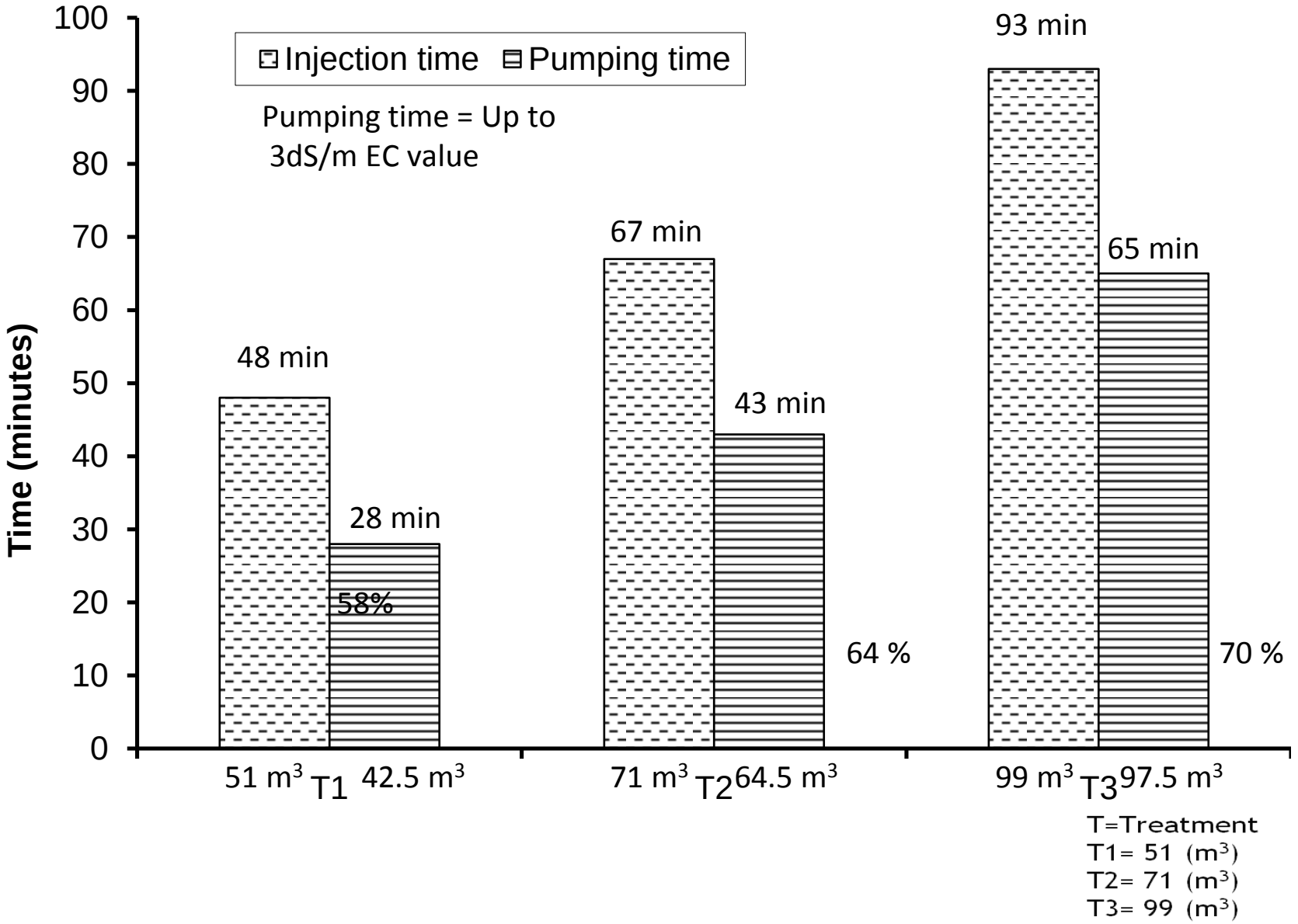
Recovered Volume up to 3.0 dS/m



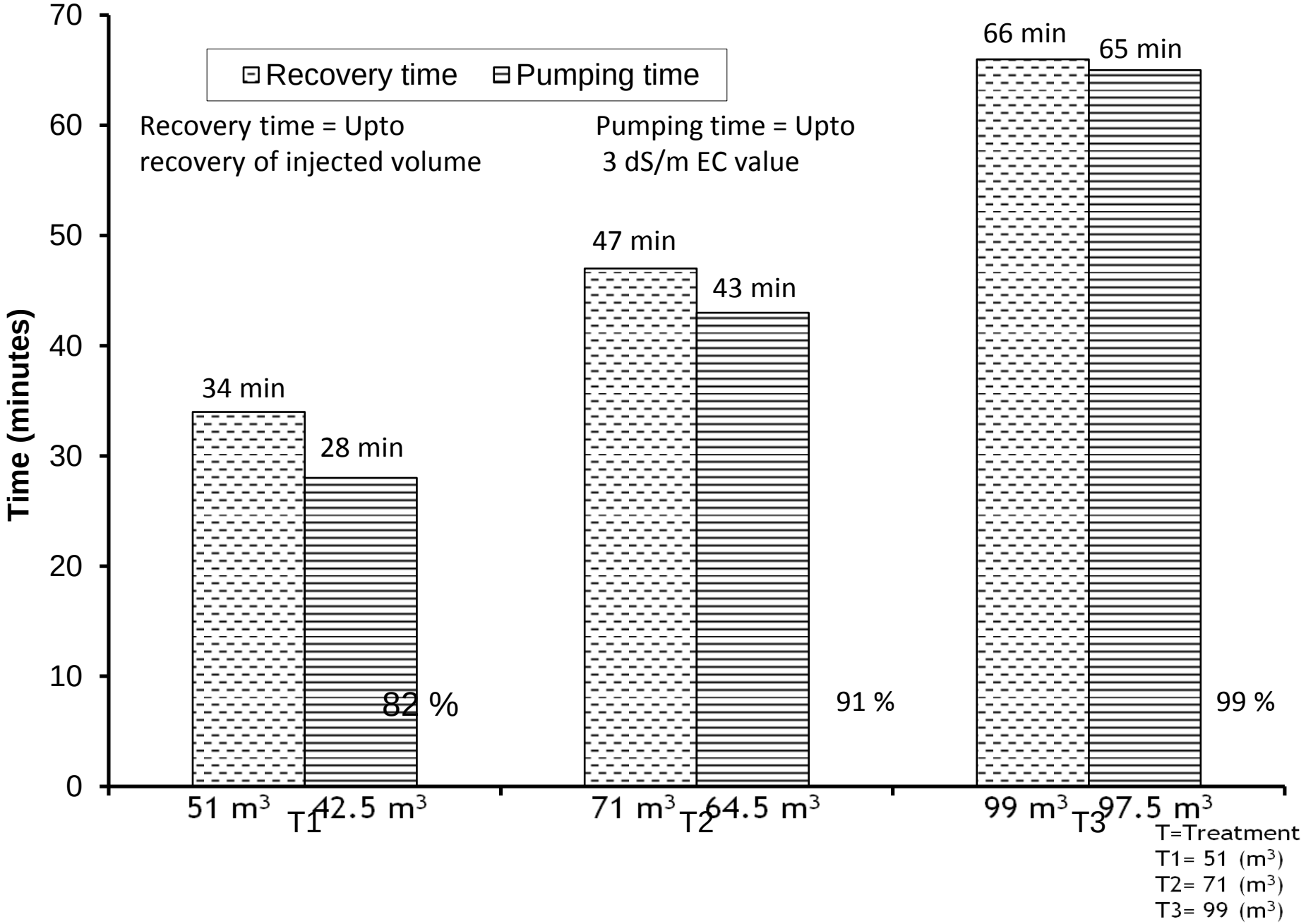
Recovery time is 70% of Injection time



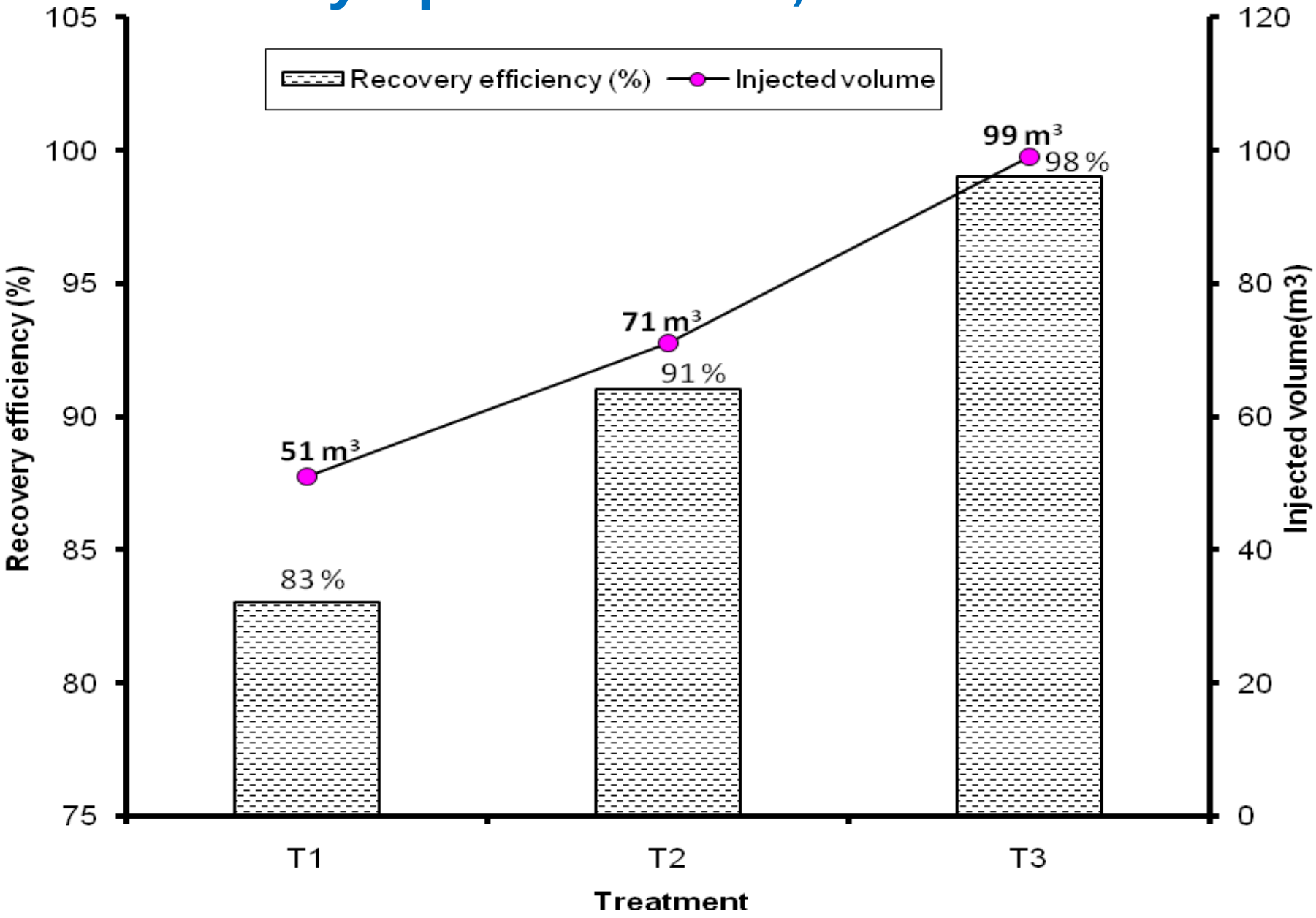
Relationship between Injection and Pumping time



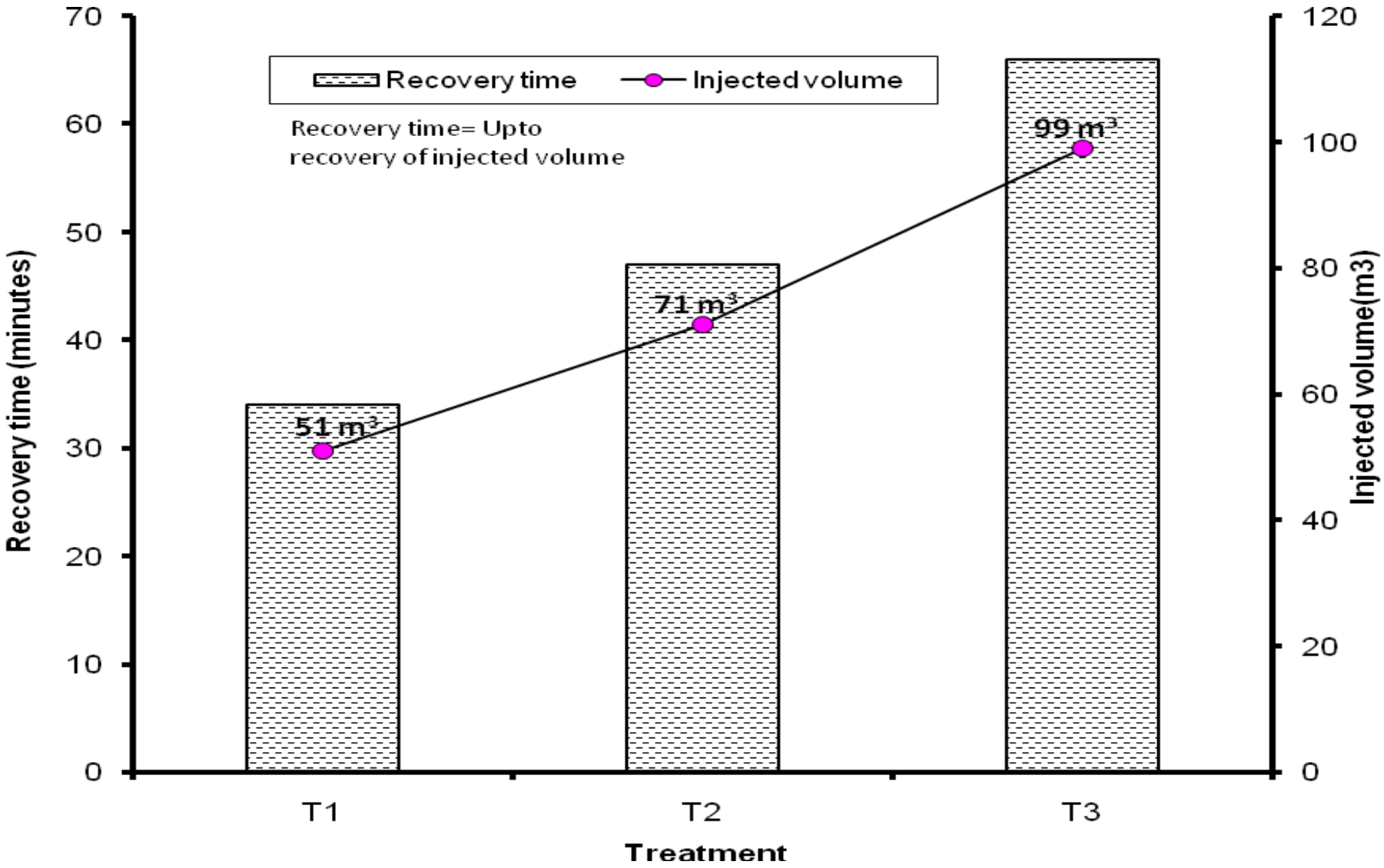
Relationship between Recovery and Pumping time



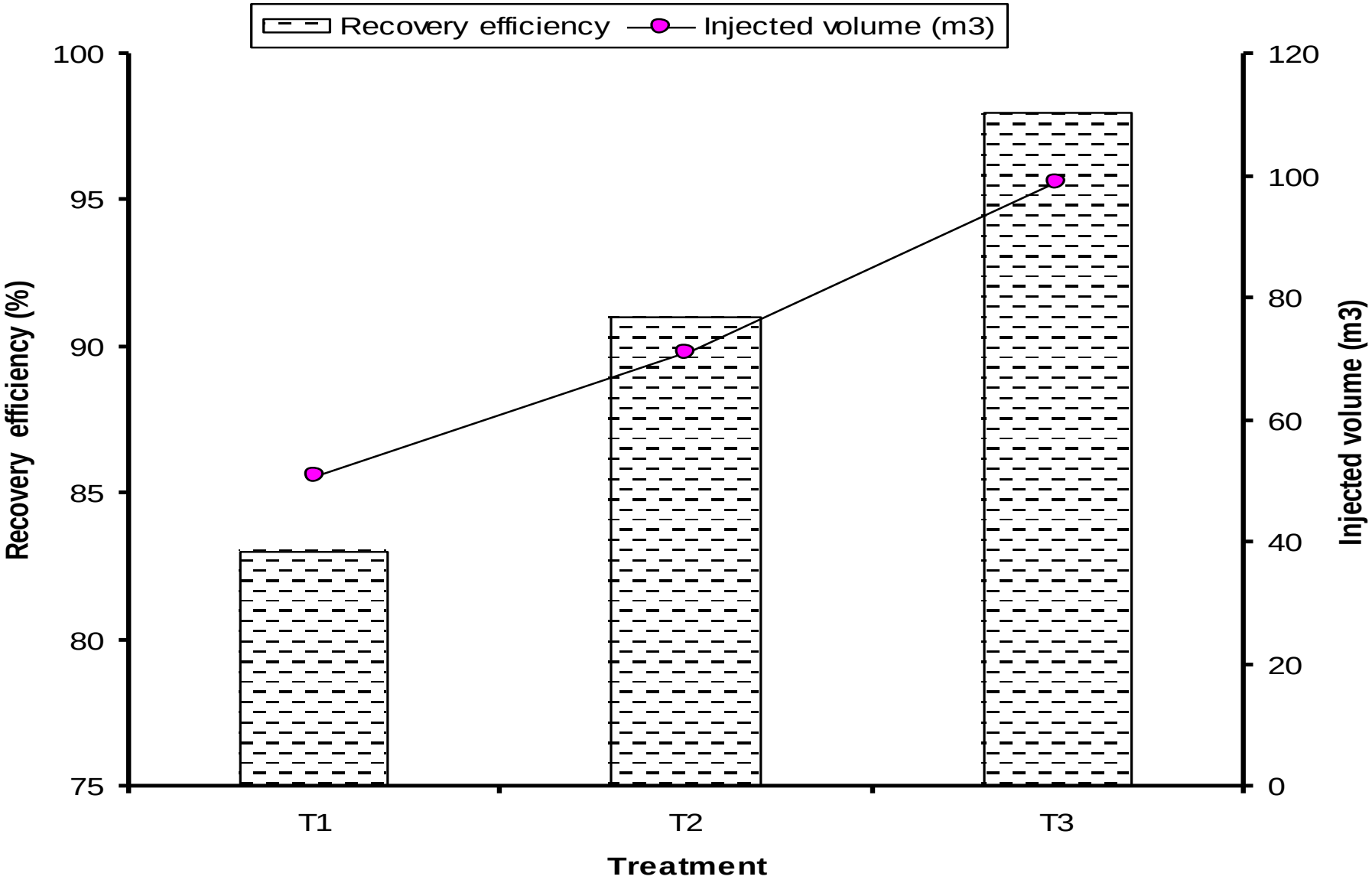
Recovery up to 3 dS / m; FAO Criteria



Recovery Time and Injected Volume



Efficiency and Injected Volume




Farmer's Day, 2009
Aquifer Storage & Recovery (ASR) Technology
ASR Benefits
ASR Findings
Water Quality Parameters
Construction Cost of Water Storage Tank
عادل کمپنیٹ
سروس موٹر

ASR Findings / Conclusions

- ASR recovery efficiency was found to be 80% for injected volume of 51 m^3; 91% for injected volume of 71 m^3 and 98% for injected volume of 99 m^3 , up to 3 dS/m.
- The recovered time was found to be 70% of injected time for injected volumes of 51, 71 and 99 m^3, respectively.
- The recovered volumes till EC value of 3 dS/m were 42.37 m^3 for 51 m^3; 64.5 m^3 for 71 m^3 and 97.5 m^3 for 99 m^3.
- The results suggested that Aquifer Storage and Recovery (ASR) technology has the potential to store water during period of surplus water to use it during peak hour demand.

Recommendations

- The injected volume of canal water should be more than 100 m^3 to recover the same volume of injected water having quality permissible for irrigation purposes.
- Farmer can pump the tubewell to irrigate the crops for the period of 42 minutes against the injection time of one hour, however, depending on the recharge and discharge rates of the site.
- Two farmers of the area have adapted ASR technology at their farms and many more are interested.

Construction Cost of Water Storage Tank

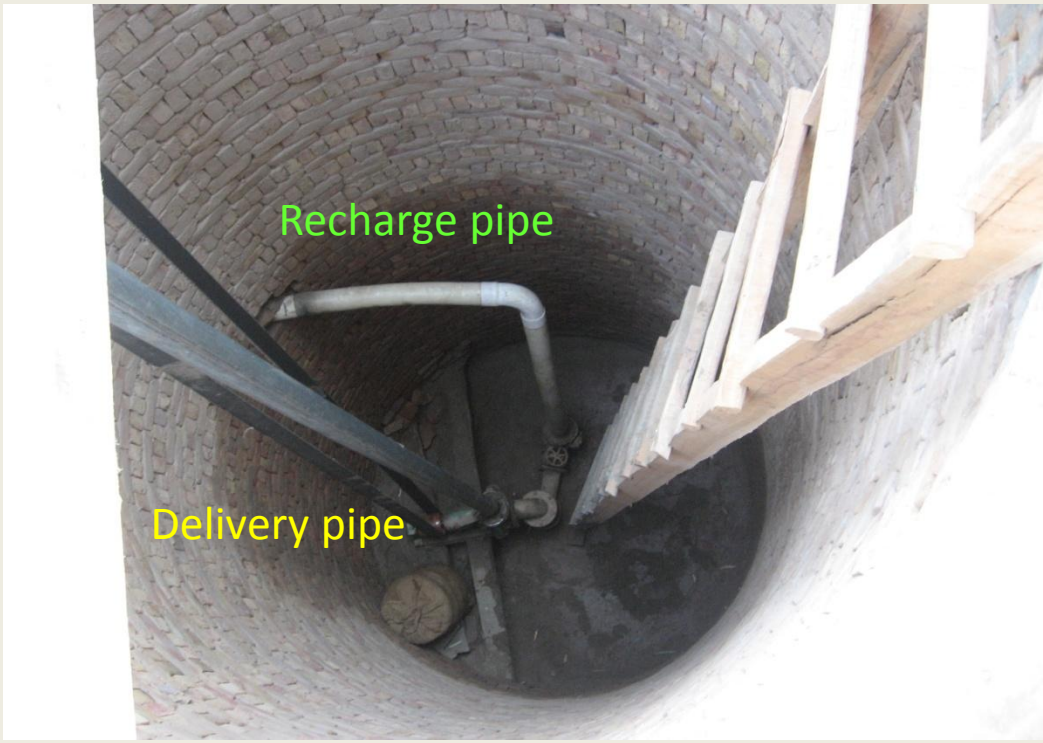
Specification of Water Storage Tank

Water storage tank size	= 15 x 15 x 13 ft
Gravel filtration basin	= 2 x 10 x 8 ft
Sediment settling basin	= 3 x 10 x 8 ft
Water intake section	= 4 x 6 x 8 ft

Total Cost	1,29,900

Aquifer Storage and Recovery Technology

- **A new technology to store water under ground for later use like**
- **Water bank**
- **Buffers between supply and demand**
- **Allows storage for irrigation**
- **No mosquito‘s**
- **No evaporation/seepage losses**
- **Underground water dam**
- **Land saving under surface storage**
- **Recovery efficiency 70 to 80%**
- **Recharge rate 0.63 cusec**
- **Pumping rate 0.89 cusec**



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بہتر مستقبل کیلئے پانی ذخیرہ کرو

☆زیرزمین پانی محفوظ کرنے کے جدید طریقے جیسے

☆پانی کا بینک

☆پانی کی فراہمی اور ضرورت میں توازن

☆آبپاشی کیلئے پانی کا ذخیرہ

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☆زیرزمین پانی کا ڈیم

☆زمین پر محفوظ کرنے پر زمین کی بچت

☆70% سے 80% تک دوبارہ پانی کا حصول

☆زیرزمین پانی محفوظ کرنے کی رفتار 0.63 کیوسک

☆پانی نکالنے کی رفتار 0.89 کیوسک

مزید معلومات کیلئے

پروفیسر ڈاکٹر اللہ بخش

شعبہ آبپاشی و نکاسی، زرعی یونیورسٹی فیصل آباد سے رابطہ کریں۔

Thanks

Suggestions / Comments