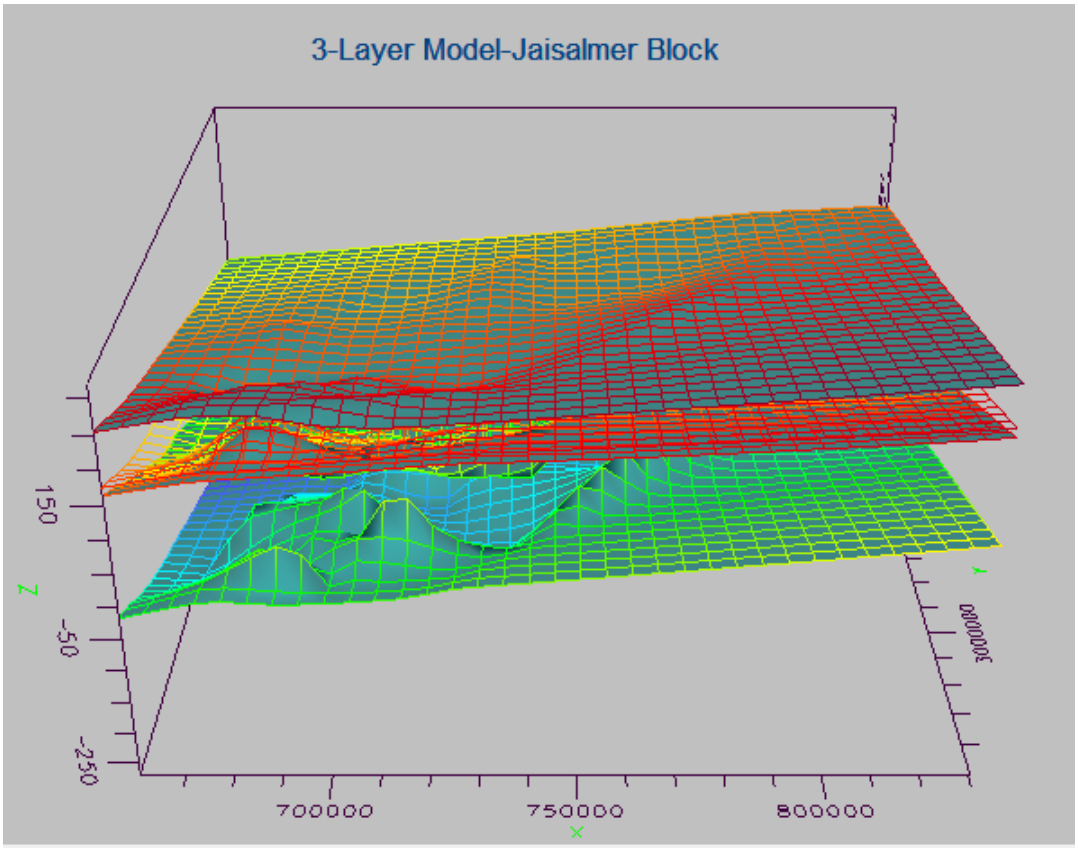
केन्द्रीय भूमि जल बोर्ड,
जल संसाधन, नदी विकास एवं गंगा संरक्षण मंत्रालय,
भारत सरकार

Central Ground Water Board
Ministry of Water Resources, River Development and Ganga Rejuvenation
Government of India

REPORT ON

GROUND WATER FLOW MODELLING OF JAISALMER BLOCK, JAISALMER DISTRICT, RAJASTHAN

(AAP 2018-19)



पश्चिमी क्षेत्र, जयपुर

Western Region, Jaipur

May 2019

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(AAP 2018-19)

By

Priya Kanwar,
Scientist C

Under Overall Supervision of

Dr. S. K. Jain,
Regional Director

पश्चिमी क्षेत्र, जयपुर

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REPORT ON
GROUND WATER FLOW MODELLING OF JAISALMER BLOCK,
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GROUND WATER FLOW MODELLING OF JAISALMER BLOCK, JAISALMER DISTRICT, RAJASTHAN (AAP 2018-19)

REGIONAL GROUNDWATER FLOW MODELLING

As a part of AAP 2018-19, the ground water flow modelling of 11,591 sq. km of Jaisalmer Block, Jaisalmer District was taken up in December-2018. The steady state and transient models were developed to evaluate the regional effects or changes in ground water resources associated with increased water demands and development. The model is developed and calibrated on the basis of hydrogeological data generated and collected during various previous studies, Aquifer Mapping Studies in Jaisalmer Block. Integrated hydrogeological, hydrological and geophysical data include the water levels of shallow and deeper zones along with the information of aquifers in terms of their depth ranges and thickness, lithological information and hydraulic properties.

Objective

The objective of the study is to –

i. Understand the aquifer dynamics and to assess the ground water potential.
ii. Design the predictive scenario of groundwater regime in case the present ground water budget pattern continues.
iii. Optimization of ground water development for sustainability of aquifers.
iv. Model the ground water flow system of Jaisalmer Block, with special emphasis on the fresh water artesian aquifers in saline areas.

Introduction of Study Area

Jaisalmer District, a part of Great Indian Thar Desert, is the third largest district of our country and is divided in three administrative blocks viz. Jaisalmer, Sam and Sankra. The Jaisalmer Block, covering an area of 11,591 sq. km is proposed for Mathematical Modelling of Ground Water System for the year 2018-19. The study area is barren, sandy, dry and scorched. It is bounded by Pakistan in north, Bikaner District in north-east, Sam Block in west & south-west and by Sankra Block in south & south-east. The area lies between north latitude 26°40'01" & 27°57'54" and east longitude 70°38'20" & 72°20'27" and is depicted in Fig. 1.

As per 2011 census, there are 375 villages in Jaisalmer Block and it the least populous CD Block of the district with total population 1,67,698 persons and sex ratio 861. Due to desertic conditions viz. dry, sandy and ill watered, vegetation is very scarce, thorny and wild, which does not survive more than a few months after rains.

Kharif is the main crop in the area. Bajra, Jowar, Creeping Pulse, Moong, Moth and Til are the important Kharif crops sown in the area. Rabi crops are grown only where applied irrigation and canal facility is available. The agricultural yield has to depend on rains. Minor irrigation is done through tanks locally known as "Khadeens" where rain water flows from their catchment areas into these tanks.

Cattle breeding is the single most important alternative source of livelihood for majority of rural population. The herds of cattle, camel, sheeps, goats, cows and bullocks serve as sole wealth of these people.

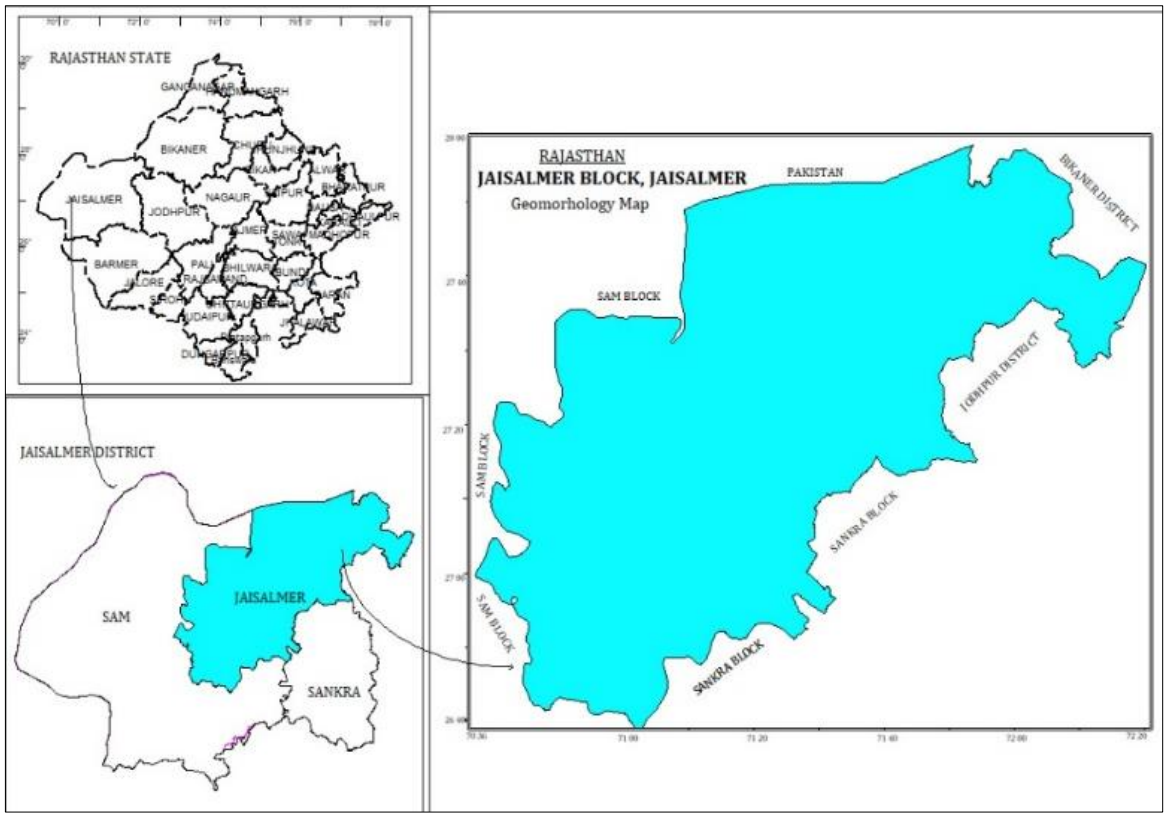


Fig.1: Base map of the area

Physiography

The Block being a part of Thar Desert, is almost sandy and dry. The area has limitless sand dunes of different shapes and varying sizes. However, the block headquarter viz. Jaisalmer town is surrounded by numerous rocky ridges and hard undulating plains with the exception of general nature of land there. These rocky ridges are usually parallel to the prevailing directions of wind. Around Jaisalmer these ridges consist of Jaisalmer Sandstone, Limestone and Lathi Sandstone. These ridges extend in the eastern direction from the southern edge of the block. So, the southern and south-eastern edge of the block is comparatively elevated and the topographic slope is towards Indus Valley viz. north-west. The elevation in the study area varies from 113 to 275 m amsl (Fig. 2)

Drainage

There is no perennial river in the area and no natural lakes. During rainy season water accumulates in several low-lying areas and inter-dunal flats which is used for drinking and domestic purposes.

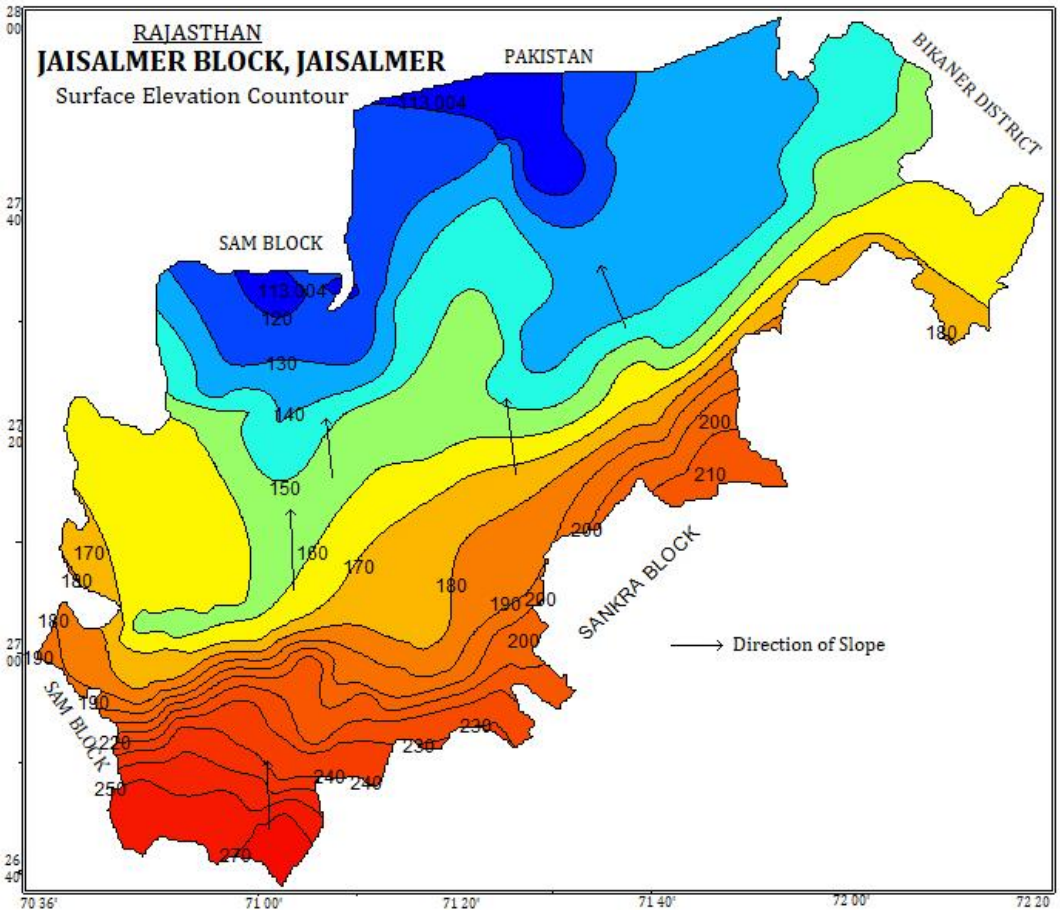


Figure 2: Surface Elevation Contour of Jaisalmer Block

Climate

The study area lies in arid tract of Thar desert characterised by extremes of hot and cold weather. As the area lies in the desert area, extreme of heat in summer and cold in winter, is the characteristic of the desert. Both day and night temperature increase gradually and reaches their maximum values in May and June. The temperature varies from 48 degree in summer to 2 degree in winter. Atmosphere is generally dry except during the monsoon period. The humidity is highest in August, with mean daily relative humidity in Jaisalmer district being 43 %. The annual maximum potential evapotranspiration in the district is 1850 mm and it is highest in the month of June and lowest in the month of December.

Rainfall

Rainfall is erratic and normal annual rainfall in Jaisalmer district is 185.5 mm. Droughts are frequent. Almost 90 % of the total annual rainfall is received during the southwest monsoon period from July to mid - September. The second half of September and October months constitutes post monsoon season. Average number of rainy days per year in the area is 12. The annual rainfall from 2001 to 2017 is presented in Figure 3.

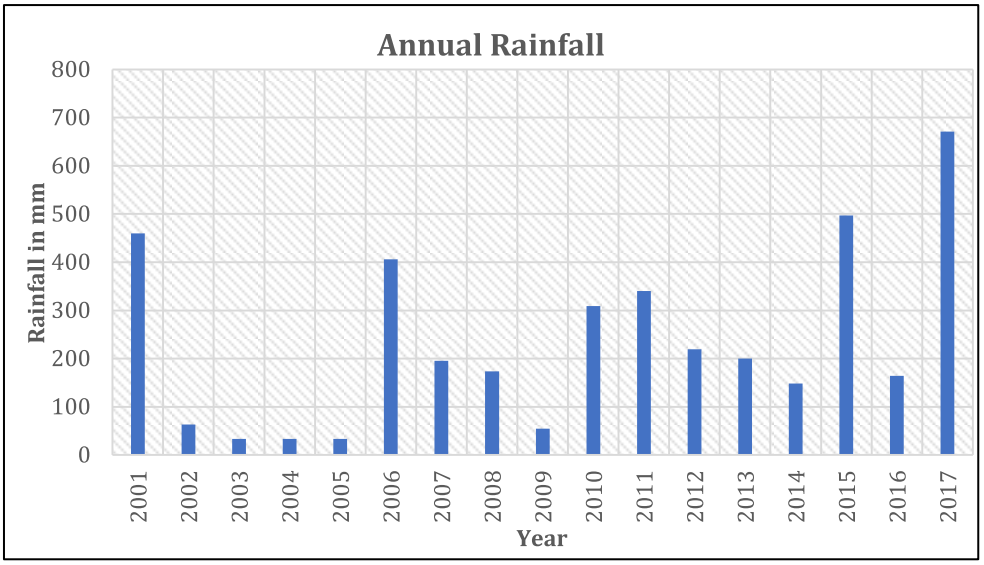


Figure 3: Annual Rainfall of Jaisalmer Block.

Geology

The area is occupied by Quaternary Alluvium in the northern part; Tertiary sandstone in central and Baisakhi, Jaisalmer and Lathi Sandstone formations of Mesozoic Age in the southern part of the Block. Geology of the area with location of exploratory boreholes and monitoring wells is presented in Figure 4.

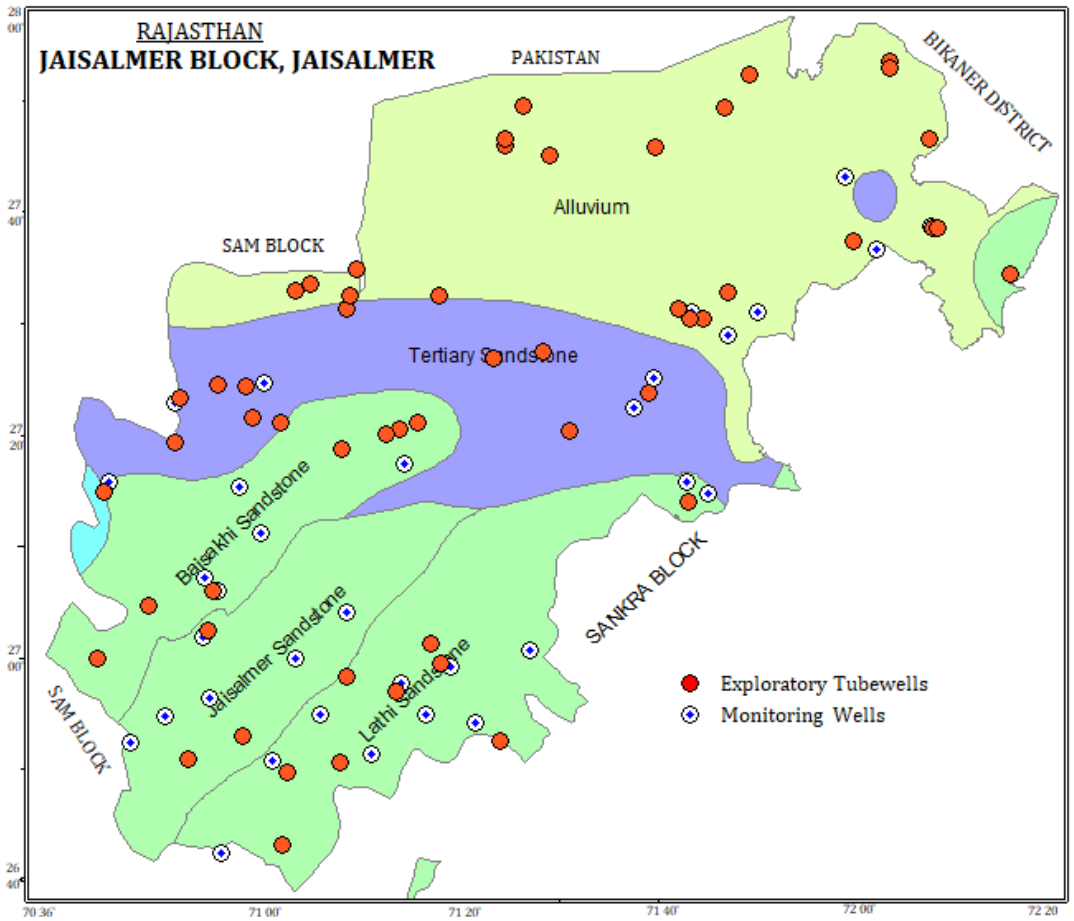


Figure 4: Geology of the Area

Groundwater Level Data

The groundwater level data from 56 Hydrograph Stations (CGWB & State GW Dept.) was used for preparing water table elevation contours. The water level data from observation wells as well as the static water level data of the exploratory wells were also taken into consideration, in the area where no observation stations of CGWB or State Ground Water department.

Out of 56 water level monitoring stations only 48 monitoring station were considered after validation (duplicate, erratic values). The water table map of unconfined and confined aquifer of the area is presented in Figure 5 & 6 respectively.

The tube wells having aquifer zones at a depth below 170 m, shallow water levels and wells having artesian conditions were considered for drawing water table elevation contours of confined aquifers. Analysis of these contours clearly indicates that the ground water flow direction follows the topographic slope not only in unconfined aquifer but also in confined aquifer viz from south-east to north-west.

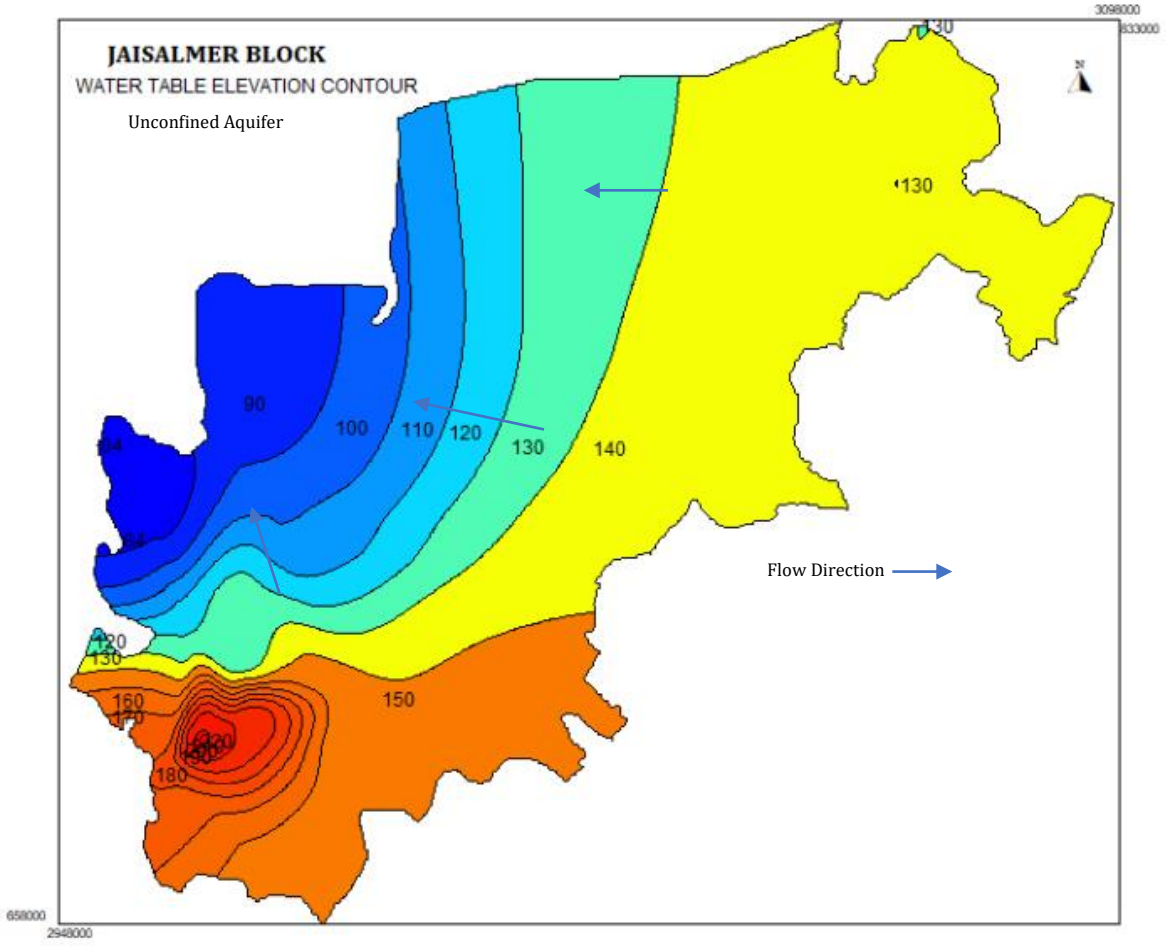


Figure 5: Water Table Contour Map of Unconfined (Shallow) Aquifer.

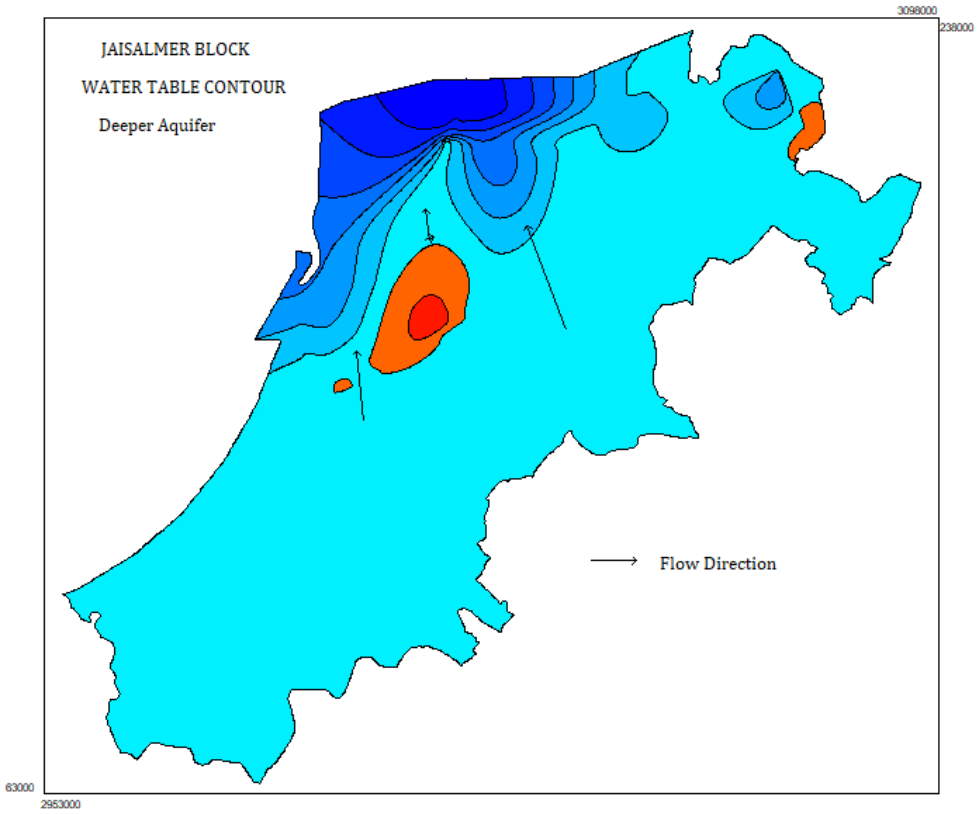


Figure 6: Water Table Contour Map of Confined (Deeper) Aquifer.

Ground Water Exploration

More than 90 tubewells are drilled in Jaisalmer Block till now by CGWB. Some wells drilled by the Rajasthan State Ground Water Department are also present in the area. Out of these tube wells drilled, 70 wells having complete data, was used in this study to demarcate different layers. A total of 29 exploratory tubewells and 25 observation wells were drilled in the block during 2017-18, through outsourcing, down to a depth of 300 m bgl. These wells were drilled with an objective to tap the deeper and confined aquifer.

To demarcate the lithological scenario of the block, all the lithologs were plotted on an A0 size map and a fence diagram depicting the 3-Dimensional lithological disposition of the block was prepared. To demarcate the major layers, thin lenses were clubbed with the major lithological formations in the lithologs.

The aquifer parameters viz. transmissivity, storativity, computed during the Aquifer tests wells were used as input parameters in the model.

Modelling Protocol

The modelling protocol used in this study for the construction of a numerical model involves the following steps:

- Data collection, acquisition and processing of primary data,
- Conceptual model building by field data input,
- Numerical model building,
- Model design/application by parameter input,

- Model Calibration and Validation,
- Prediction,
- Presentation of Results,
- Post audit through field data,

Development of Conceptual Model

Based on the available geological, hydrogeological, hydrological, geophysical and meteorological data, a ground water model of Jaisalmer Block has been conceptualized. The study area is occupied by younger alluvium and sandstone formations of different periods. The tertiary sandstone that lies adjacent to the alluvium resembles it. Baisakhi sandstone has very less groundwater potential whereas Jaisalmer and Lathi sandstones of Jurassic age have comparatively higher ground water potential. Groundwater is found to occur in unconfined conditions in the weathered formation and unconfined/confined in alluvium at deeper depths, separated by an impervious layer viz. aquitard and fractured sandstone formation. The ground water exploration is mostly confined to 300 m bgl, thus the thickness of this three-layer model was assumed to be 300 m.

Grid Design

The total area of the model is 11,591 sq. km which is discretised into 31 rows and 35 columns, with the cell size of 5000 x 5000 m (Fig. 7). Active node numbering 589 are used to cover the study area shown as white coloured cells. Remaining nodes about 496 are not considered for computation are shown in grey colour cells and are outside the model area.

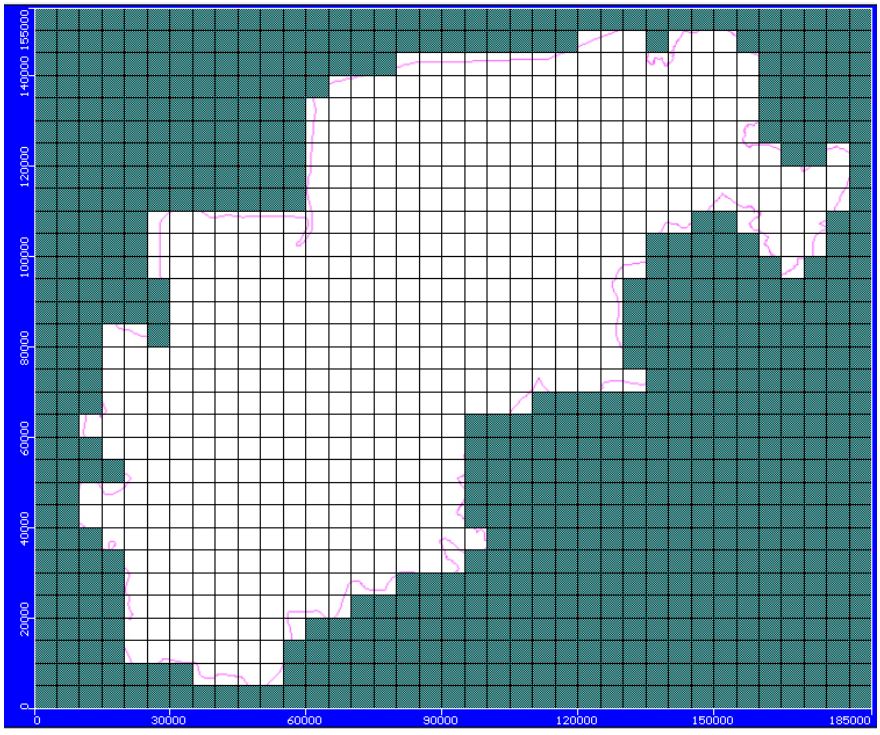


Figure 7: Model Grid

The available elevation data for EW's and water level monitoring stations has been assigned and interpolated for grid model by natural neighbour method.

Assumption in Conceptual Model

Following general simplified assumptions are used in the development and calibration of model :

1. A three-layer aquifer system has been assumed Figure 8.
2. General ground water flow direction is from south east to north-west.

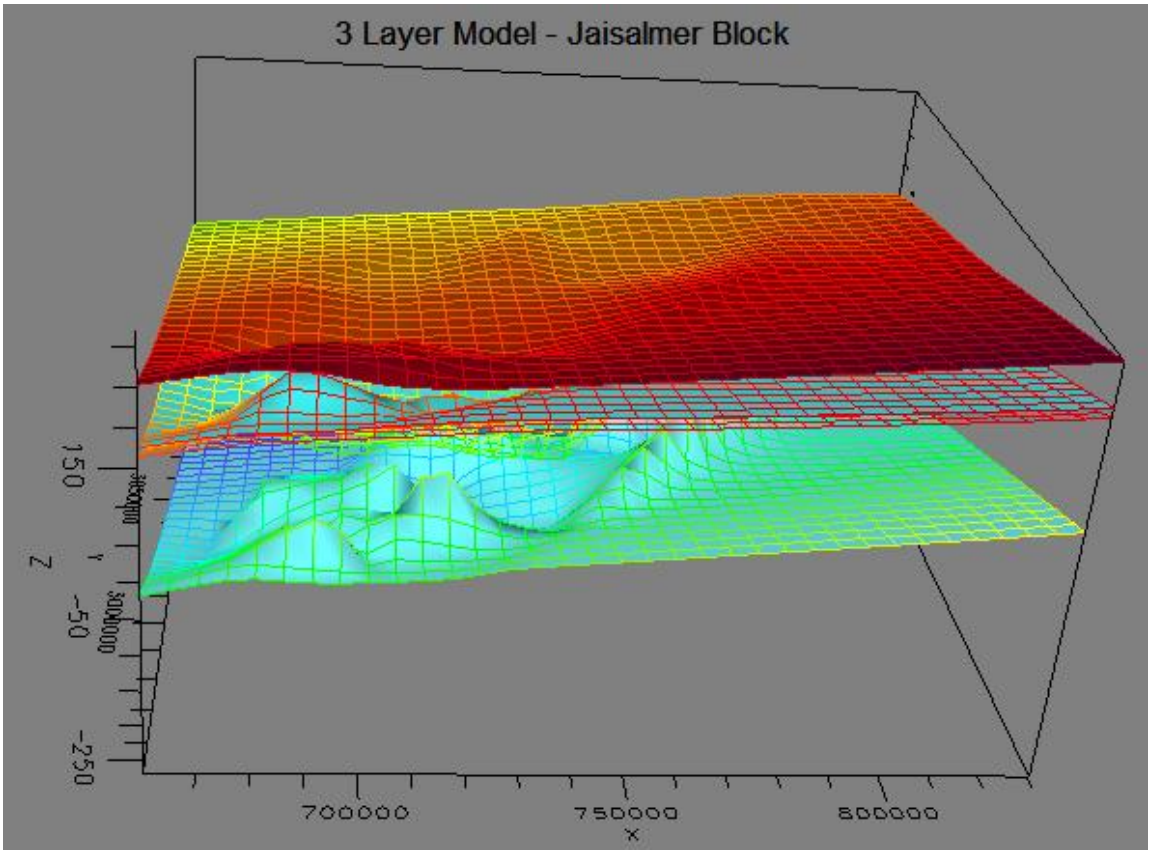


Figure 8: Assumed three-layer aquifer system.

Aquifer Geometry

The physical parameters, that includes aquifer top and bottom elevations, are assigned to the model. The aquifer geometry is mainly derived from the subsurface characterization using the borehole logs of 70 exploratory wells, dug well section and geological information collected during the field work. Based on lithologs, the model is characterized by three layers, out of these, first unconfined aquifer (top layer) and second confined aquifer is separated by a 30-50 m thick impervious clay layer.

Table 1: Layer Characterization of Jaisalmer Model

Layers	Aquifer Type		Top Elevation Range	Bottom Elevation Range	Average Thickness (m)
Layer I	Unconfined	Dynamic GW	275.1 to 113	222 to -73	100 - 125
Layer II	Impervious	-	222 to -73	200 to -111	30 - 50
Layer III	Confined	In Storage	200 to -111	113.7 to -187	150 - 170

Boundary Conditions

Defining the boundary conditions of the modelling area was a difficult task, as there is no physical / geomorphological feature in and around the study area such as neither river nor hill etc. Hence, ground water flow direction and comparatively higher elevation along the south-eastern edge viz. Lathi sandstone, and some of the parts on the north western edge of the model are considered to have constant head boundaries Figure 9.

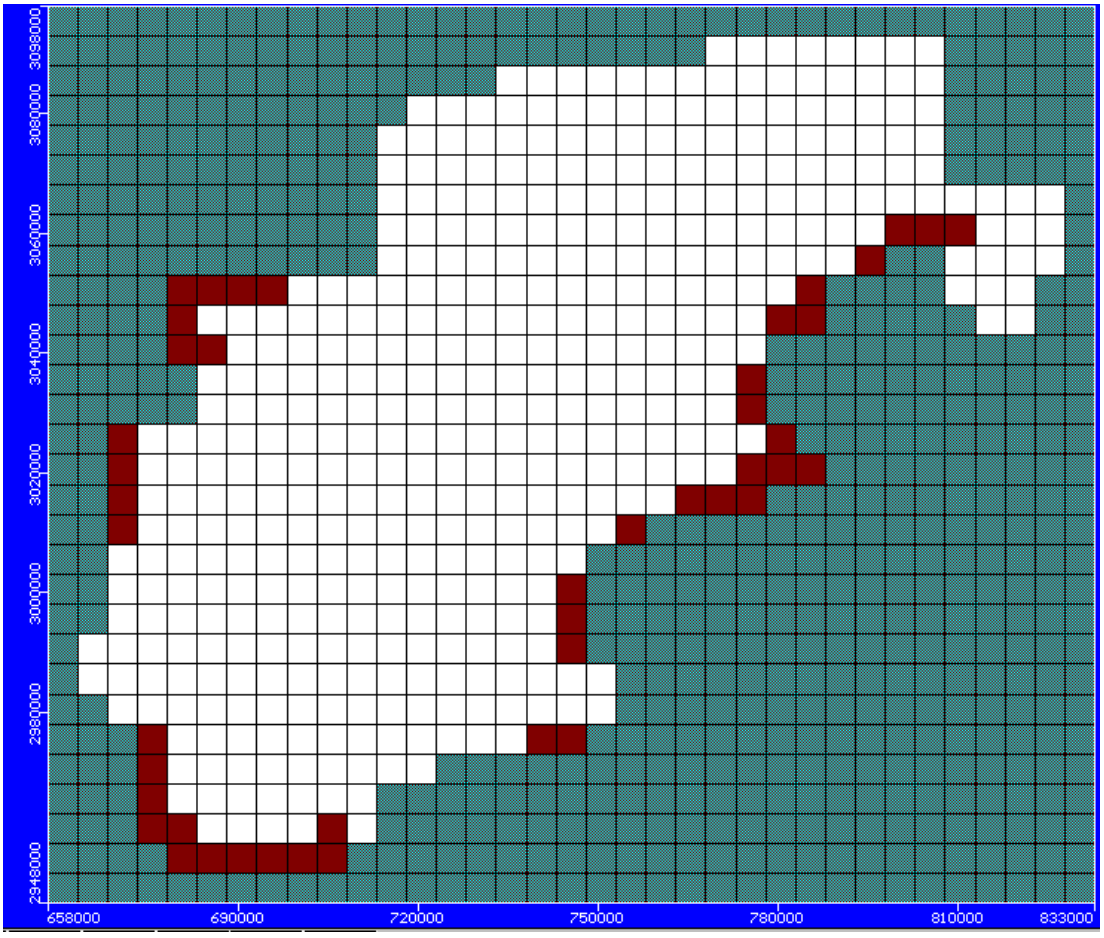


Figure 9: Boundary Conditions of the Modelling Area.

Input Parameters

Initial Groundwater head

After detailed analysis of the hydrographs, rainfall and water level fluctuation, it was decided that the average water table elevation of pre-monsoon season from May-2012 to May-2018 will be taken as initial heads in steady state simulation. As there were no control points in the western part of the model area, the static water level data of the exploratory tubewells was considered for initial head values. For Initial heads, data of 45 wells was considered (Annexure I) whereas the data of only 22 observation points was available in time series of 7 years, for input in head observations in transient model (Annexure III).

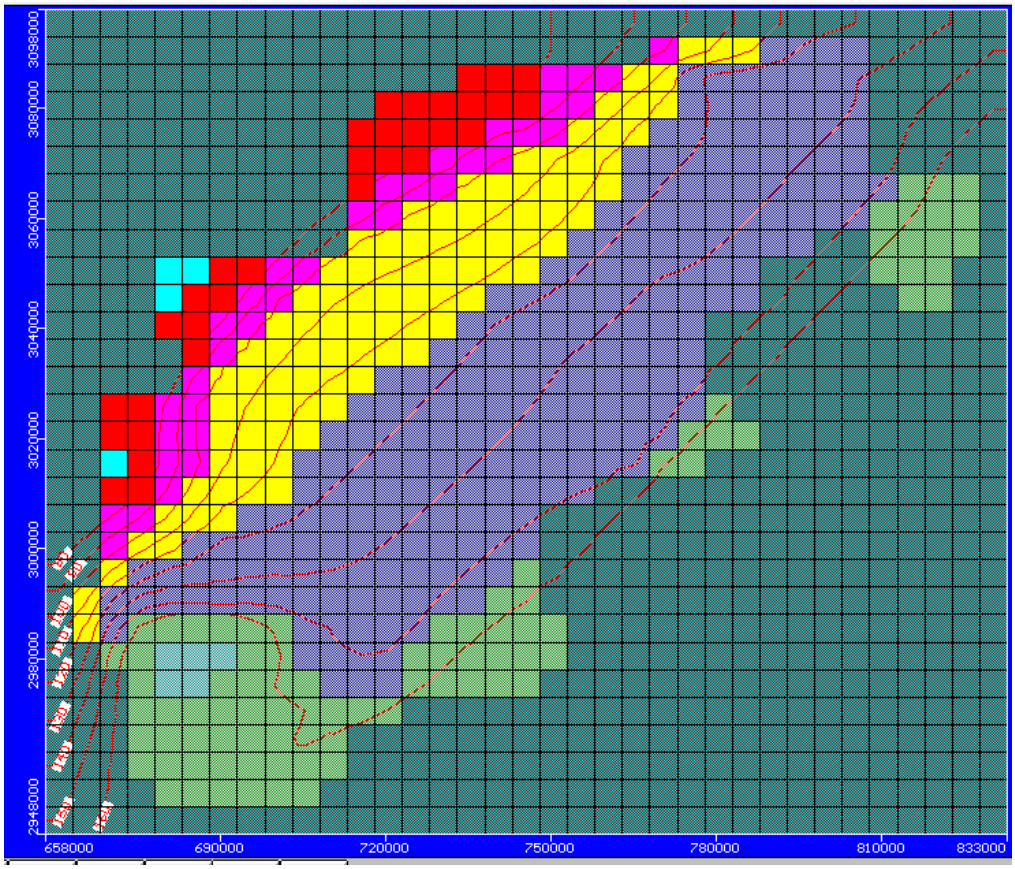


Figure 10: Initial Head Contours

Hydraulic conductivity and specific yield

Considering the geological and geomorphologic characteristics, the area is mainly divided into two major zones of different hydro-geological characters i.e. Alluvium and Sandstone. Alluvium is Quaternary and extends in the northern part of study area whereas the sandstone belongs to different ages and bears different hydrogeologic properties and behaviour. Therefore, following five hydrogeological zones are utilized to estimate zone budget in the model (Figure 11).

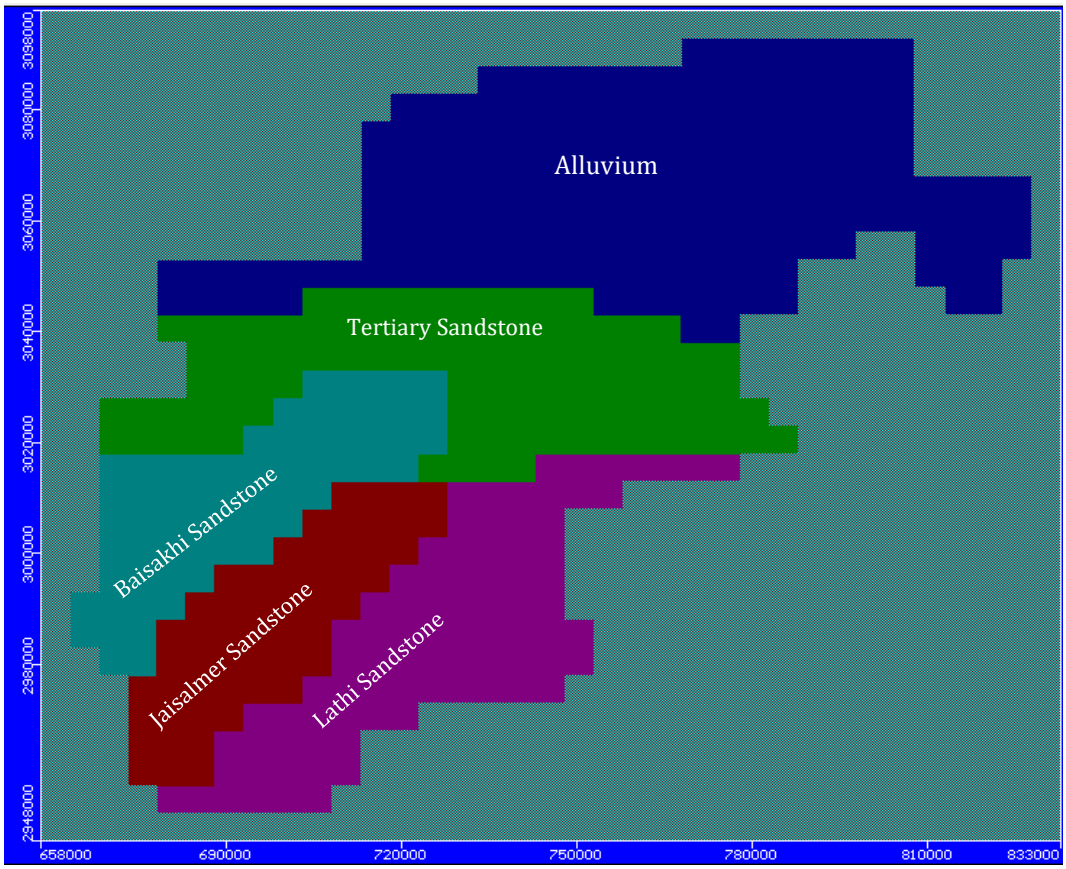


Figure.11 Hydrogeological Zones in the model area.

For inputting the aquifer properties in the model, the available data and the data generated during the fieldwork has been considered. Similar zones have been considered and assigned suitable values of Hydraulic conductivity and Storage Parameters as given below.

Table 2: Aquifer Parameters of the hydrogeological formations as assigned to the model

Hyrdrogeological Zones	K	Ss	Sy	Effective Porosity	Total porosity
Alluvium	1.698	1.00E-05	0.2	0.15	0.3
Teriary Sandstone	1.787	1.00E-05	0.04	0.15	0.3
Baisakhi Sandstone	0.284	1.00E-05	0.07	0.15	0.3
Jaisalmer Sandstone	5	1.00E-05	0.07	0.15	0.3
Lathi Sandstone	11.1	1.00E-05	0.1	0.15	0.3
Aquitard	0.0001	1.00E-06	0.01	0.01	0.4

Recharge due to rainfall

Recharge to this model consisted of infiltration from precipitation. Recharge was applied to the active model area as a spatially varying, specified flux to the uppermost active layer. In general, precipitation recharge varies spatially with land-surface permeability, which is a function of soil characteristics and land use. In Jaisalmer Block,

being a dry desertic area as such no significant land use pattern is there. Agriculture is confined mostly to monsoon season and the only urban area, lies around Jaisalmer Town. The rainfall infiltration factor is taken as 0.05 as considered during resource estimation.

Draft

Within the study domain, discharge input is the groundwater pumping in the area. The time variant groundwater draft has been assigned to each grid using the annual draft from Ground Water Resource Estimation. The draft generated in the area has been subtracted from the recharge and net recharge is assigned to each zone as mentioned in the table 3. The draft for deeper/confined aquifer is not available.

Table 3: Recharge and Draft for all Hydrogeological Zones for all time steps

Start Time	Time	Formation	Area (sq km)	Draft (mcm)	Draft (m/day)	Rainfall (m)	RIF	Recharge (m/day)	Net Recharge (m/day)
0	365	Alluvium	4228.03	0.1215	1.57462E-07	0.22	0.05	0.00003	2.98425E-05
365	730	Alluvium	4228.03	0.162	1.04975E-07	0.20	0.05	2.73973E-05	2.72923E-05
730	1095	Alluvium	4228.03	0.274	3.55099E-07	0.15	0.05	2.0274E-05	1.99189E-05
1095	1460	Alluvium	4228.03	0.386	5.00249E-07	0.50	0.05	6.81507E-05	6.76504E-05
1460	1895	Alluvium	4228.03	0.405	5.24873E-07	0.21	0.05	2.90959E-05	2.8571E-05
1895	2190	Alluvium	4228.03	0.517	6.70023E-07	0.33	0.05	4.57534E-05	4.50834E-05
0	365	Tertiary	2276.85	1.6246	1.95488E-06	0.22	0.05	0.00003	2.80451E-05
365	730	Tertiary	2276.85	3.0567	3.67812E-06	0.20	0.05	2.73973E-05	2.37191E-05
730	1095	Tertiary	2276.85	4.39	5.28247E-06	0.15	0.05	2.0274E-05	1.49915E-05
1095	1460	Tertiary	2276.85	5.73	6.89489E-06	0.50	0.05	6.81507E-05	6.12558E-05
1460	1895	Tertiary	2276.85	7.099	8.5422E-06	0.21	0.05	2.90959E-05	2.05537E-05
1895	2190	Tertiary	2276.85	8.43	1.01438E-05	0.33	0.05	4.57534E-05	3.56096E-05
0	365	Baisakhi	1387.5	0	0	1.22	0.05	0.000166986	1.67E-04
365	730	Baisakhi	1387.5	0	0	0.20	0.05	2.73973E-05	2.73973E-05
730	1095	Baisakhi	1387.5	0	0	0.15	0.05	2.0274E-05	2.0274E-05
1095	1460	Baisakhi	1387.5	0	0	0.50	0.05	6.81507E-05	6.81507E-05
1460	1895	Baisakhi	1387.5	0	0	0.21	0.05	2.90959E-05	2.90959E-05
1895	2190	Baisakhi	1387.5	0	0	0.33	0.05	4.57534E-05	4.57534E-05
0	365	Jaisalmer	1487.5	4.98	9.17233E-06	0.22	0.05	0.00003	2.08277E-05
365	730	Jaisalmer	1487.5	5.70605	1.05096E-05	0.20	0.05	2.73973E-05	1.68877E-05
730	1095	Jaisalmer	1487.5	5.73	1.05537E-05	0.15	0.05	2.0274E-05	9.72027E-06
1095	1460	Jaisalmer	1487.5	5.76	1.0609E-05	0.50	0.05	6.81507E-05	5.75417E-05
1460	1895	Jaisalmer	1487.5	5.8	1.06826E-05	0.21	0.05	2.90959E-05	1.84133E-05
1895	2190	Jaisalmer	1487.5	5.83	1.07379E-05	0.33	0.05	4.57534E-05	3.50155E-05
0	365	Lathi	2125.12	46.03	5.93423E-05	0.22	0.05	0.00003	-2.93423E-05
365	730	Lathi	2125.12	57.8877	7.46294E-05	0.20	0.05	2.73973E-05	-4.72321E-05
730	1095	Lathi	2125.12	58.48	7.5393E-05	0.15	0.05	2.0274E-05	-5.5119E-05
1095	1460	Lathi	2125.12	59.08	7.61665E-05	0.50	0.05	6.81507E-05	-8.01584E-06
1460	1895	Lathi	2125.12	59.59	7.6824E-05	0.21	0.05	2.90959E-05	-4.77281E-05
1895	2190	Lathi	2125.12	60.19	7.75976E-05	0.33	0.05	4.57534E-05	-3.18441E-05

Steady State Simulation

The model was simulated in steady state condition using the finite-difference approximation of three-dimensional partial differential equation of groundwater flow in the aquifer using average water table elevation of pre-monsoon season from May 2012 to May 2018 in the area.

Steady State calibration

The model was calibrated for steady state conditions. The average water table elevation of pre-monsoon season from May 2012 to May 2018 were considered for steady state model calibration.

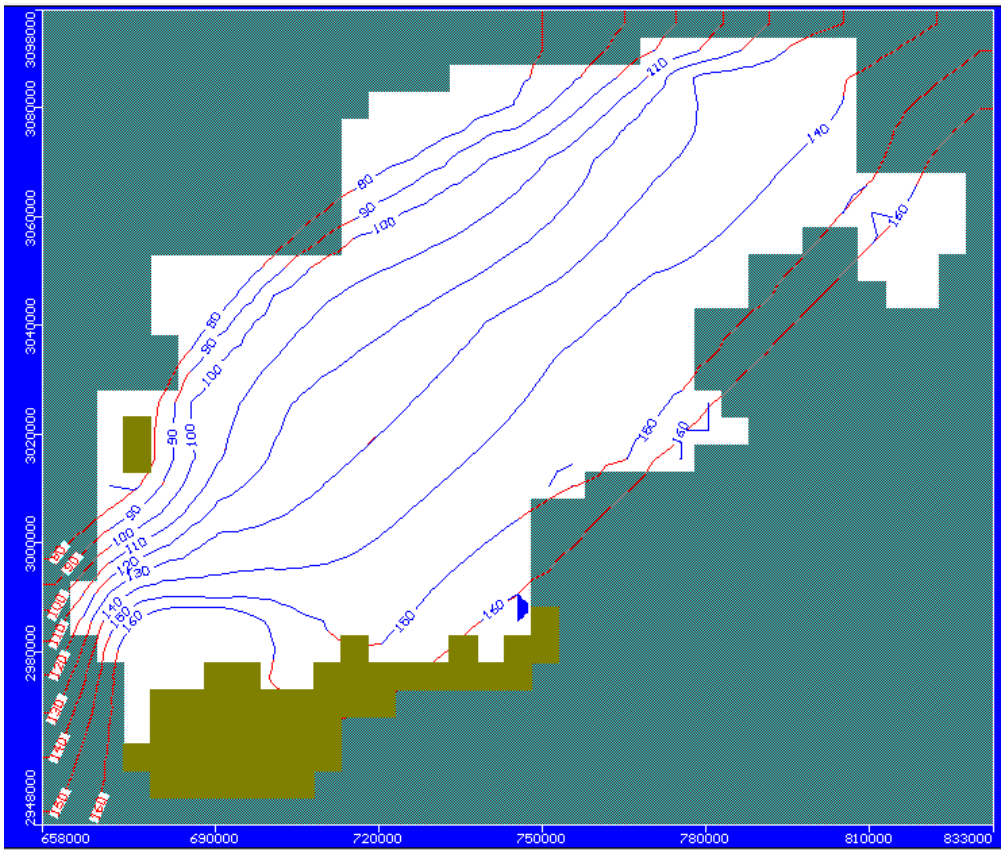


Figure 12. Comparison of computed and observed groundwater head under steady state

Transient State Simulation

In Transient state, head changes with time thus it is also called time dependent, unsteady, non-equilibrium, or non-steady state problem.

As the calculated heads of steady state were superimposing the observed heads same values were taken as initial heads in transient state. In addition to the final hydraulic conductivity values and storage parameters of steady state model, grid wise calculated ground water recharge and draft has been assigned to the transient state model. Transient state simulation was carried out for a period of 4 years from May 2012 to May 2016 with yearly stress periods and 4 time steps.

Transient State calibrations

The calibration of transient model was achieved by several trials until a good match between computed and observed heads was obtained over space and time by slight modification of the input and output parameters for every run. In the north western part of the model area, there are no observation wells and no data were available for any of wells in any time period thus in this part match of the contours was not done.

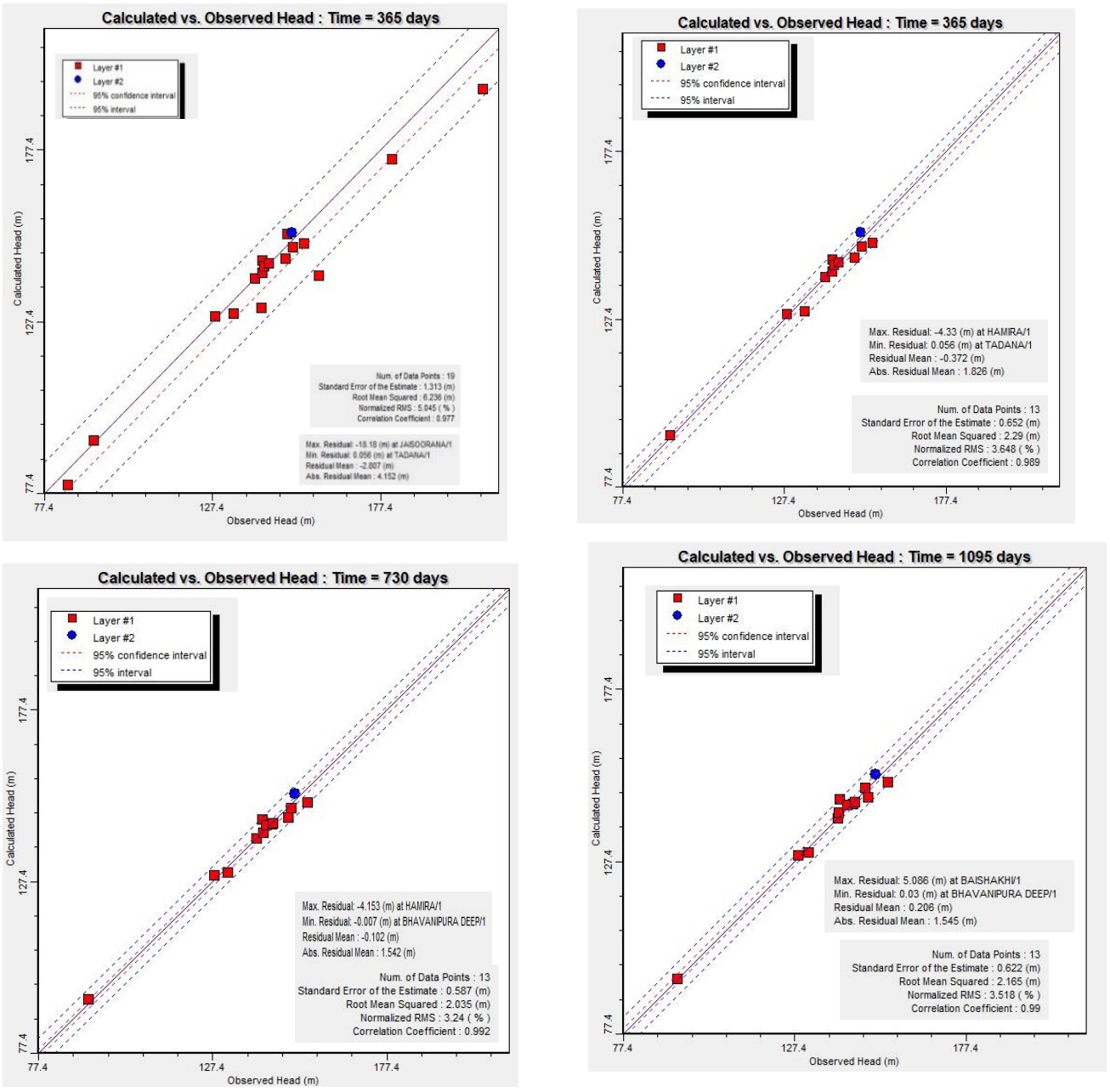


Figure 13: Head Scatter Graphs for Different Time Steps of Calibrated Model

Model Validation

The transient model was calibrated for two years viz. May 2017 and May 2018. The calculated and observed values of head was found to be comparatively matching with

RMS error of 2.555 and 2.498 and the normalised RMS error comes to 1.151 and 3.959 for 2017 and 2018 respectively. The normalised RMS of all the time steps is shown in figure 15.

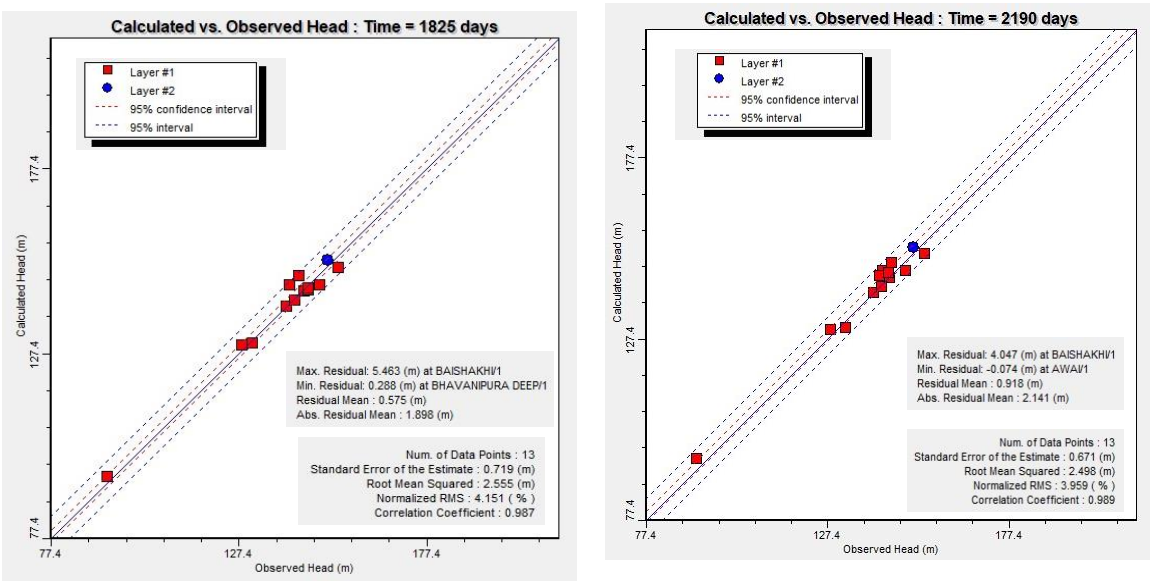


Figure 14 : Head Scatter Graph of Observation Points for Validation Periods 2017 and 2018.

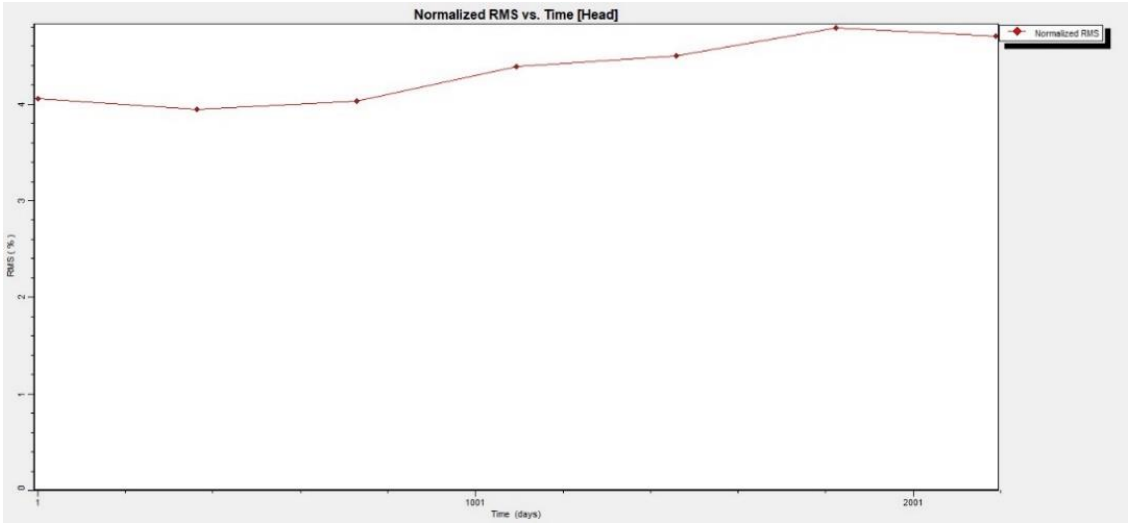
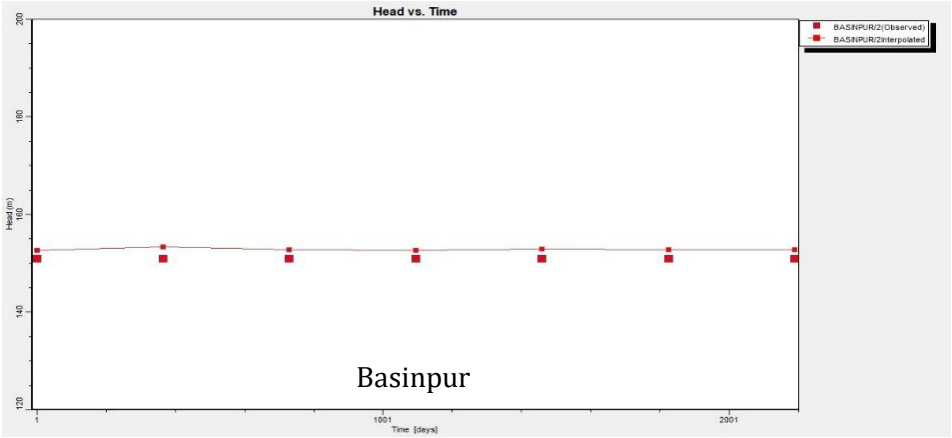


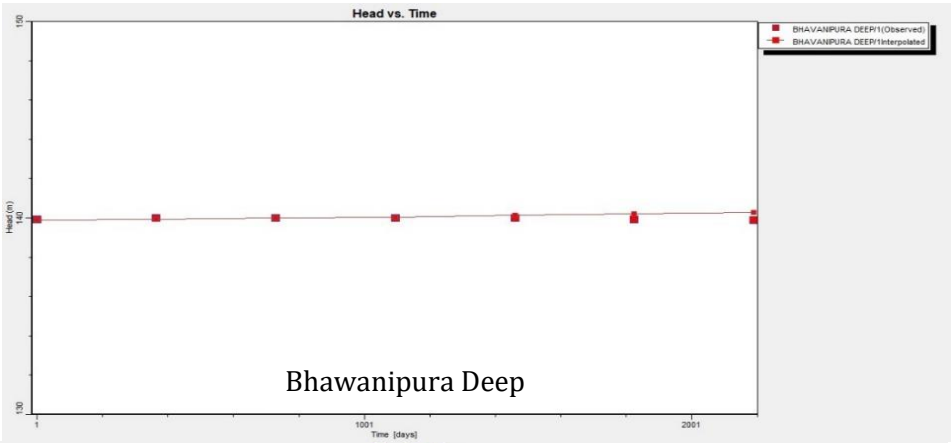
Figure 15 : Normalised RMS of all the time steps.

Observed and Calculated Head Difference

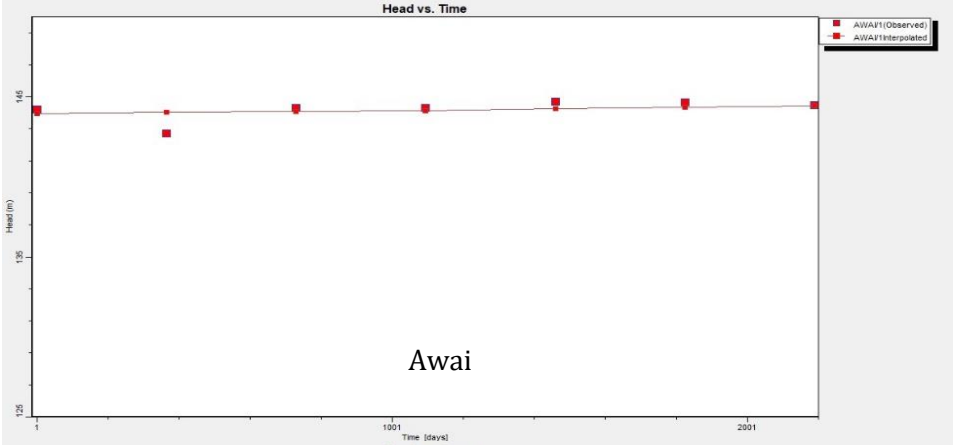
The difference in observed/ measured head values and the values calculated by the model for each time step viz. calibrated as well as validated is presented in the tables below. Three wells viz. Jaisoorana, Jaisalmer and Mohangarh are even though following the same trend in the hydrograph the head difference is more. The hydrographs of some wells with observed and calculated heads are shown in Figure 16.



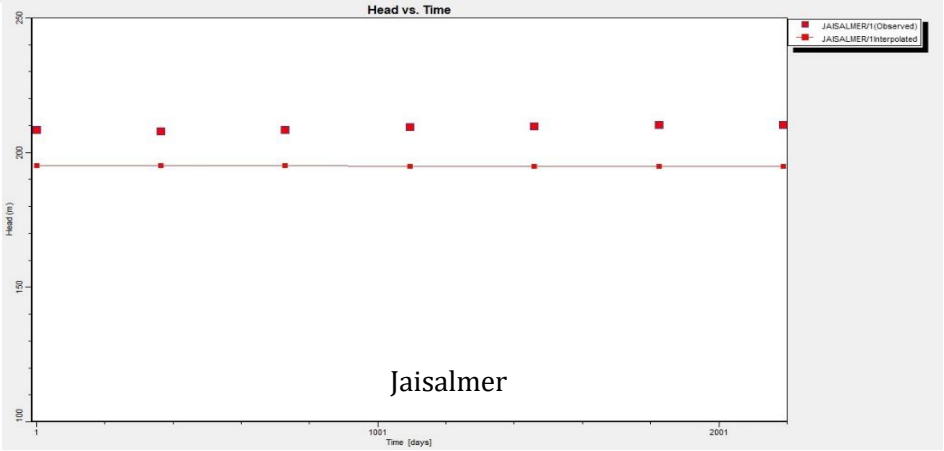
Basinpur



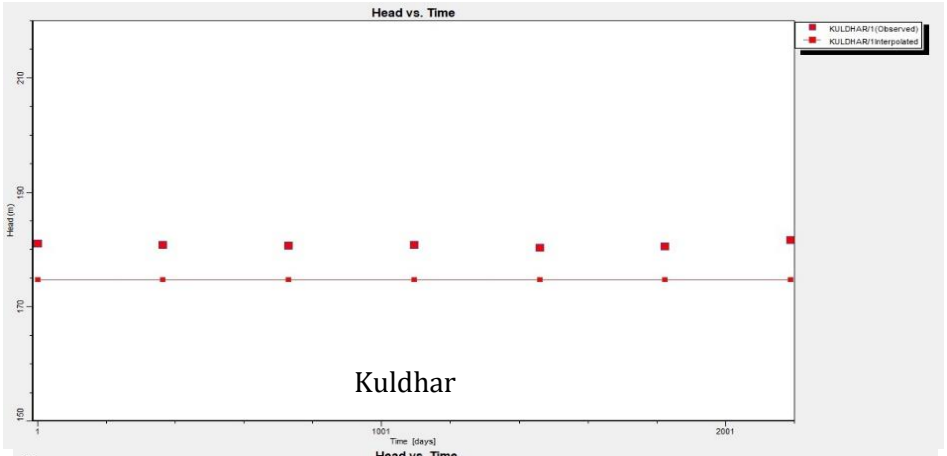
Bhawanipura Deep



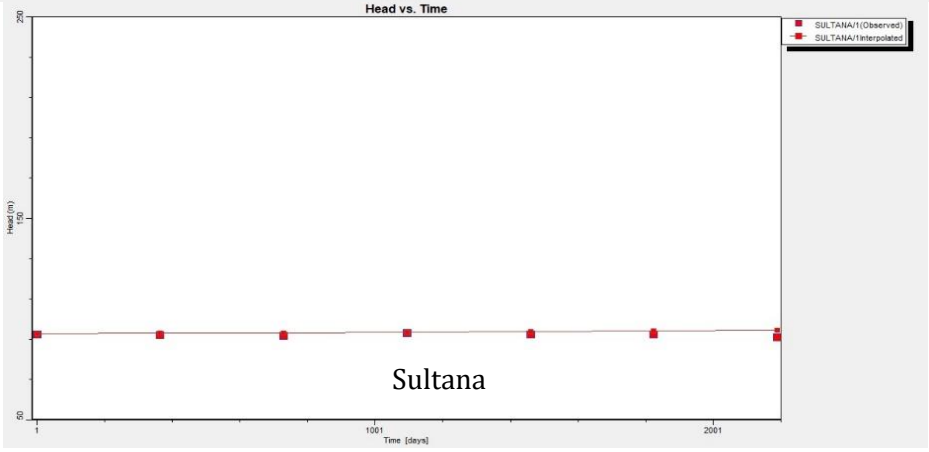
Awai



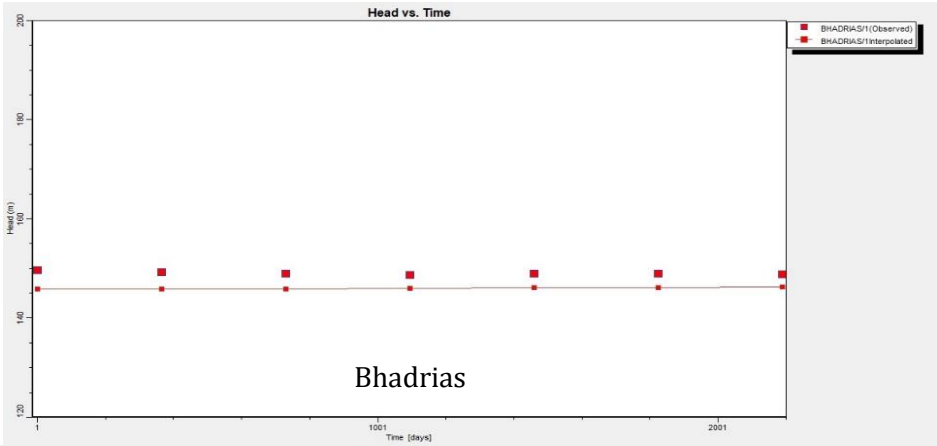
Jaisalmer



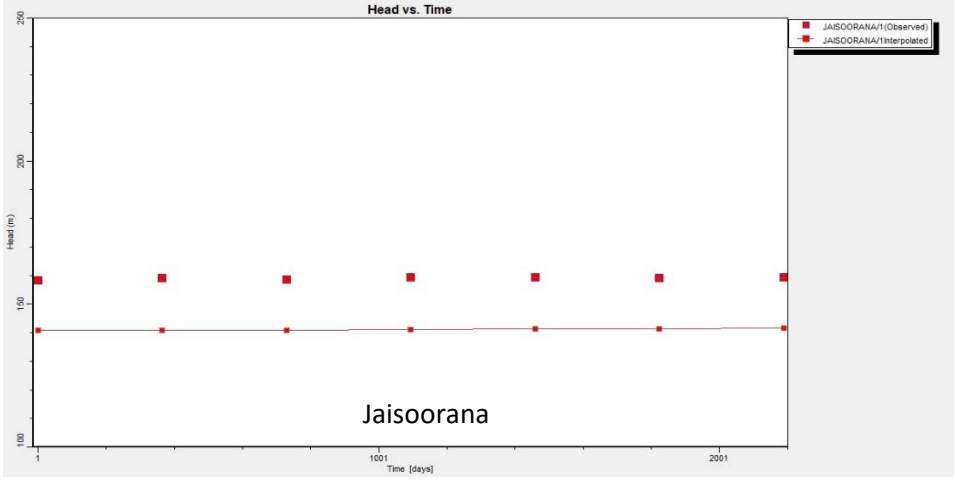
Kuldhar



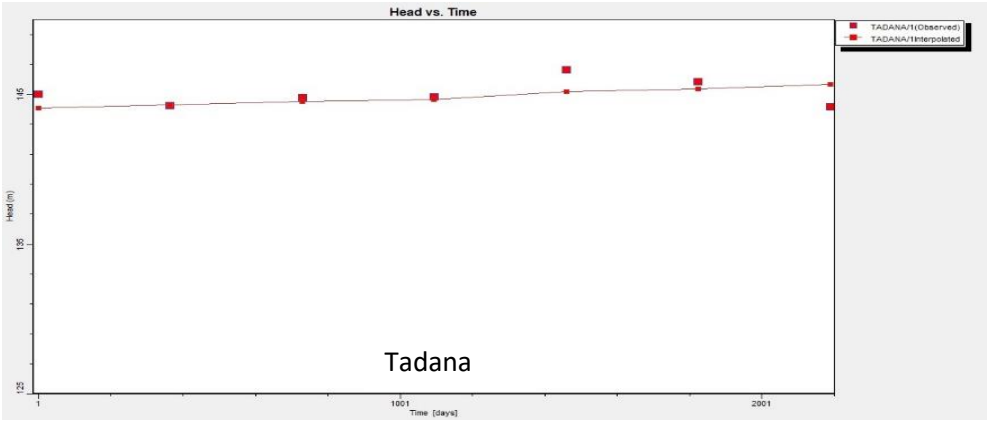
Sultana

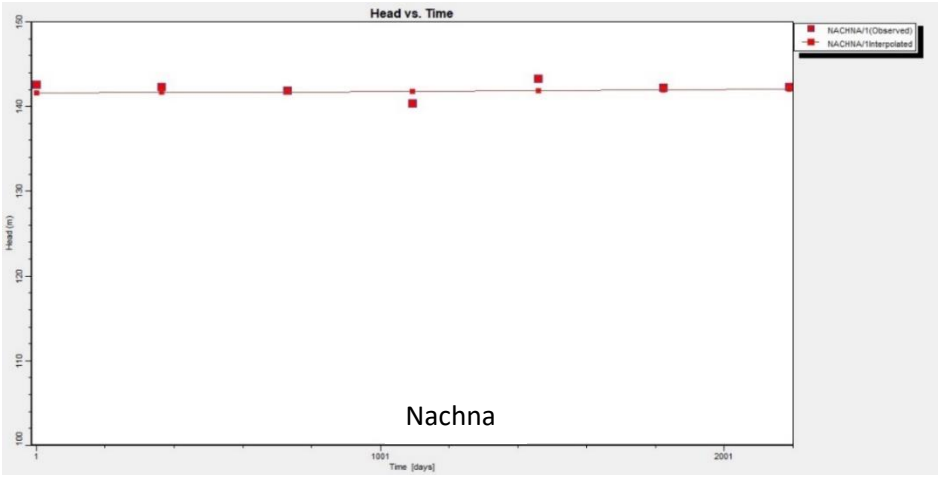


Bhadrias



Jaisoorana





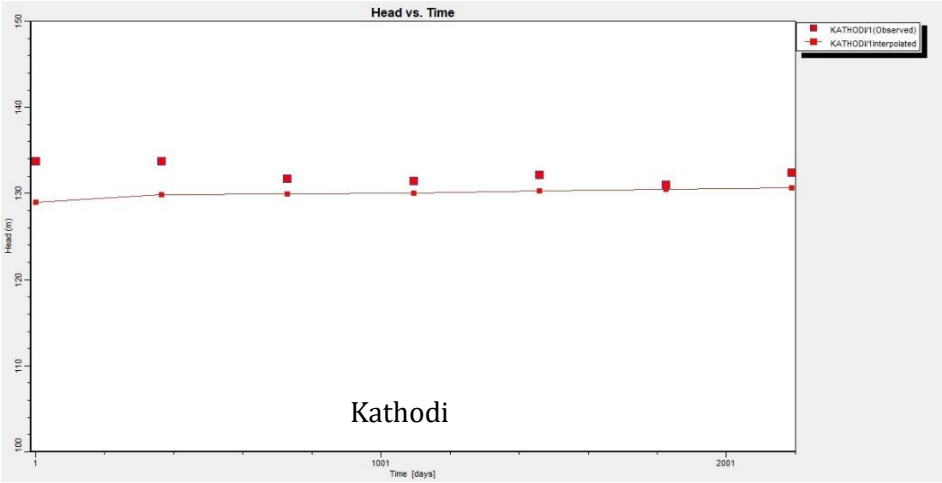


Figure 16: Hydrographs of Observation Points

Table 5: Difference in Observed and Calculated heads of Calibrated Data for 2013 to 2016

Time			1			2013			2014			2015			2016		
Well/Point	X model	Y model	Observ	Calcu	Calc-obs	Obs	Calc	Calc-obs	Obs	Calc	Calc-obs	Obs	Calc	Calc-obs	Obs	Calc	Calc-obs
AJA1SAR	768858.5	3018073	149.00	152.80	3.80	149.60	152.93	3.33	148.80	153.00	4.20	147.69	153.02	5.33	146.50	153.34	6.84
AWAI	780207.9	3046450	144.20	143.96	-0.24	142.70	144.03	1.33	144.30	144.09	-0.21	144.30	144.14	-0.16	144.70	144.27	-0.43
BAISHAKHI	688633.8	2991399	143.10	145.04	1.94	142.30	145.29	2.99	141.60	145.47	3.87	140.52	145.61	5.09	140.86	145.99	5.13
BASINPUR	708248.4	2978782	151.02	152.65	1.63	151.02	153.31	2.29	151.02	152.85	1.83	151.02	152.70	1.68	151.02	152.89	1.87
BHADRIAS	775337	3042587	149.75	145.84	-3.91	149.20	145.89	-3.31	149.00	145.94	-3.06	148.70	145.97	-2.73	149.00	146.09	-2.91
BHAVANIPURA DEEP	794375.4	3069245	139.92	139.89	-0.03	140.00	139.94	-0.06	140.00	139.99	-0.01	140.00	140.03	0.03	140.00	140.15	0.15
BHOJKA	721814.9	2984129	152.60	149.24	-3.36	151.20	149.14	-2.06	149.95	148.97	-0.98	148.05	148.77	0.72	144.80	148.75	3.95
HAMIRA	703960.7	2987926	154.90	150.22	-4.68	154.65	150.32	-4.33	154.55	150.40	-4.15	154.65	150.44	-4.21	154.28	150.72	-3.56
JAISALMER	689741.6	2981327	208.52	195.19	-13.33	207.92	195.13	-12.79	208.32	195.03	-13.29	209.42	194.90	-14.52	209.77	195.01	-14.76
JAISOORANA	712483.3	2995783	158.30	140.71	-17.59	159.00	140.82	-18.18	158.45	140.91	-17.54	159.44	140.97	-18.47	159.31	141.27	-18.04
KATHODI	688741.9	3001030	133.75	129.01	-4.74	133.75	129.85	-3.90	131.75	129.95	-1.80	131.42	130.02	-1.40	132.15	130.34	-1.81
KULDHAR	676681.8	2973683	181.08	174.77	-6.31	180.78	174.76	-6.02	180.67	174.76	-5.91	180.78	174.74	-6.04	180.30	174.77	-5.53
LANELA	679452.1	2996284	127.25	128.10	0.85	128.10	128.98	0.88	128.00	129.13	1.13	128.30	129.24	0.94	128.43	129.60	1.17
MOHANGARH	721749.8	3020328	143.00	130.61	-12.39	142.00	131.47	-10.53	143.78	131.62	-12.16	143.67	131.72	-11.95	143.58	132.08	-11.50
NACHNA	769138.7	3046243	142.60	141.63	-0.98	142.30	141.68	-0.62	141.90	141.72	-0.18	140.40	141.76	1.36	143.30	141.88	-1.42
PAREWAR	672626.4	3016823	84.75	80.00	-4.75	84.31	80.00	-4.31	84.26	80.00	-4.26	83.40	80.00	-3.40	83.25	80.00	-3.25
SATYAYA	763192.4	3035380	142.86	143.39	0.53	142.79	143.64	0.85	142.76	143.86	1.10	142.67	143.99	1.32	142.62	144.54	1.92
SULTANA	683618	3030150	92.25	92.66	0.41	91.89	92.95	1.06	91.75	93.19	1.44	93.10	93.36	0.26	92.55	93.94	1.39
TADANA	759857.5	3030299	145.00	144.08	-0.92	144.26	144.32	0.06	144.81	144.52	-0.29	144.84	144.64	-0.20	146.63	145.19	-1.44

Table 6 : Calculated vs observed heads of validated data for 2017 and 2018.

Well Name	X-Model	Y-Model	X-World	Y-World	2017			2018		
					Obs.	Calc.	Calc.-Obs.	Obs.	Calc.	Calc.-Obs.
AJA1SAR/1	768858.5	3018073	768600.4	3018480	146.55	153.401	6.851001	143.8	153.5589	9.758884
AWAI/1	780207.9	3046450	779845.6	3046898	144.67	144.3329	-0.33707	144.5	144.4257	-0.07428
BAISHAKHI/1	688633.8	2991399	688474.2	2991511	140.71	146.1726	5.462638	142.39	146.4375	4.047469
BASINPUR/2	708248.4	2978782	708135.1	2978966	151.02	152.7872	1.767216	151.02	152.7701	1.750126
BHADRIAS/1	775337	3042587	774988.9	3043017	148.96	146.1443	-2.81567	148.9	146.2261	-2.67387
BHAVANIPURA D	794375.4	3069245	793929.3	3069745	139.92	140.2076	0.287626	139.9	140.291	0.391016
BHOJKA/1	721814.9	2984129	721681.9	2984363	143.4	148.5776	5.177576	144.91	148.4666	3.556629
HAMIRA/1	703960.7	2987926	703813.8	2988094	153.9	150.8062	-3.09379	154.15	150.9749	-3.17507
JAISALMER/1	689741.6	2981327	689619	2981444	210.22	194.913	-15.307	210.22	194.9025	-15.3176
JAISOORANA/1	712483.3	2995783	712307.4	2995983	159.2	141.3699	-17.8301	159.35	141.5522	-17.7978
KATHODI/1	688741.9	3001030	688546.9	3001142	131	130.4609	-0.53908	132.4	130.6647	-1.73534
KULDHAR/1	676681.8	2973683	676587.4	2973752	180.5	174.7556	-5.74437	181.63	174.7606	-6.86941
LANELA/1	679452.1	2996284	679274.7	2996362	128.18	129.7552	1.575173	128.11	129.9993	1.889344
MOHANGARH/1	721749.8	3020328	721483.8	3020562	144.1	132.2269	-11.8732	145.9	132.4654	-13.4346
NACHNA/1	769138.7	3046243	768777.3	3046650	142.25	141.9296	-0.32036	142.3	142.0101	-0.28985
PAREWAR/1	672626.4	3016823	672373.6	3016876	83.6	80	-3.6	83.7	80	-3.7
SATYAYA*/1	763192.4	3035380	762870.9	3035766	145.73	144.7265	-1.00347	141.78	145.0477	3.267668
SULTANA/1	683618	3030150	683316.2	3030244	92.35	94.15956	1.809561	91.05	94.51086	3.460857
TADANA/1	759857.5	3030299	759554.6	3030672	145.85	145.3597	-0.4903	144.15	145.6723	1.522302

Cumulative Budget – Transient State

The ground water budget for transient state simulation in Jaisalmer Block gives an accounting of recharge to block, discharge from the block and flow between hydrogeologic units viz., Storage, Constant Heads, Wells, Recharge etc in the block. Five budget zones were assigned throughout the block using zone-budget to determine the overall hydraulic budget for the area. The ground water of each formation (zone for the transient run for different stress periods along with the percent discrepancy between the total in and out is given in Table 7.

Table 7: Formation wise budget (m^3) of Ground water for the transient run

Alluvium (Zone 2)		01-Jun-12	01-Jun-13	01-Jun-14	01-Jun-15	01-Jun-16	01-Jun-17	01-Jun-18
Time	**Days:**	1	365	730	1095	1460	1825	2190
STORAGE	**(IN)**	5618.7	3413.2	2313.6	1989.8	1093.3	750.07	506.16
CONSTANT HEAD	**(IN)**	3344.1	4684.3	4031.1	3665.1	3417.9	3249.8	3138.7
RECHARGE	**(IN)**	138760	138760	126900	92619	314340	133460	209250
Zone 3 to 2	**(IN)**	4293.5	4148.3	3945.8	3811.8	3868.2	3853.8	3914.2
Zone 7 to 2	**(IN)**	1034.2	2112.5	2636.6	3047.4	3340.7	3596.9	3787.5
Total (IN)		153050	153110	139830	105130	326060	144910	220600
STORAGE	**(OUT)**	154650	151720	137810	102650	323220	141810	217270
CONSTANT HEAD	**(OUT)**	201.9	314.19	421.59	507.73	559.03	589.8	620.99
Zone 2 to 3	**(OUT)**	262.14	247.96	246.14	248.85	223.24	230.7	229.96
Zone 2 to 7	**(OUT)**	3.3818	808.7	1344.3	1736.2	2046	2278.2	2471.4
Total	**(OUT)**	155110.42	153110	139830	105140	326060	144910	220600
SUM	**(IN – OUT)**	-2065.8	0.084119	0.39106	-9.2645	0.37942	-0.58352	-0.06743
DISCREPANCY [%]		-1.34	0	0	-0.01	0	0	0

Tertiary Sandstone (Zone 3)								
Time	**Days:**	1	365	730	1095	1460	1825	2190
Storage	**(IN)**	5043.4	2345.1	1293.4	765.68	469.72	317.57	204.25
Constant Head	**(IN)**	2782.9	2899	2201.9	1979.4	1844.7	1759.5	1701.5
Recharge	**(IN)**	64492	64492	54533	34477	140880	47265	81880
Zone 2 to 3	**(IN)**	262.14	247.96	246.14	248.85	233.24	230.7	229.96
Zone 4 to 3	**(IN)**	2429.7	2742.4	2857.8	2913	2898.9	2904.1	2892.1
Zone 5 to 3	**(IN)**	206.09	210.95	213.54	216.46	212.55	213.52	211.81
Zone 6 to 3	**(IN)**	2164.6	2818.8	2725.9	2602.5	2392.3	2247.6	2100
Zone 7 to 3	**(IN)**	445.58	1083.9	1360.6	1552.3	1665.1	1779.3	1850.1
Total (IN)		77826	76840	65432	44755	150590	56717	91070
Storage	**(OUT)**	72649	70918	59214	38211	143590	49533	83614
Constant Head	**(OUT)**	114.62	499.24	658.19	898.18	1049	1140.9	1208.6
Zone 3 to 2	**(OUT)**	4293.5	4148.3	3945.8	3811.8	3868.2	3853.8	3914.2
Zone 3 to 4	**(OUT)**	898.36	713.36	743.34	765.53	817.31	839.46	869.12
Zone 3 to 6	**(OUT)**	0	0	0	0	0	0.45572	16.933
Zone 3 to 7	**(OUT)**	2.9824	561.54	871.55	1068.7	1263.1	1349.2	1446.9
Total (OUT)		77958	76840	65432	44755	150590	56717	91070
Difference:	**IN-OUT**	-131.67	-0.13698	-0.03634	-0.037755	0.20661	0.25027	0.066891
Discrepancy (%)		-0.17%	0%	0%	0%	0%	0%	0%

Baisakhi Sandstone (zone 4)								
Time	**Days:**	1	365	730	1095	1460	1825	2190
Storage	**(IN)**	7054.7	2874.2	1483.7	1022.8	675.9	451.37	285.45
Constant Head	**(IN)**	613.9	87.751	0	0.055439	0	0	0
Recharge	**(IN)**	250500	250500	41085	30300	102220	43635	68625
Zone 3 to 4	**(IN)**	898.36	713.36	743.34	765.53	817.31	839.46	869.12
Zone 5 to 4	**(IN)**	7744	7197.1	7045.8	6877.6	6751.1	6638.4	6549.7
Zone 7 to 4	**(IN)**	3.8848	679.59	1019.1	1223.5	1409.5	1526.9	1618.6
Total (IN)		266810	257660	51377	40189	111880	53091	77948
Storage	**(OUT)**	263870	726.56	46035	34243	105510	46469	71134
Constant Head	**(OUT)**	106.54	6.00E-05	1241.4	1587.3	1803.6	1947.5	2049.2
Wells	**(OUT)**	6.00E-05	2742.4	7.00E-05	8.00E-05	9.00E-05	0.0001	0.0001
Zone 4 to 3	**(OUT)**	2429.7	89.036	2857.8	2913	2898.9	2904.1	2892.1
Zone 4 to 5	**(OUT)**	309.38	835.81	89.836	89.811	94.206	94.848	97.015
Zone 4 to 7	**(OUT)**	5.3923	262050	1152.9	1356.4	1568.9	1676.2	1776.1
Total (OUT)		266720	262050	51377	40189	111880	53091	77948
Difference:	**(IN-OUT)**	90.984	0.12364	-0.17369	0.10269	-0.15157	-0.15083	-0.24816
Discrepancy (%)		0.03%	0%	0%	0%	0%	0%	

Jaisalmer Sandstone (Zone 5)								
Time	**(Days):**	1	365	730	1095	1460	1825	2190
Storage	**(IN)**	18448	10557	8801.1	9036.6	2200.4	5701.6	2064.3
Constant Head	**(IN)**	283.97	90.054	296.09	523.8	534.85	592.77	628.45
Recharge	**(IN)**	23422	23422	18990	10935	64688	20700	39375
Zone 4 to 5	**(IN)**	309.38	89.036	89.836	89.811	94.206	94.848	97.015
Zone 6 to 5	**(IN)**	2924.7	2318.2	2098.8	2141.1	1979.3	1906	1827.7
Zone7 to 5	**(IN)**	8.0726	1076.5	1759.2	2249.1	2434.9	2657.1	2779.2
Total (IN)		45397	37553	32035	24975	71931	31652	46772
Storage	**(OUT)**	31189	23155	17279	10348	57738	17663	32980
Constant Head	**(OUT)**	3989.4	2587.1	1870.2	1319	1551.2	1148.4	1104.2
Zone 5 to 2	**(OUT)**	206.09	210.95	213.54	216.46	212.55	213.52	211.81
Zone 5 to 4	**(OUT)**	7744	7197.1	7045.8	6877.6	6751.1	6638.4	6549.7
Zone 5 to 6	**(OUT)**	2393.5	3418.9	4223.2	4566.8	3851.8	4058.8	3916.7
Zone 5 to 7	**(OUT)**	4.6185	984.21	1403.8	1647.2	1826.9	1930.8	2008.9
Total (OUT)		45526	37553	32035	24975	71931	31653	46771
Difference:	**(IN-OUT)**	-129.42	-0.22457	0.000793	-0.03492	-0.06242	-0.23663	0.3587
Percent Discrepancy		-0.28%	0%	0%	0%	0%	0%	0%

Lathi Sandstone (Zone 6)								
Time	**(days):**	1	365	730	1095	1460	1825	2190
Storage	**(IN)**	45161	32915	52952	61347	6215.8	51765	30591
Constant Head	**(IN)**	10579	14512	14464	15087	12448	13491	13035
Recharge	**(IN)**	0	0	0	0	0	0	0
Zone 3 to 6	**(IN)**	0	0	0	0	0	0.45572	16.933
Zone 5 to 6	**(IN)**	2393.5	3418.9	4223.2	4566.8	3851.8	4058.8	3916.7
Zone 7 to 6	**(IN)**	1016.4	2781	3295	3743.3	3836.5	4089.5	4227.3
Total (IN)		59150	53626	74935	84745	26352	73405	51787
Storage	**(OUT)**	9426	7085.2	3760.7	2574.7	8795.8	1522	1745
Constant Head	**(OUT)**	3338.5	202.94	205.36	201.31	481.92	292.69	347.83
Recharge	**(OUT)**	40343	40343	64941	75776	11021	65588	43780
Zone 6 to 3	**(OUT)**	2164.6	2818.8	2725.9	2602.5	2392.3	2247.6	2100
Zone 6 to 5	**(OUT)**	2924.7	2318.2	2098.8	2141.1	1979.3	1906	1827.7
Zone 6 to 7	**(OUT)**	939.59	858.55	1202.7	1449	1681.6	1849	1987.3
Total (OUT)		59136	53626	74935	84745	26352	73405	51788
Difference:	**IN-OUT**	14.52	0.14747	-0.06387	-0.01535	0.29926	0.26116	-0.36999
Discrepancy (%)		0.02%	0%	0%	0%	0%	0%	0%

Aquitard (zone 7)								
Time	**(days):**	1	365	730	1095	1460	1825	2190
Storage	**(IN)**	11060	9849.1	15818	18571	3065.4	16060	10895
Constant Head	**(IN)**	1888.5	4080.9	4092.3	4112.4	4087.8	4086.2	4068.3
Recharge	**(IN)**	6958	6958	2965.5	1851.7	8985	3081	5533.8
Zone 2 to 7	**(IN)**	3.3818	808.7	1344.3	1736.2	2046	2278.2	2471.4
Zone 3 to 7	**(IN)**	2.9824	561.54	871.55	1068.7	1263.1	1349.2	1446.9
Zone 4 to 7	**(IN)**	5.3923	835.81	1152.9	1356.4	1568.9	1676.2	1776.1
Zone 5 to 7	**(IN)**	4.6185	984.21	1403.8	1647.2	1826.9	1930.8	2008.9
Zone 6 to 7	**(IN)**	939.59	858.55	1202.7	1449	1681.6	1849	1987.3
Total (IN)		20863	24937	28851	31793	24525	32311	30187
Storage	**(OUT)**	6701	7606.1	3415.5	2062.8	9237.6	3155.2	5575.7
Constant Head	**(OUT)**	935.67	58.125	12.072	0.29502	0.3186	0.33288	0.3445
Recharge	**(OUT)**	9535.5	9535.5	15350	17911	2604.9	15502	10348
Zone 7 to 2	**(OUT)**	1034.2	2112.5	2636.6	3047.4	3340.7	3596.9	3787.5
Zone 7 to 3	**(OUT)**	445.58	1083.9	1360.6	1552.5	1665.1	1779.3	1850.1
Zone 7 to 4	**(OUT)**	3.8848	679.59	1019.1	1223.5	1409.5	1526.9	1618.6
Zone 7 to 5	**(OUT)**	8.0726	1076.5	1759.2	2249.1	2434.9	2657.1	2779.2
Zone 7 to 6	**(OUT)**	1016.4	2781	3295	3743.3	3836.5	4089.5	4227.3
Total (OUT)		19680	24933	28848	31790	24529	32308	30187
Difference:	**In-out**	1182.3	3.6416	3.19	3.2927	-4.7007	3.2118	0.249
Discrepancy (%)		5.83%	0.01%	0.01%	0.01%	-0.02%	0.01%	0%

Mass Balance

Mass balance is one of the key indicators of a successful simulation of a ground water flow model. The mass balance showing cumulative inflows and outflow and percent discrepancy in each time step provides the detail information about the entire model domain. If the mass balance error for a simulation is less than 2% the results of the simulation may be considered to be acceptable provided model is also calibrated. The Mass balance of the present simulated model for each time period following its graphical representation are given below.

Table 8: Mass Balance of Validated Model of Jaisalmer Block.

Cumulative Volumes Report [m^3]								
Time		1	365	730	1095	1460	1825	2190
Storage	**(IN)**	92386.8	22643334	52814920	86662704	91670720	1.19E+08	1.35E+08
Constant Head	**(IN)**	19492.5	9612165	18768484	28027816	36179388	44639852	52878760
Recharge	**(IN)**	484129	1.77E+08	2.66E+08	3.28E+08	5.58E+08	6.49E+08	7.97E+08
Total (IN)		596008	2.09E+08	3.38E+08	4.43E+08	6.86E+08	8.13E+08	9.85E+08
Storage	**(OUT)**	538483	1.89E+08	2.87E+08	3.56E+08	5.93E+08	6.88E+08	8.38E+08
Constant Head	**(OUT)**	8685.85	1615782	3224990	4872520	6859949	8728619	10674475
Wells	**(OUT)**	6.00E-05	0.0219	0.04745		0.1095	0.146	0.1825
Recharge	**(OUT)**	49878	18205472	47511688	81707440	86680744	1.16E+08	1.36E+08
Total (OUT)		45526	2.09E+08	3.38E+08	4.43E+08	6.86E+08	8.13E+08	9.85E+08
Difference:	**(IN-OUT)**	-1039.1	576	1760	-416	-1920	-0.23663	0.3587
Percent Discrepancy		-0.17	0%	0%	0%	0%	0%	0%

The rate of ground water inflow and outflow from the system in different time steps (each year) in meter cube per day along with the total inflow or outflow and discrepancy is presented in table 9 and its pictorial representation is given in Figure17.

Table 9: Rate of Ground Water Inflow and Outflow in Validated Model of Jaisalmer Block

Rates for Time Step Report [m^3/day]								
Time		1	365	730	1095	1460	1825	2190
Storage	**(IN)**	92386.8	61953.15	82661.88	92733.65	13720.59	75046.16	44545.77
Constant Head	**(IN)**	19492.5	26353.49	25085.81	25368.03	22333.07	23179.36	22572.36
Recharge	**(IN)**	484129	484128.5	244472	170182.4	631112.5	248136	404663.8
Total (IN)		596008	572435.1	352219.7	288284.1	667166.2	346361.5	471781.9
Storage	**(OUT)**	538483	518137.6	267516.6	190089.3	648099.7	260149.1	412322.8
Constant Head	**(OUT)**	8685.85	4415.1	4408.789	4513.778	5445.011	5119.646	5331.113
Wells	**(OUT)**	6.00E-05	6.00E-05	7.00E-05	0.00008	9.00E-05	0.0001	0.0001
Recharge	**(OUT)**	49878	49878	80291	93686.99	13625.5	81090	54128
Total (OUT)		45526	572430.8	352216.4	288290.1	667170.2	346361.5	471781.9
Difference:	**(IN-OUT)**	-1039.1	4.375	3.3125	-5.9688	-4	2.7188	-0.03125
Percent Discrepancy		-0.17	0%	0%	0%	0%	0%	0%

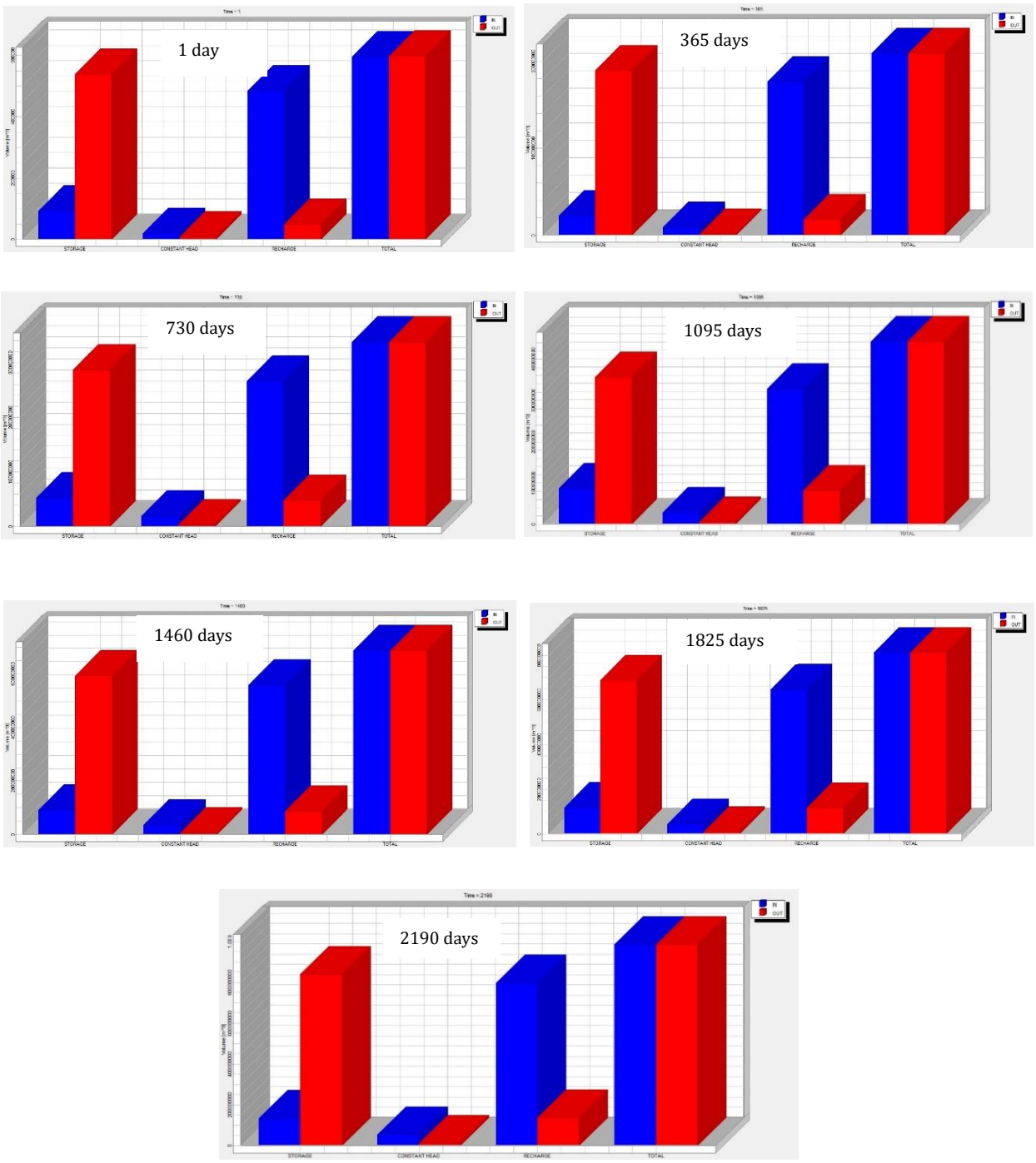


Figure 17: Hydrographs of Observation Points

Model Limitations

- Water level data of deeper aquifer is not available in time series.
- The draft data for confined/deeper aquifer is not available, so the zone budget of deeper aquifer cannot be obtained.
- Recharge and Discharge values are not separately simulated in the model. Net Recharge termed Recharge minus Discharge and value of it is applied to the model

in the Recharge Module of the model. Net Recharge is approximated and applied to the each cell.

- Present model requires further refinement. Future modelling study requires additional hydraulic Head in the north-western part of the block to establish the precise flow along the boundary.
- As the area is rainfall deficit, there is no scope of enhancing the recharge in the area only draft can be changed to produce different scenarios.
- Draft is limited to the Jaisalmer and Lathi formations and very little from Tertiary formation, due to water quality. The quality of water in alluvium being saline, there is negligible draft and no draft in Baisakhi formation.
- Further refinement and ground water flow model forecast for deeper horizons will be studied and from this model of Jaisalmer Block other scenario will be generated, when the ground water modelling study of entire Jaisalmer District will be taken up as a whole unit, during AAP 2019-20.

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Annexure I

Data Points for Initial Heads

SITE_NAME	Easting_long	Northing_lat	WT_01_05_2012	average WT
AJASAR	768600.44	3018479.88	149.8	147.5343
AWAI	779845.62	3046897.98	144.2	143.3386
BAISHAKHI	688474.22	2991510.98	143.1	140.3257
BARORA GAON	716889.41	2972574.85	153.16	153.16
BASINPUR	708135.09	2978966.22	151.02	151.02
BHADRIAS	774988.91	3043017.36	149.75	149.0729
Bhavanipura Deep	793929.31	3069744.74	139.92	139.9629
HAMIRA	703813.84	2988094.25	154.9	151.5829
JAISALMER	689618.99	2981443.6	208.52	209.1986
LANELA	679274.67	2996362.36	127.25	130.3386
MOOLSAGAR	682218.28	2978120.31	223.8	222.0071
NACHNA	768777.29	3046649.94	142.6	142.15
NEWEATA	799351.1	3058008.21	144.55	146.7586
Bhojka	721681.86	2984363.24	152.6	147.8443
Bhopa	692088.26	2955582.56	156.2	159.0543
Kuldhar	676587.4	2973751.53	181.08	180.1057
Parewar	672373.64	3016876.35	84.75	59.99571
Satyaya	762870.85	3035765.68	142.86	143.03
Tadana	759554.63	3030672.24	145	144.7914
Sultana	683316.16	3030243.62	92.25	91.96286
Kathodi	688546.94	3001142.48	133.75	131.7457
Akal ka Tala	773562.04	3080913.22	125.64	125.64
Arjana	690175.07	3033251.34	101.67	101.67
Arjana Gaucher	695016.41	3032961.4	102.38	102.38
Bharewala	762100.98	3073850.4	122.38	122.38
DABLA	702789.61	2969114.86	163.25	163.25
Dadhurewala	740192.56	3080414.43	73.6	73.6

SITE_NAME	Easting_long	Northing_lat	WT_01_05_2012	average WT
DHAISAR	738476.74	2975038.12	171.14	171.14
Ghantiyali	744292.94	3039573.29	135	135
Kalanio ka was	737374.32	3074848.47	93.5	93.5
Khiya	683285.72	3023638.13	102.7	102.7
Nedhai	696025.35	3027990	110.61	110.61
Panna	807649.09	3076430.4	141.34	141.34
Poonam singh ki	800810.45	3089137.58	136.9	136.9
Raichandwala	777515.98	3086482.23	133	133
RAJWAI	695350.37	2975026.16	162.22	162.22
Sankhala	700770.88	3027046.71	119.62	119.62
Kalaro ki Dhani	744803.51	3072235.6	103	103
Chhatrel	670774.46	2987599.93	148.73	148.73
JJW 95 RD	726846	3048749.91	114.44	114.44
Bhurababa	711388.39	3046134.1	109.57	109.57
Shastri Nagar	712912.52	3052811.32	104.75	104.75
RD 135	705359.45	3050309.93	103.54	103.54
Boha	694184.09	3016363.79	116.95	111.7257

Annexure II

Data of Jaisalmer Block for Top and Bottom of all three layers of the model

S. No.	Bore	Easting	Northing	Long	Lat	Top_1	Top_2	Top_3	Bot_3
1	Ajasar	769038.44	3015196.02	71.7167	27.2333	213	149	113	43
2	Akal	698945.64	2963191.04	71.001	26.776	257.5	189	166	-42.5
3	Akal ka Tala	773562.04	3080913.22	71.7772	27.825	131	-1	-73	-169
4	Arjana	690175.07	3033251.34	70.9236	27.4094	134	-10	-62	-166
5	Asayah	711565.39	2971132.12	71.1292	26.8458	232.2	151	132	15.2
6	Awaya	800838.13	3088028.94	72.0556	27.8833	140	-4	-69	-87
7	Bahadur Singh Ki Dhani (Satyaya)	762012.16	3033341.14	71.6497	27.3983	167	106	45	-133
8	Bandhe Khan Ki Dhani (Bahla)	737181.55	3073614.04	71.4067	27.7661	135	50	-15	-162
9	Basanpir	708403.55	2975357.53	71.0981	26.8844	211.2	170	155	66
10	Bhagu Ka Gaon	716969.06	2979481.46	71.185	26.9203	216	179	155	106
11	Bharewala	762100.98	3073850.4	71.6594	27.7636	135	-18	-85	-165
12	Bhatia Kharin	678516.76	2993869.23	70.8	27.0556	157.6	65	47	-5.7
13	Bhawanipura	793889.05	3069777.05	71.9806	27.7203	153	73	48	-48
14	Bhilani	689283.13	2992487.35	70.9083	27.0417	159	87	38	-0.8
15	Bhojak	720884.28	2982841.71	71.225	26.95	192	95	70	-108
16	Bhu	693821.97	2960008.48	70.949	26.748	264.2	186	172	64
17	Bhurababa	711388.39	3046134.1	71.1403	27.5225	123.3	78	7	-66
18	Bodana (Gauchar)	809363.49	3061808.17	72.1353	27.645	165.4	50	-35	-121
19	Bulli	703049.26	3049041.01	71.0564	27.55	119	64	45	-174
20	Chandan	728247.99	2987595.91	71.3	26.9917	186	151	92	-114
21	Chhatrel	670774.46	2987599.93	70.7211	27	184	84	67	-116
22	Chinnu	795472.98	3059022.79	71.994	27.623	169	45	-41	-128
23	Choudhariya	690018.13	2998959.46	70.9167	27.1	168	60	7	-40
24	DABLA	702789.61	2969114.86	71.0406	26.8289	236.1	187	168	16.1

S. No.	Bore	Easting	Northing	Long	Lat	Top_1	Top_2	Top_3	Bot_3
25	Dadhurewala	740192.56	3080414.43	71.4386	27.8269	116	-8	-84	-181
26	Dhaisar	738476.74	2975038.12	71.4006	26.8767	230.8	191	165	-14.6
27	Dhawa	686294.49	2971198.62	70.875	26.85	250	222	200	10
28	Fakiro Ki Dhani	720547.49	3026409.14	71.2294	27.3431	150	-16	-74	-147
29	Ghantiyali	744292.94	3039573.29	71.4719	27.4578	137	-18	-51	-117
30	Hamir Nada	727468.62	3030071.1	71.3	27.375	153	57	-4	-47.4
31	Hamira	707459.51	2985571.74	71.0903	26.9767	217	117	107	87
32	Hariyar	738000	3055000	71.4064	27.5989	139	-73	-111	-146
33	Hazi Khan Mohammad ki Dhani	718452.88	3025629.18	71.2081	27.3364	159	57	-22	-141
34	Jaisalmer	695538.1	2975095.58	70.9686	26.8839	239.5	178	128	49
35	Jaluwala EW	778320.08	3083240.06	71.826	27.845	130.6	-73	-93	-124
36	Jawahar Nagar-EW I	712141.45	3048297.54	71.1483	27.5419	118	48	-12	-75
37	Jesurana	723169.23	2993966.65	71.25	27.05	177	38	15	-108
38	Jeths	726527.19	2991045.28	71.2833	27.0231	176	112	41	-104
39	JJW 95 RD	726846	3048749.91	71.2972	27.5436	149.1	89	24	-47
40	Kabirpura	761203.34	3050854.9	71.6453	27.5564	136.9	33	-36	-63
41	Kalanio ka was	737374.32	3074848.47	71.4089	27.7772	115.3	2	-63	-181
42	Kalaro ki Dhani	744803.51	3072235.6	71.4837	27.7523	113	21	-55	-187
43	Khara Rann	698336.94	2995398.48	71	27.0667	159	69	7	-3.3
45	Khiya	683285.72	3023638.13	70.8525	27.3236	167	122	49	-117
46	Kita	702284.85	2957159.73	71.0336	26.7211	275.1	194	184	-5
47	Lanela	679304.75	2996340.62	70.8083	27.0778	164.4	61	39	-40
48	Laro ka Toba	736118.19	3038326.84	71.389	27.448	155	-35	-60	-145
49	Ludarwa	678657.34	2984019.84	70.8	26.9667	176.1	135	116	-77.5
50	Mahadev Nagar	711047.07	3022817.91	71.1328	27.3122	153.1	81	11	-147
51	Mandha	689017.34	3024899.31	70.9106	27.3342	158.4	53	8	-137
52	Moklat	704281.75	2978869.72	71.0572	26.9167	219.7	123	101	-81
53	Nasirpura	779161.33	3067266.61	71.8308	27.7008	135	72	40	-65.3

S. No.	Bore	Easting	Northing	Long	Lat	Top_1	Top_2	Top_3	Bot_3
54	Nedhai	696025.35	3027990	70.9819	27.3611	150.1	58	-24	-151
55	Panna	807649.09	3076430.4	72.1217	27.7772	156.6	63	-11	-142
56	Panodhar Rai	723694.6	3027541.07	71.2614	27.3528	154.9	60	-20	-144
57	Pohada	691462.59	2994670.52	70.9306	27.0611	158	74	13	-94
58	Poonam singh ki Dhani	800810.45	3089137.58	72.0556	27.8933	149.2	19	-26	-151
59	Raichandwala	777515.98	3086482.23	71.8186	27.8744	135.7	-30	-70	-163
60	Rajwai	695350.37	2975026.16	70.9667	26.8833	237.59	199	175	-62.4
62	RD 135	705359.45	3050309.93	71.08	27.5611	121.3	61	21	-4.7
63	Ridhwa	712570.17	2985191.88	71.1417	26.9725	196	116	100	-75
64	Sankhala	700770.88	3027046.71	71.0297	27.3519	140	44	-36	-101
65	Shekho ka tala	766580.06	3047211.79	71.6989	27.5225	141	-10	-70	-151
66	Sodakar	742568.09	2990171.05	71.4447	27.0125	207	102	85	-34
67	Sujio	739602.74	2999814.07	71.4167	27.1	184	19	-10	-116
68	Sultana	683999.07	3030885.51	70.8608	27.3889	149.3	63	-23	-150
69	Tamri Mata Ka Mandir	677363.1	2958138.21	70.7833	26.7333	269.1	187	170	7.85
70	Tota	773837.66	3017363.76	71.7656	27.2519	213.7	142	124	113.7

Annexure III

Head Observation Data of Jaisalmer Block from May 2012 to May 2018

Well Name	X [m]	Y [m]	Screen ID	Screen Elev. [m]	Obs. Time [day]	HEAD [m]
AJA1SAR	768600.4	3018480	1	144	1	149
AJA1SAR	768600.4	3018480	1	144	365	149.6
AJA1SAR	768600.4	3018480	1	144	730	148.8
AJA1SAR	768600.4	3018480	1	144	1095	147.69
AJA1SAR	768600.4	3018480	1	144	1460	146.5
AJA1SAR	768600.4	3018480	1	144	1825	146.55
AJA1SAR	768600.4	3018480	1	144	2190	143.8
AWAI	779845.6	3046898	1	55	1	144.2
AWAI	779845.6	3046898	1	55	365	142.7
AWAI	779845.6	3046898	1	55	730	144.3
AWAI	779845.6	3046898	1	55	1095	144.3
AWAI	779845.6	3046898	1	55	1460	144.7
AWAI	779845.6	3046898	1	55	1825	144.67
AWAI	779845.6	3046898	1	55	2190	144.5
BAISHAKHI	688474.2	2991511	1	102	1	143.1
BAISHAKHI	688474.2	2991511	1	102	365	142.3
BAISHAKHI	688474.2	2991511	1	102	730	141.6
BAISHAKHI	688474.2	2991511	1	102	1095	140.52
BAISHAKHI	688474.2	2991511	1	102	1460	140.86
BAISHAKHI	688474.2	2991511	1	102	1825	140.71
BAISHAKHI	688474.2	2991511	1	102	2190	142.39
BARORA GAON	716889.4	2972575	1	171	1	153.16
BARORA GAON	716889.4	2972575	1	171	365	153.16
BARORA GAON	716889.4	2972575	1	171	730	153.16
BARORA GAON	716889.4	2972575	1	171	1095	153.16
BARORA GAON	716889.4	2972575	1	171	1460	153.16
BARORA GAON	716889.4	2972575	1	171	1825	153.16

Well Name	X [m]	Y [m]	Screen ID	Screen Elev. [m]	Obs. Time [day]	HEAD [m]
BARORA GAON	716889.4	2972575	1	171	2190	153.16
BASINPUR	708135.1	2978966	2	131	1	151.02
BASINPUR	708135.1	2978966	2	131	365	151.02
BASINPUR	708135.1	2978966	2	131	730	151.02
BASINPUR	708135.1	2978966	2	131	1095	151.02
BASINPUR	708135.1	2978966	2	131	1460	151.02
BASINPUR	708135.1	2978966	2	131	1825	151.02
BASINPUR	708135.1	2978966	2	131	2190	151.02
BHADRIAS	774988.9	3043017	1	60	1	149.75
BHADRIAS	774988.9	3043017	1	60	365	149.2
BHADRIAS	774988.9	3043017	1	60	730	149
BHADRIAS	774988.9	3043017	1	60	1095	148.7
BHADRIAS	774988.9	3043017	1	60	1460	149
BHADRIAS	774988.9	3043017	1	60	1825	148.96
BHADRIAS	774988.9	3043017	1	60	2190	148.9
BHAVANIPURA DEEP	793929.3	3069745	1	70	1	139.92
BHAVANIPURA DEEP	793929.3	3069745	1	70	365	140
BHAVANIPURA DEEP	793929.3	3069745	1	70	730	140
BHAVANIPURA DEEP	793929.3	3069745	1	70	1095	140
BHAVANIPURA DEEP	793929.3	3069745	1	70	1460	140
BHAVANIPURA DEEP	793929.3	3069745	1	70	1825	139.92
BHAVANIPURA DEEP	793929.3	3069745	1	70	2190	139.9
BHOJKA	721681.9	2984363	1	99	1	152.6
BHOJKA	721681.9	2984363	1	99	365	151.2
BHOJKA	721681.9	2984363	1	99	730	149.95
BHOJKA	721681.9	2984363	1	99	1095	148.05
BHOJKA	721681.9	2984363	1	99	1460	144.8
BHOJKA	721681.9	2984363	1	99	1825	143.4
BHOJKA	721681.9	2984363	1	99	2190	144.91

Well Name	X [m]	Y [m]	Screen ID	Screen Elev. [m]	Obs. Time [day]	HEAD [m]
BHOPA	692088.3	2955583	1	198	1	156.2
BHOPA	692088.3	2955583	1	198	365	156.4
BHOPA	692088.3	2955583	1	198	730	156.47
BHOPA	692088.3	2955583	1	198	1095	156.6
BHOPA	692088.3	2955583	1	198	1460	161.8
BHOPA	692088.3	2955583	1	198	1825	162.1
BHOPA	692088.3	2955583	1	198	2190	163.81
HAMIRA	703813.8	2988094	1	117	1	154.9
HAMIRA	703813.8	2988094	1	117	365	154.65
HAMIRA	703813.8	2988094	1	117	730	154.55
HAMIRA	703813.8	2988094	1	117	1095	154.65
HAMIRA	703813.8	2988094	1	117	1460	154.28
HAMIRA	703813.8	2988094	1	117	1825	153.9
HAMIRA	703813.8	2988094	1	117	2190	154.15
JAISALMER	689619	2981444	1	162	1	208.52
JAISALMER	689619	2981444	1	162	365	207.92
JAISALMER	689619	2981444	1	162	730	208.32
JAISALMER	689619	2981444	1	162	1095	209.42
JAISALMER	689619	2981444	1	162	1460	209.77
JAISALMER	689619	2981444	1	162	1825	210.22
JAISALMER	689619	2981444	1	162	2190	210.22
JAISOORANA	712307.5	2995983	1	73	1	158.3
JAISOORANA	712307.5	2995983	1	73	365	159
JAISOORANA	712307.5	2995983	1	73	730	158.45
JAISOORANA	712307.5	2995983	1	73	1095	159.44
JAISOORANA	712307.5	2995983	1	73	1460	159.31
JAISOORANA	712307.5	2995983	1	73	1825	159.2
JAISOORANA	712307.5	2995983	1	73	2190	159.35
KATHODI	688546.9	3001142	1	68	1	133.75

Well Name	X [m]	Y [m]	Screen ID	Screen Elev. [m]	Obs. Time [day]	HEAD [m]
KATHODI	688546.9	3001142	1	68	365	133.75
KATHODI	688546.9	3001142	1	68	730	131.75
KATHODI	688546.9	3001142	1	68	1095	131.42
KATHODI	688546.9	3001142	1	68	1460	132.15
KATHODI	688546.9	3001142	1	68	1825	131
KATHODI	688546.9	3001142	1	68	2190	132.4
KULDHAR	676587.4	2973752	1	143	1	181.08
KULDHAR	676587.4	2973752	1	143	365	180.78
KULDHAR	676587.4	2973752	1	143	730	180.67
KULDHAR	676587.4	2973752	1	143	1095	180.78
KULDHAR	676587.4	2973752	1	143	1460	180.3
KULDHAR	676587.4	2973752	1	143	1825	180.5
KULDHAR	676587.4	2973752	1	143	2190	181.63
LANELA	679274.7	2996362	1	72	1	127.25
LANELA	679274.7	2996362	1	72	365	128.1
LANELA	679274.7	2996362	1	72	730	128
LANELA	679274.7	2996362	1	72	1095	128.3
LANELA	679274.7	2996362	1	72	1460	128.43
LANELA	679274.7	2996362	1	72	1825	128.18
LANELA	679274.7	2996362	1	72	2190	128.11
MOHANGARH	721483.8	3020562	1	55	1	143
MOHANGARH	721483.8	3020562	1	55	365	142
MOHANGARH	721483.8	3020562	1	55	730	143.78
MOHANGARH	721483.8	3020562	1	55	1095	143.67
MOHANGARH	721483.8	3020562	1	55	1460	143.58
MOHANGARH	721483.8	3020562	1	55	1825	144.1
MOHANGARH	721483.8	3020562	1	55	2190	145.9
NACHNA	768777.3	3046650	1	22	1	142.6
NACHNA	768777.3	3046650	1	22	365	142.3

Well Name	X [m]	Y [m]	Screen ID	Screen Elev. [m]	Obs. Time [day]	HEAD [m]
NACHNA	768777.3	3046650	1	22	730	141.9
NACHNA	768777.3	3046650	1	22	1095	140.4
NACHNA	768777.3	3046650	1	22	1460	143.3
NACHNA	768777.3	3046650	1	22	1825	142.25
NACHNA	768777.3	3046650	1	22	2190	142.3
NEWEATA	799351.1	3058008	1	63	1	144.55
NEWEATA	799351.1	3058008	1	63	365	144.75
NEWEATA	799351.1	3058008	1	63	730	144.15
NEWEATA	799351.1	3058008	1	63	1095	144.55
NEWEATA	799351.1	3058008	1	63	1460	149.31
NEWEATA	799351.1	3058008	1	63	1825	144.55
NEWEATA	799351.1	3058008	1	63	2190	144.45
PAREWAR	672373.6	3016876	1	81	1	84.75
PAREWAR	672373.6	3016876	1	81	365	84.31
PAREWAR	672373.6	3016876	1	81	730	84.26
PAREWAR	672373.6	3016876	1	81	1095	83.4
PAREWAR	672373.6	3016876	1	81	1460	83.25
PAREWAR	672373.6	3016876	1	81	1825	83.6
PAREWAR	672373.6	3016876	1	81	2190	83.7
SATYAYA	762870.9	3035766	1	79	1	142.86
SATYAYA	762870.9	3035766	1	79	365	142.79
SATYAYA	762870.9	3035766	1	79	730	142.76
SATYAYA	762870.9	3035766	1	79	1095	142.67
SATYAYA	762870.9	3035766	1	79	1460	142.62
SATYAYA	762870.9	3035766	1	79	1825	145.73
SATYAYA	762870.9	3035766	1	79	2190	141.78
SULTANA	683316.2	3030244	1	55	1	92.25
SULTANA	683316.2	3030244	1	55	365	91.89
SULTANA	683316.2	3030244	1	55	730	91.75

Well Name	X [m]	Y [m]	Screen ID	Screen Elev. [m]	Obs. Time [day]	HEAD [m]
SULTANA	683316.2	3030244	1	55	1095	93.1
SULTANA	683316.2	3030244	1	55	1460	92.55
SULTANA	683316.2	3030244	1	55	1825	92.35
SULTANA	683316.2	3030244	1	55	2190	91.05
TADANA	759554.6	3030672	1	100	1	145
TADANA	759554.6	3030672	1	100	365	144.26
TADANA	759554.6	3030672	1	100	730	144.81
TADANA	759554.6	3030672	1	100	1095	144.84
TADANA	759554.6	3030672	1	100	1460	146.63
TADANA	759554.6	3030672	1	100	1825	145.85
TADANA	759554.6	3030672	1	100	2190	144.15