Groundwater mapping in Faryab, Afghanistan

Overview

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Objectives

- Hydrogeological map using methodology and international legend of the IAH
- Hydrogeological Atlas to explain and inform map
- WebGIS map portal

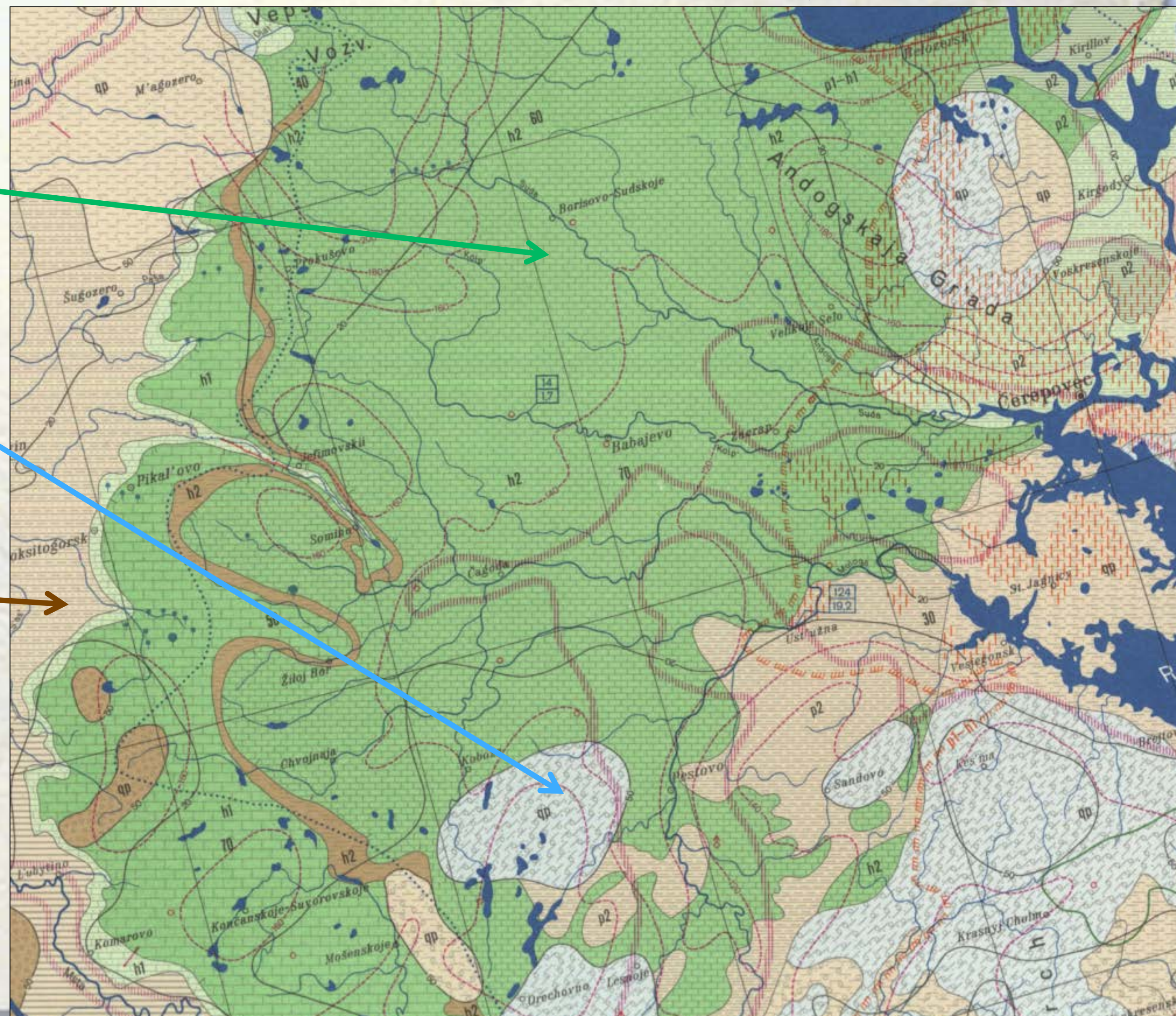
International Association of Hydrogeologists / UNESCO

An extract of the IAH/UNESCO 1:500,000 sheet for Moscow.

Green shows fractured / fissured aquifers

Blue shows granular aquifers

Brown shows aquitards (poor aquifers)

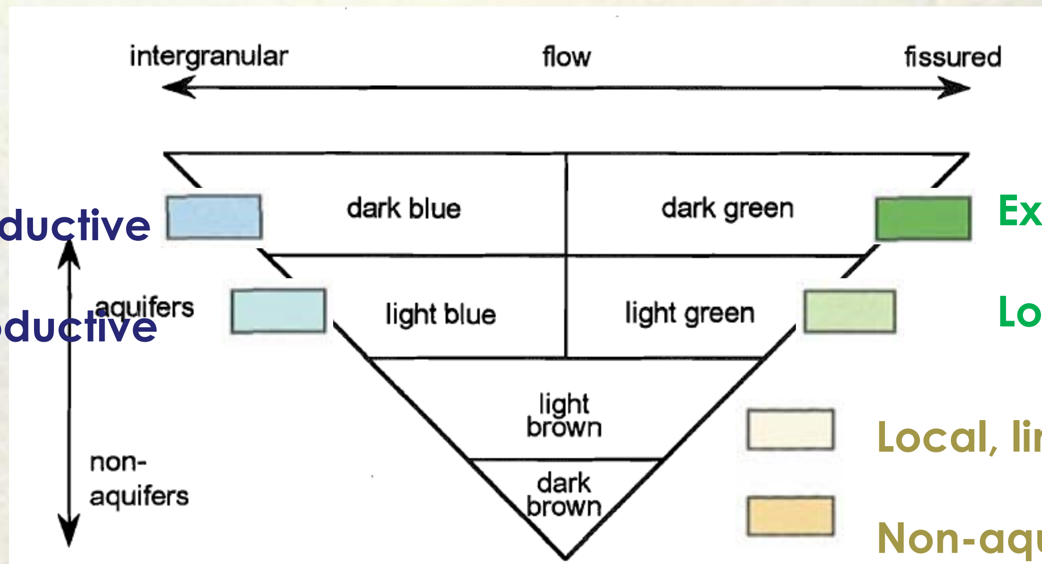


Aquifer Designation in Faryab

According to International Association of Hydrogeologists' Legend

INTERGRANULAR

FISSURED / FRACTURED



Extensive, productive

Local, less productive

Extensive, productive

Local, less productive

Local, limited

Non-aquifer

POOR or NON AQUIFER

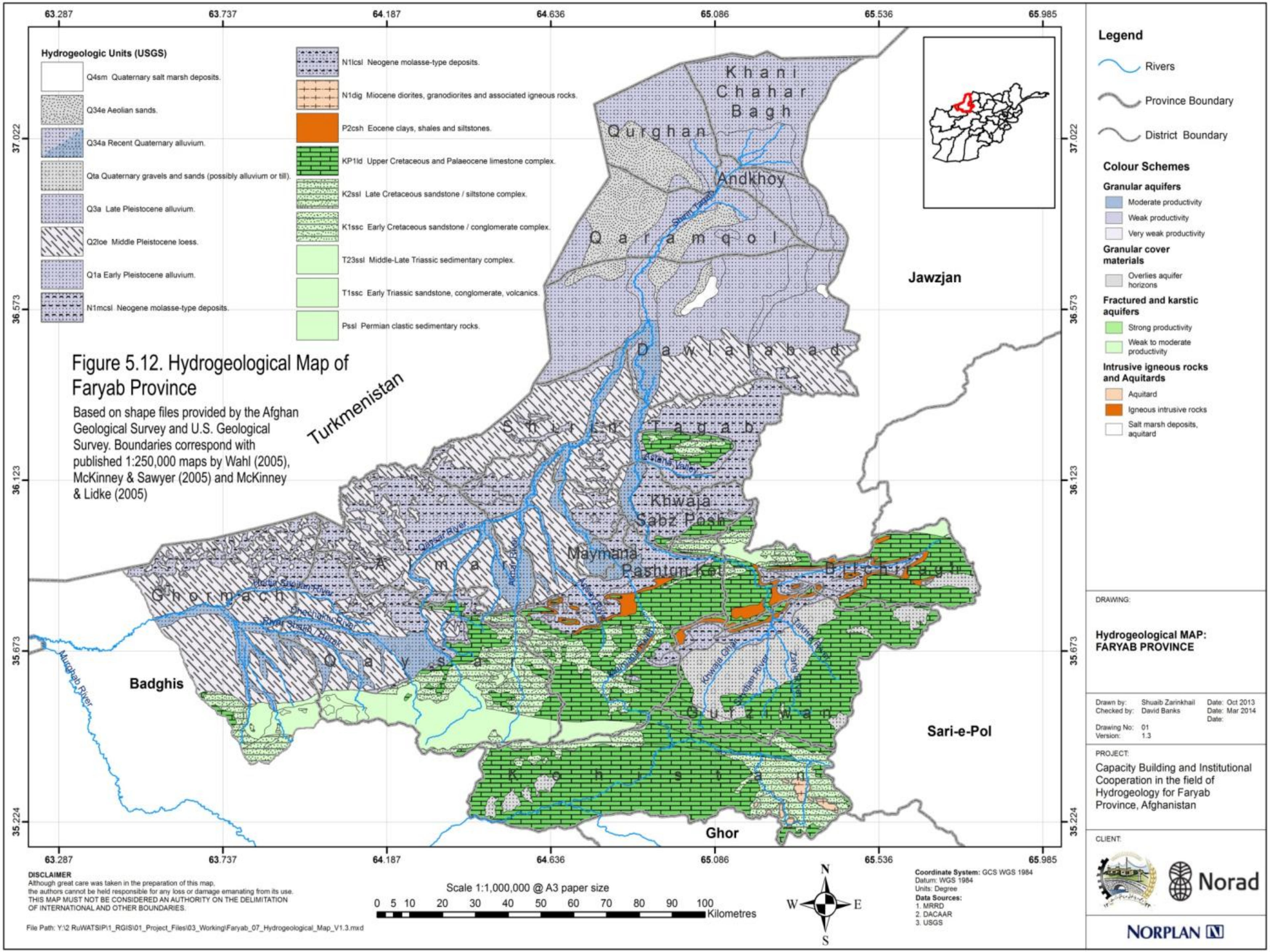
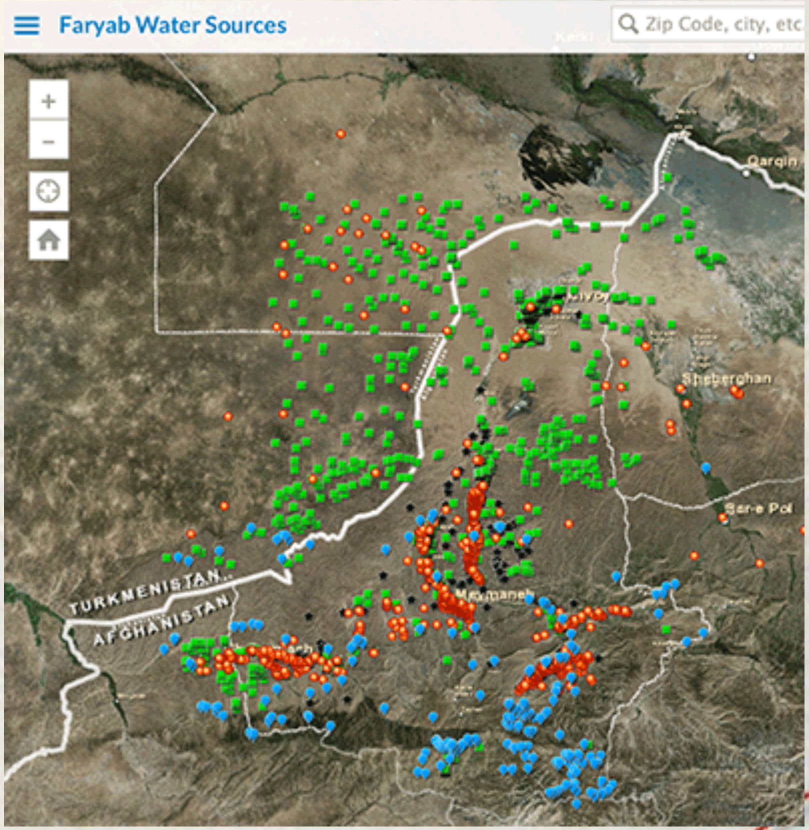


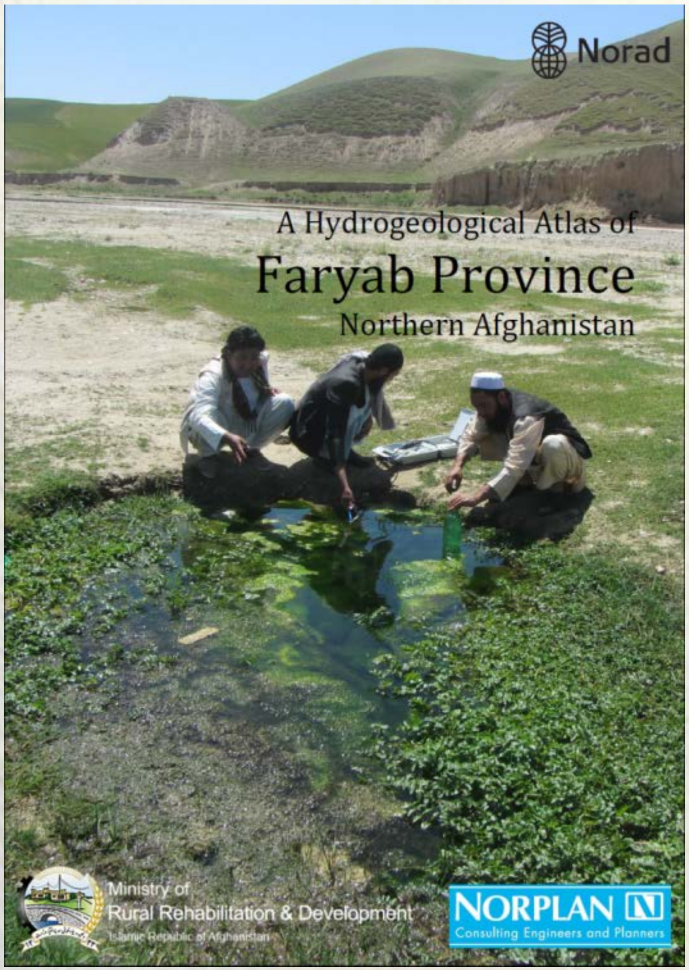
Figure 5.12. Hydrogeological Map of Faryab Province

WebGIS Portal

- Andreas to describe



Hydrogeological Atlas



Chapter 1 Introduction. Faryab Province: A History of Water Resources

Chapter 2 Faryab: Location, Topography and Climate

Chapter 3 Faryab: River and Surface Waters

Chapter 4 Faryab: Geology

Chapter 5 Faryab: Hydrogeology

Chapter 6 Faryab: Groundwater Levels and Flow

Chapter 7 Faryab: Thermogeology

Chapter 8 Faryab: Groundwater Salinity

Chapter 9 Faryab: Groundwater Hydrochemical Types

Chapter 10 Faryab: Groundwater Chemistry

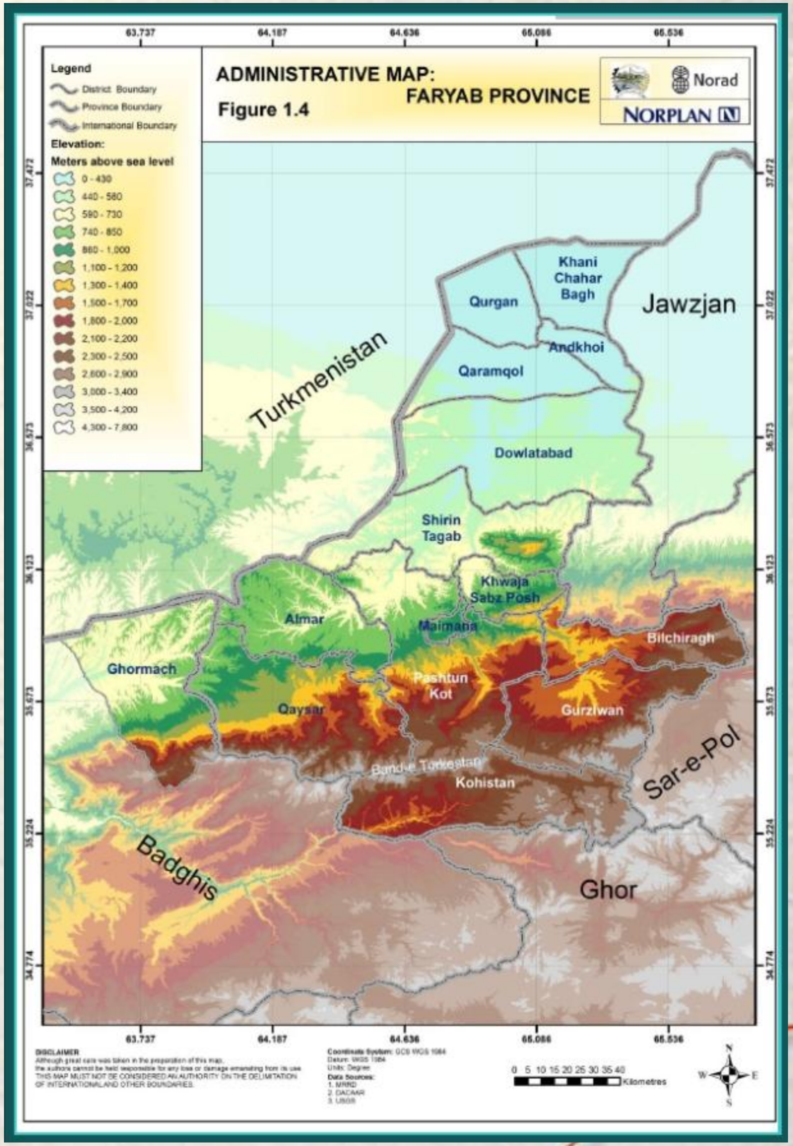
Chapter 11 Faryab: Stable Isotopes in Groundwater

Chapter 12 Summary, Conclusions and Recommendations

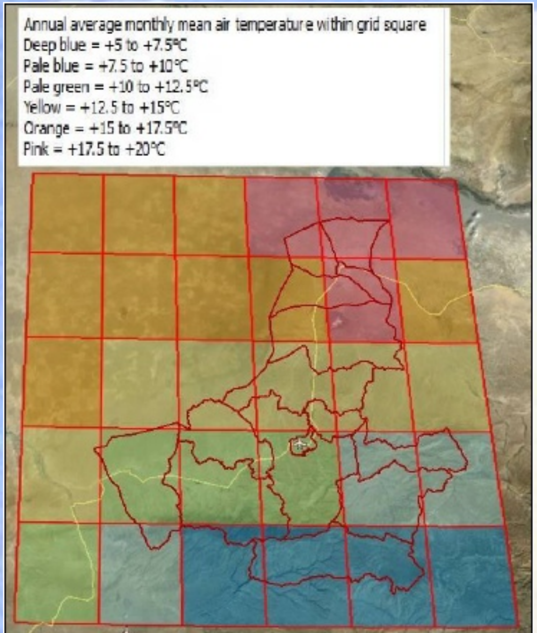
Population and Topography

Table 1.1. The Districts of Faryab Province (as of 2013)

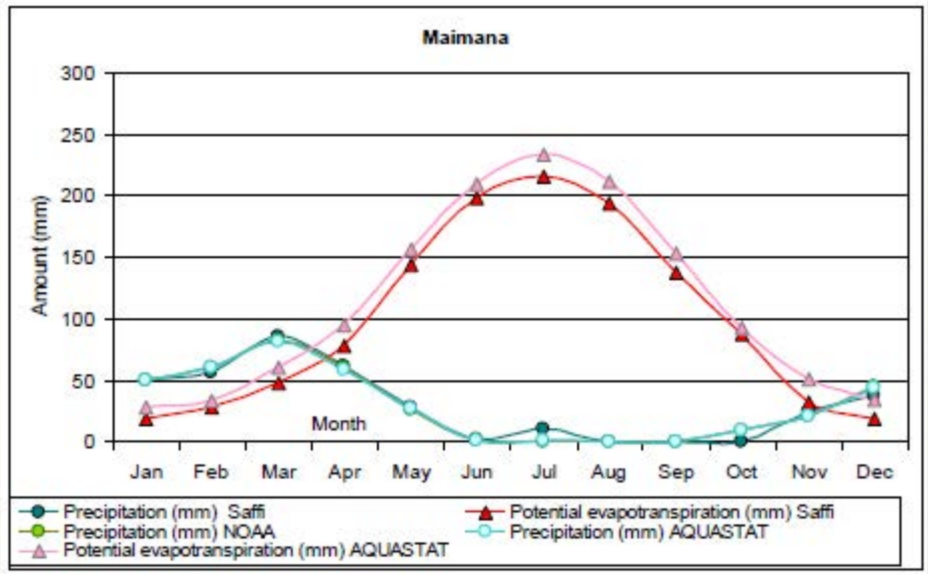
District	Population (CSO 2013)	Area (km²) (Wikipedia)
Qaysar	138,400	2,502
Almar	68,300	1,525
Kohistan	53,100	2,254
Gurziwan	73,700	1,875
Pashtun Kot	183,500	4,000
Khwaja Sabz Posh	49,400	800
Bilchiragh	50,700	1,189
Maimana	78,500	133**
Shirin Tagab	79,100	3,500
Dowlatabad	47,200	2,598
Qaramqol	19,100	2,192
Qurgan	45,800	797
Andkhoi	38,700	381
Khani Chahar Bagh	22,500	1,056
Ghormach	52,566*	2,083



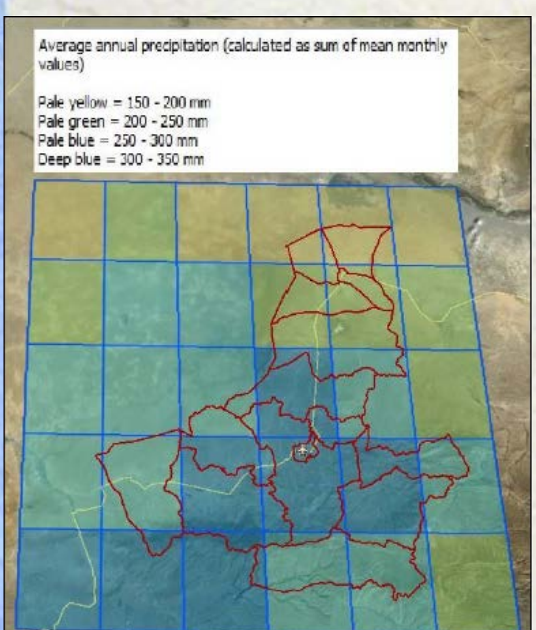
Climate



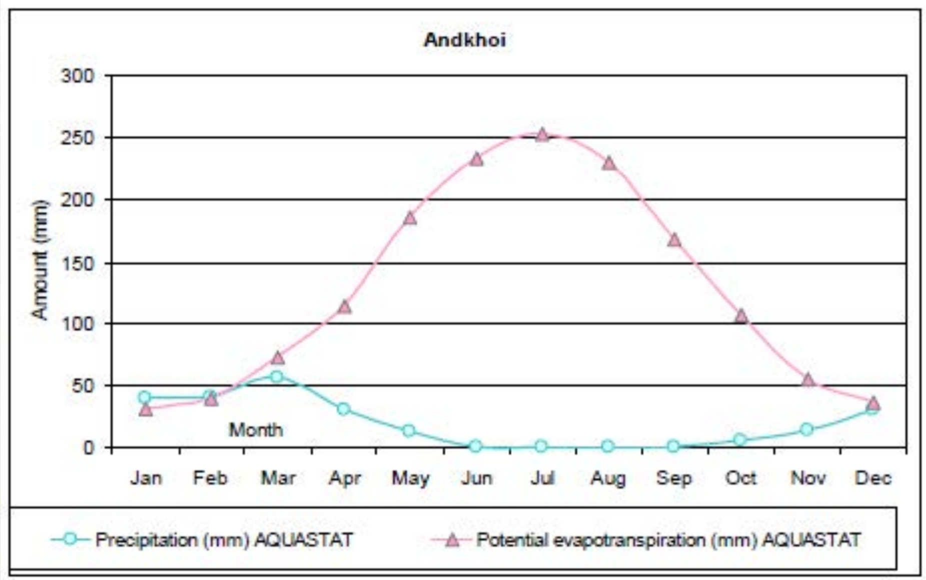
Annual average monthly mean air temperature within grid square
Deep blue = +5 to +7.5°C
Pale blue = +7.5 to +10°C
Pale green = +10 to +12.5°C
Yellow = +12.5 to +15°C
Orange = +15 to +17.5°C
Pink = +17.5 to +20°C



Maimana
Amount (mm)
300
250
200
150
100
50
0
Month
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Precipitation (mm) Saffi
Precipitation (mm) NOAA
Potential evapotranspiration (mm) AQUASTAT
Potential evapotranspiration (mm) Saffi
Precipitation (mm) AQUASTAT



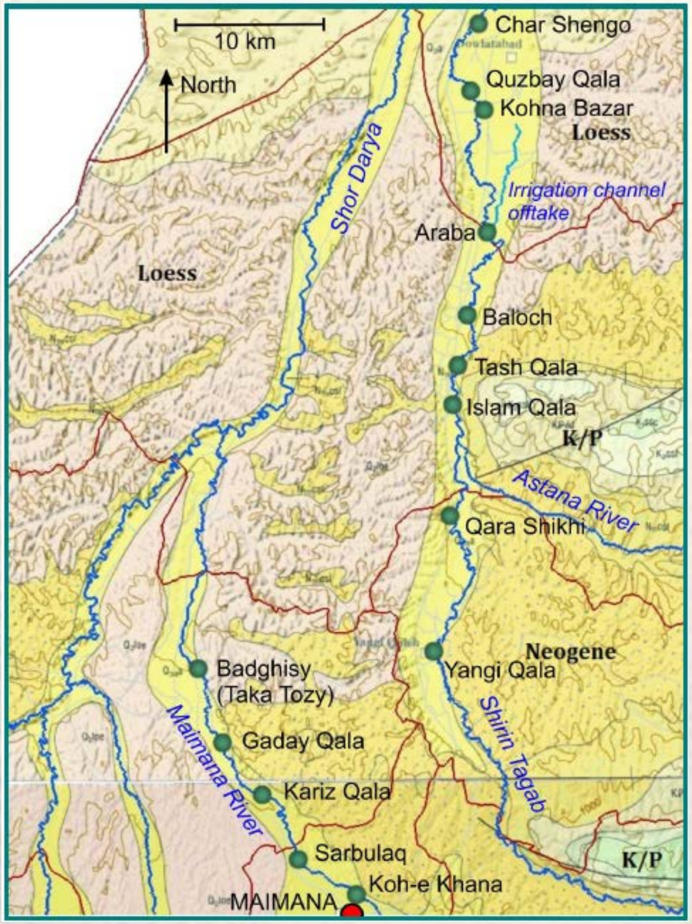
Average annual precipitation (calculated as sum of mean monthly values)
Pale yellow = 150 - 200 mm
Pale green = 200 - 250 mm
Pale blue = 250 - 300 mm
Deep blue = 300 - 350 mm

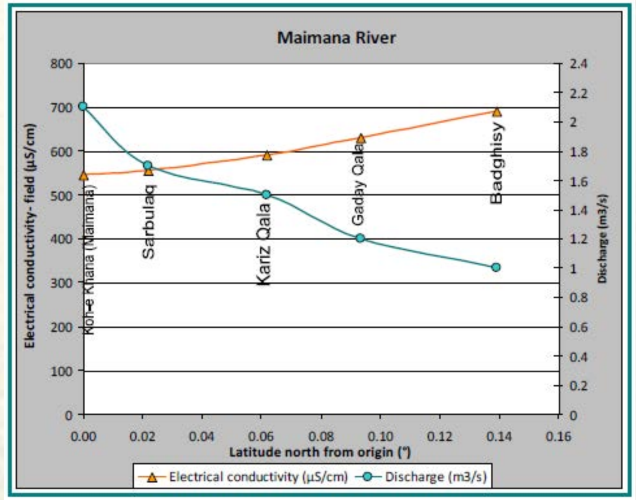


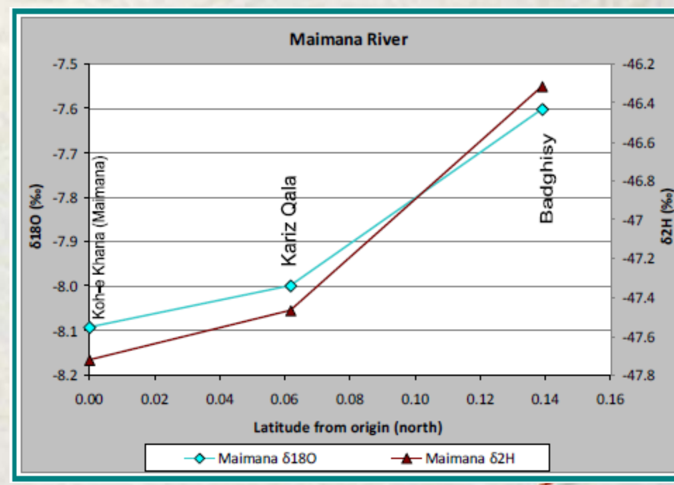
Andkhoi
Amount (mm)
300
250
200
150
100
50
0
Month
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Precipitation (mm) AQUASTAT
Potential evapotranspiration (mm) AQUASTAT

River flows

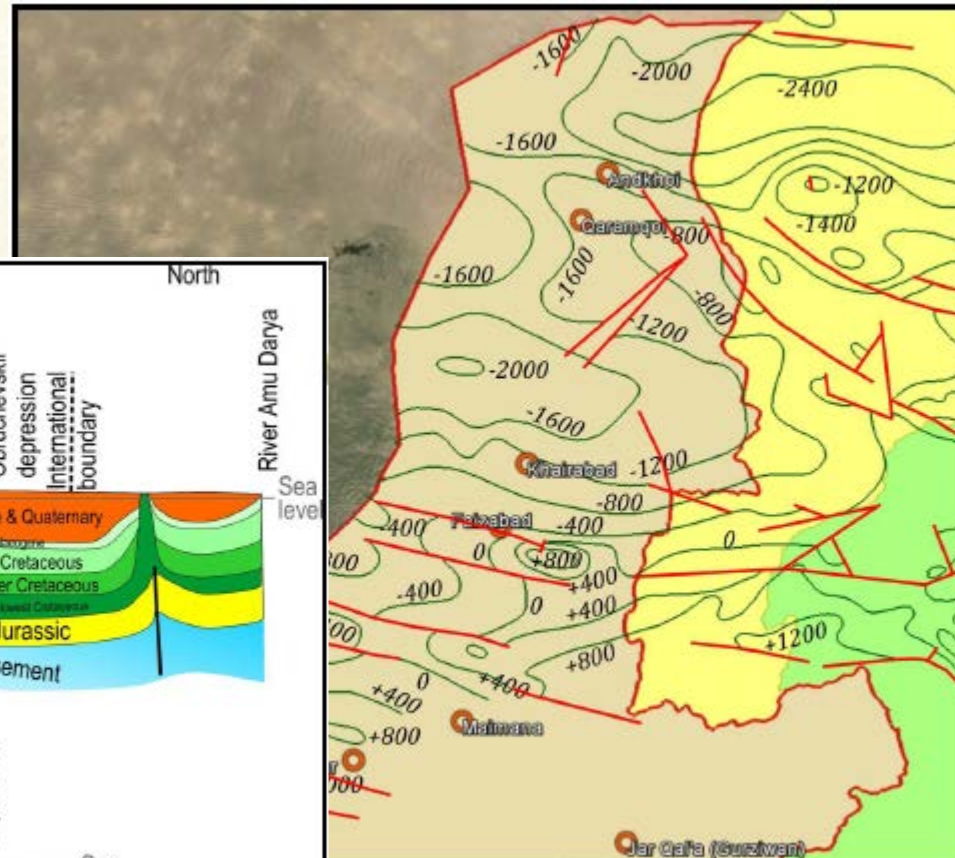
Heavily influenced by evapotranspiration



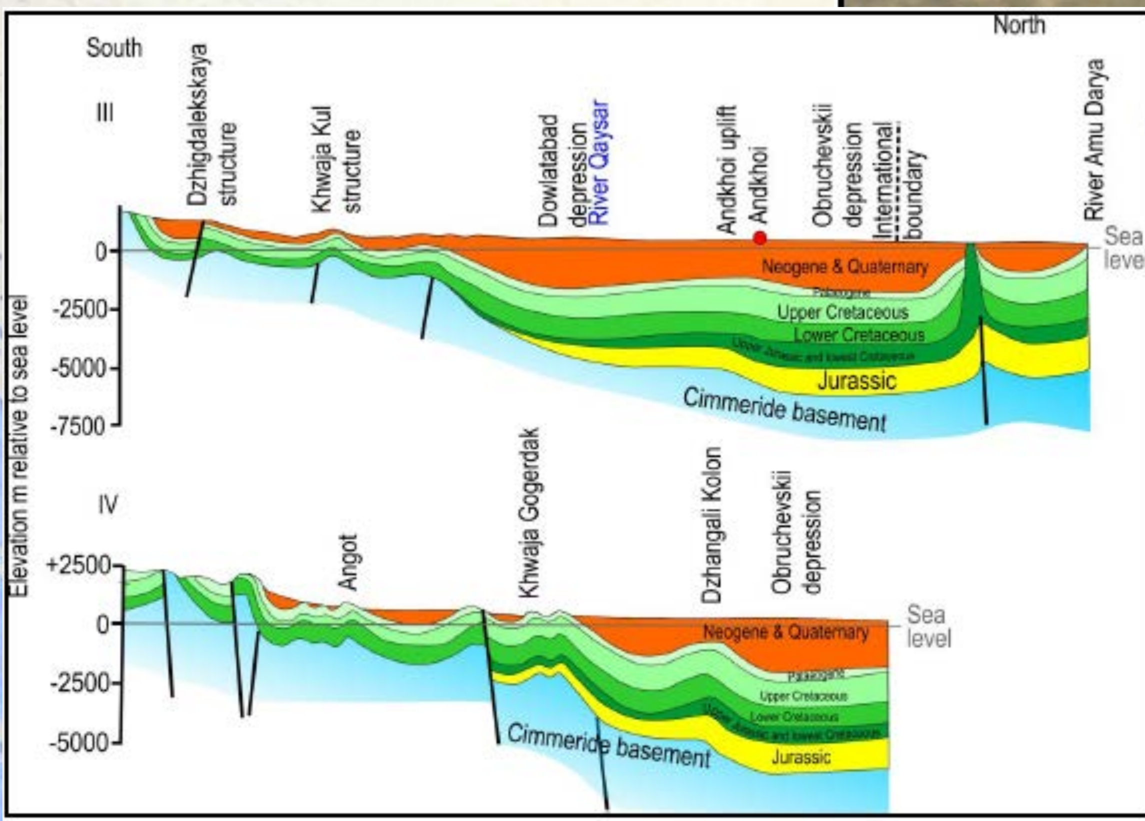




Geology



ours on the top of the Campanian-Palaeocene Ghory relative to sea level in Faryab. Based Steinshouer et al. s.usgs.gov/of/2006/1179/metadata/ghorydpafg.htm. Red et al. 2006).



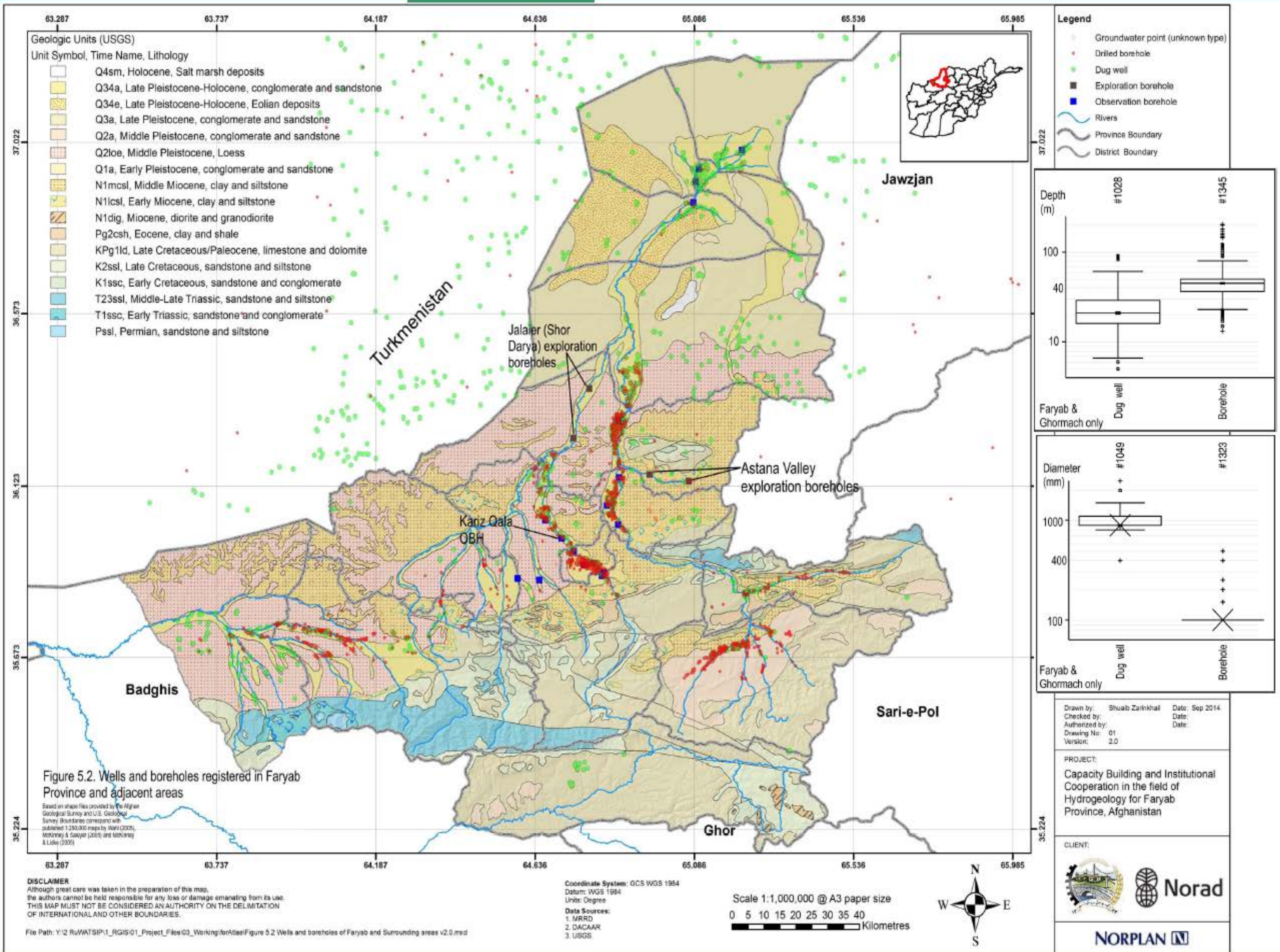


Figure 5.2. Wells and boreholes registered in Faryab Province and adjacent areas

Aquifer properties

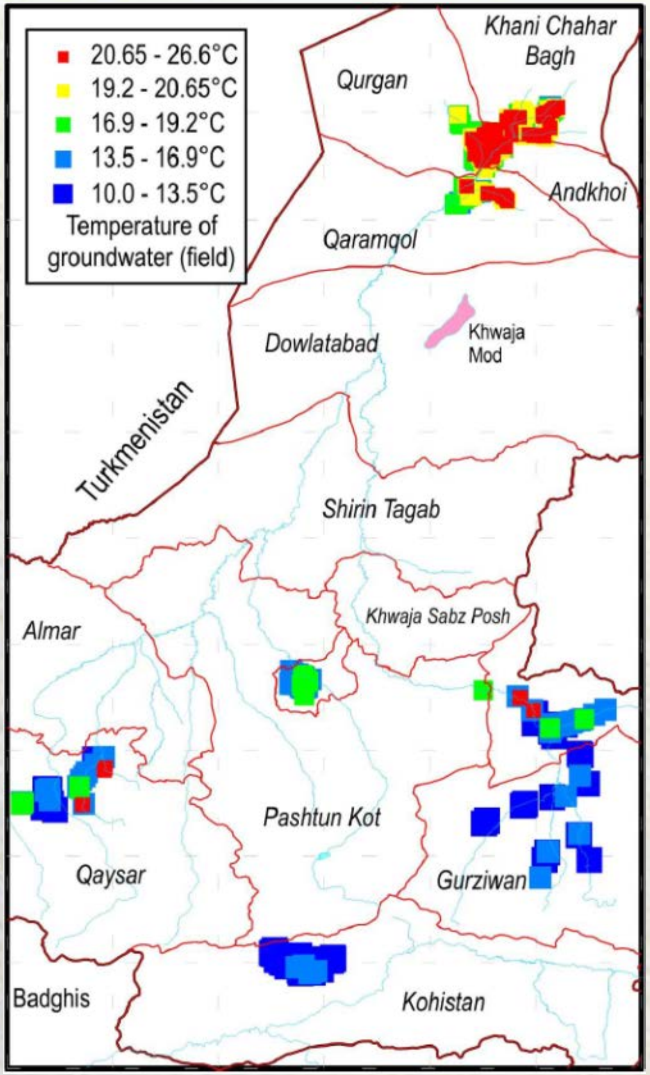
	Aquifer	T (high)	T (low)	Saturated depth	K (high)	K (low)
		m²/d	m²/d	m	m/d	m/d
Qaysar area						
Arzolik borehole		51	31	53.6	0.9	0.6
Qaysar Health Centre		49	30	25.28	2.0	1.2
Sar Asyab borehole		57	35	122.5	0.5	0.3
Almar area						
Sarf Ali borehole		*	*	25.8	*	*
Qara Tana borehole		*	*	62.9	*	*
Nughayli Bala borehole		27	17	49	0.6	0.3
Shoran Shikhan borehole		13	8	45	0.3	0.17
Almar Markaz (Centre)	Quaternary	20	12	14	1.4	0.9
Bish Qara and Noqholi Payan borehole		40	24	38.3	1.0	0.6
Maimana area						
Jamshidi Bala borehole	Neogene	18	11	65.2	0.3	0.16
Bakhshi Sayd Alli borehole	Neogene	9	6	56.2	0.16	0.10
Maimana University borehole	Quaternary	81	49	49	1.6	1.0
NCA Maimana (Koh-e Khana) test borehole	Quaternary	258	157	77.7	3.3	2.0
Bibi Aina borehole	Quaternary (some Neogene)	230	141	139	1.7	1.0
Toshkur Bibi Amina		617	376	24	25.7	15.7
Further north						
Shirin Tagab Health Centre		73	44	20.5	3.5	2.2
Shirin Tagab Markaz (Centre)	Quaternary	655	399	18.1	36.2	22.1
Astana 1 deep bore (Mahad)	Neogene	27	16	190	0.14	0.09
Astana 2 deep bore (Gul Qudoq)	Neogene	2.1	1.3	191	0.01	0.01
Jalaier 1 deep bore (Chokazie village)	Neogene	62	38	177	0.4	0.21
Jalaier 2 deep bore (Atomchi village)	Neogene	1.0	0.6	183.3	0.005	0.003
Dowlatabad Markaz (Centre), bore 2	Quaternary	144	88	29	5.0	3.0

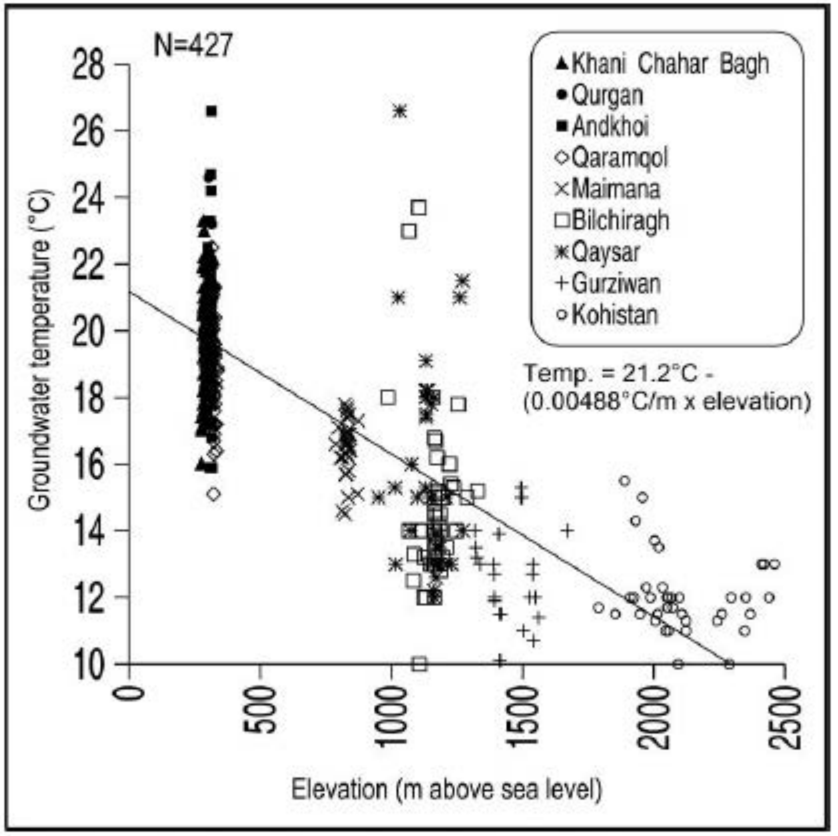
Table 5.2. Boreholes in Faryab with pumping / drawdown data. Transmissivity range estimated by Logan approximation. * = transmissivity very low (pump dry).

The transmissivities of the Quaternary aquifer system range from several hundred m²/d in northern Maimana (Bibi Aina, Toshkur Bibi Amina, Koh-e Khana) and the Shirin Tagab valley, down to a few tens of m²/d around Qaysar and Almar.

For the Neogene, the transmissivities are even lower, ranging from around 1 m2/d to 40-60 m²/d.

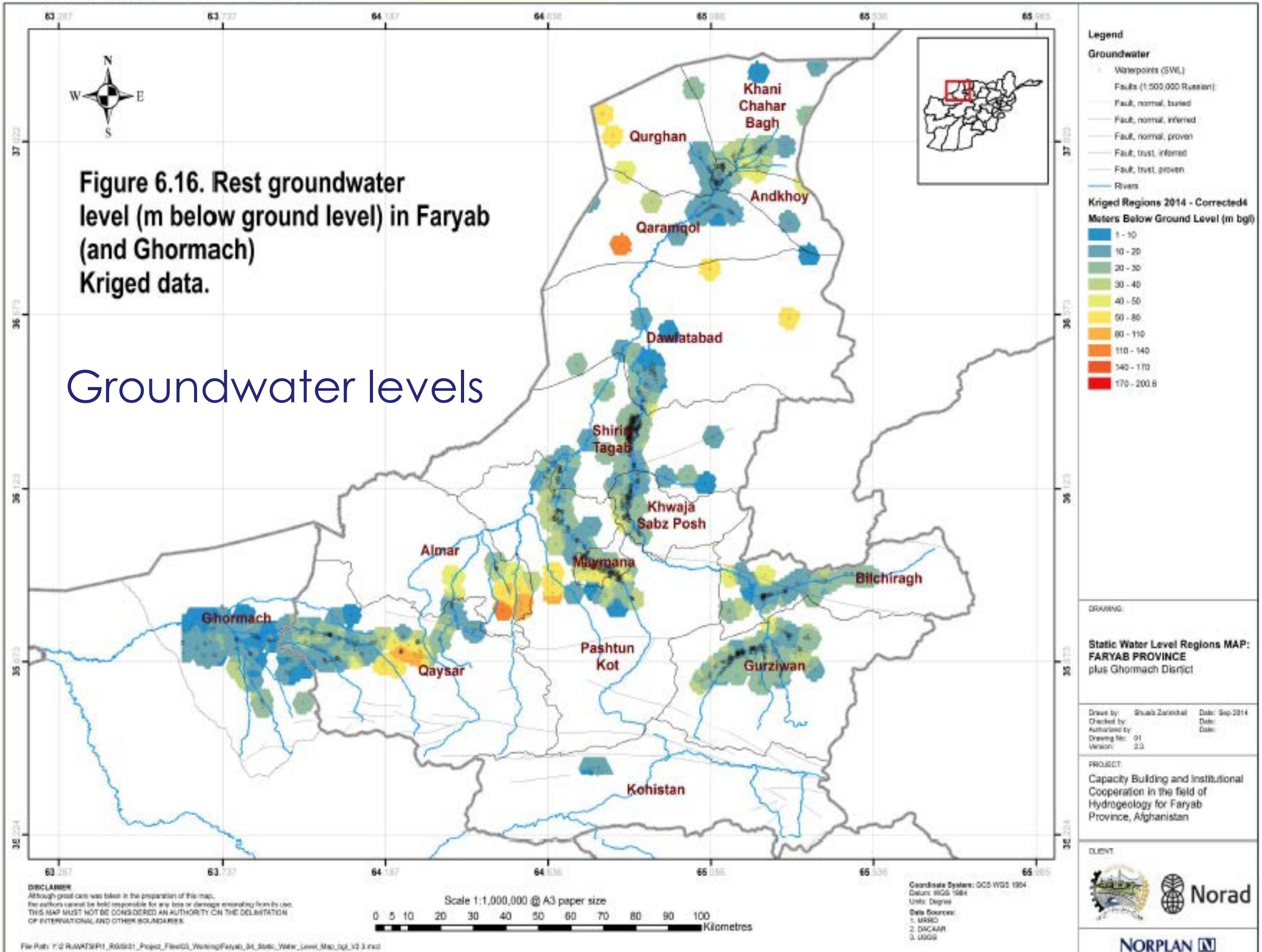
Thermogeology



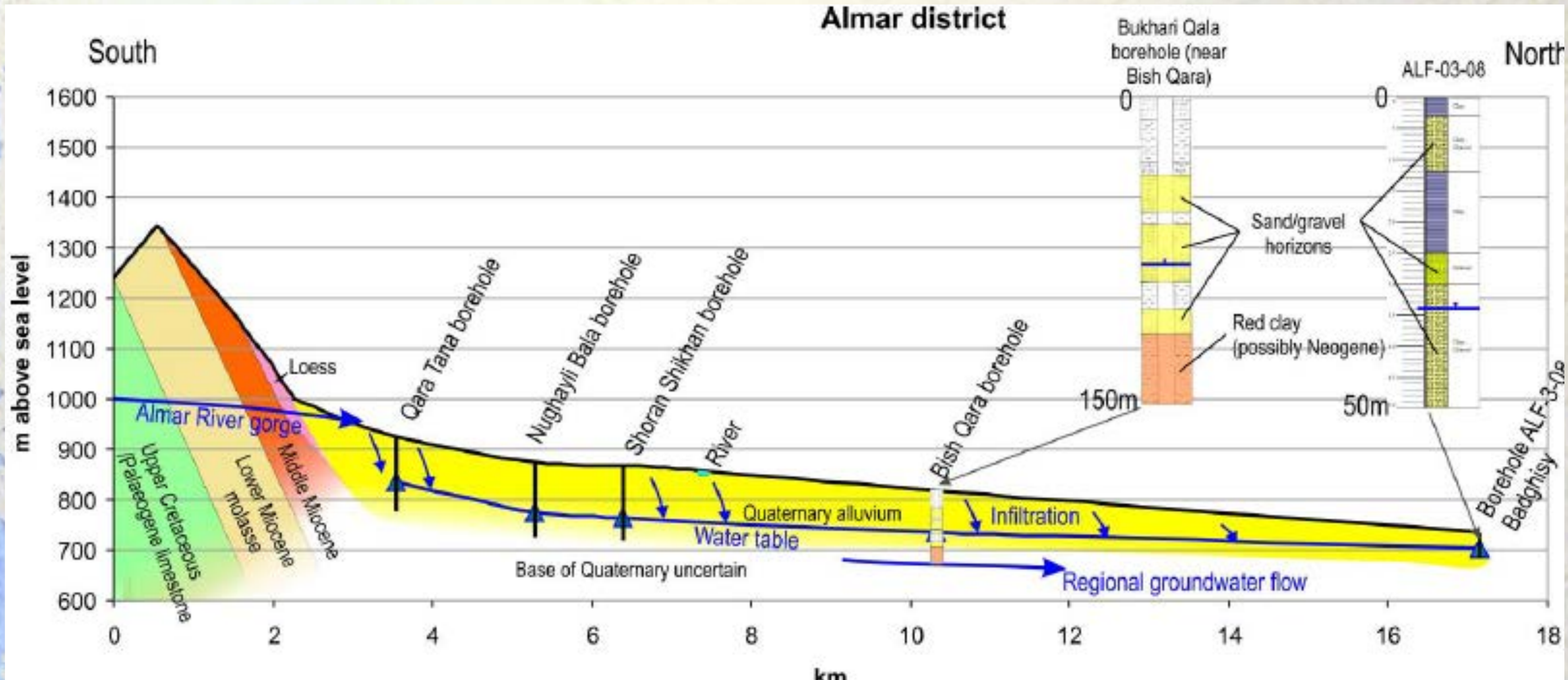


Significant potential for ground sourced space cooling and heating

Groundwater levels



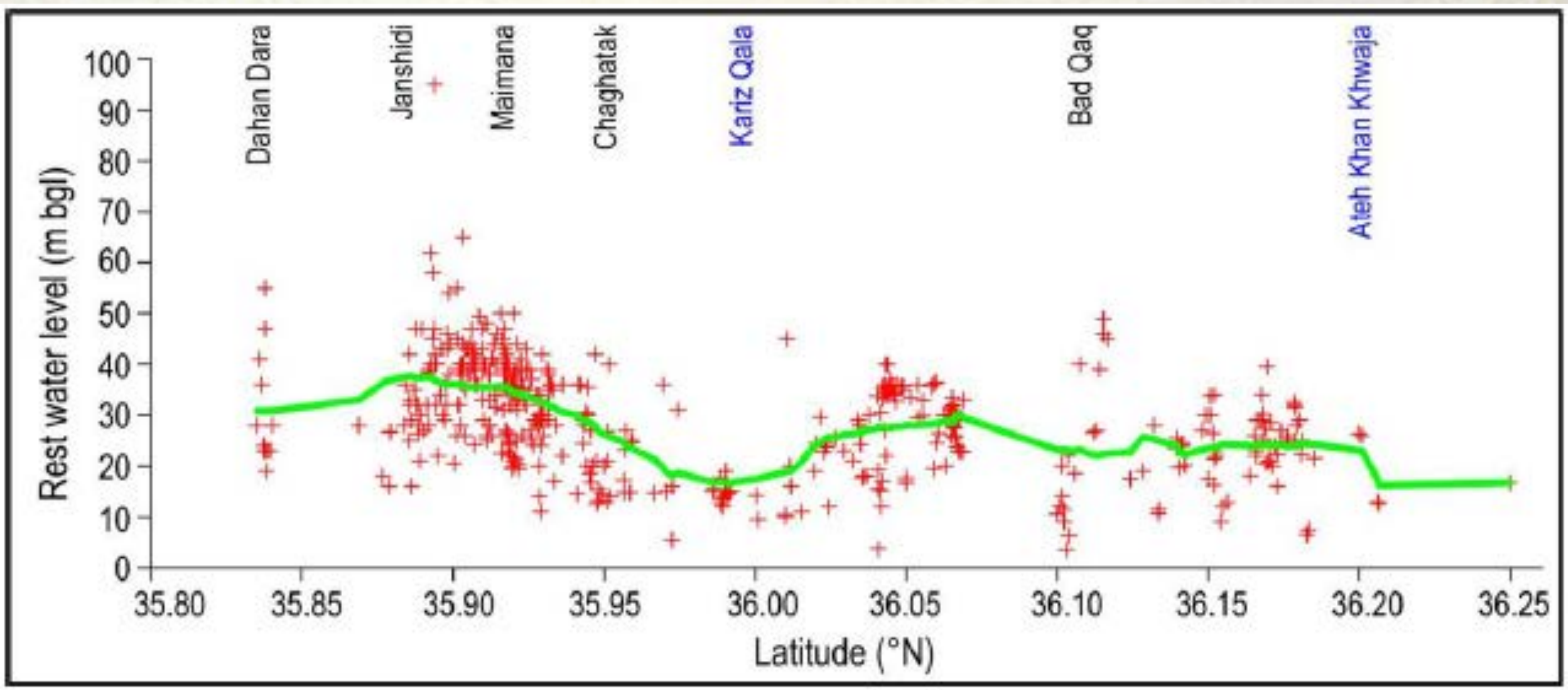
Groundwater levels



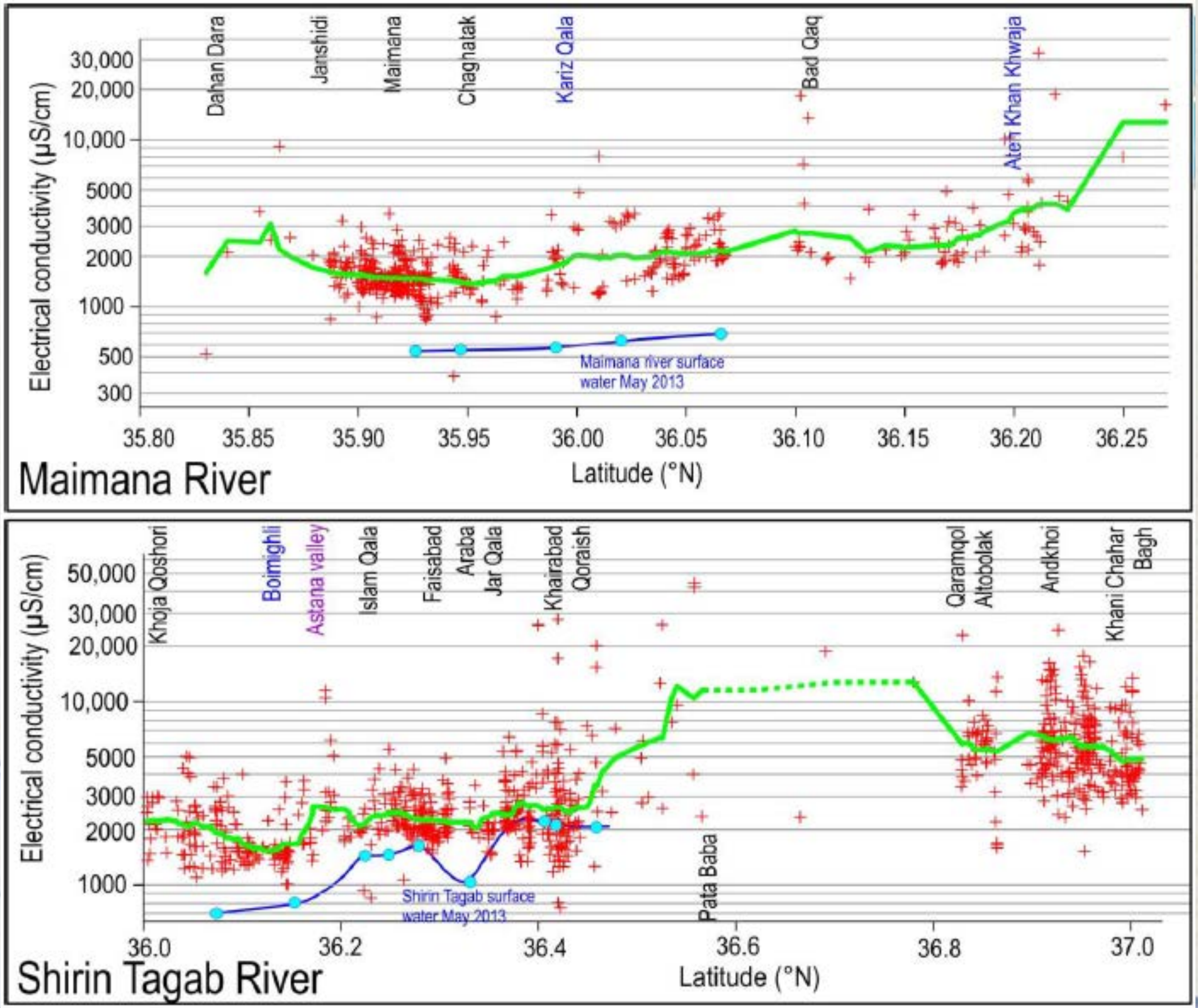
Such sections help to explain why groundwater levels are so deep in some areas (Qaysar, Almar)

Groundwater levels

- Groundwater levels typically 15 – 40 m below ground in valleys
- Approach surface near springs
- Potential for infiltration of river water to aquifer

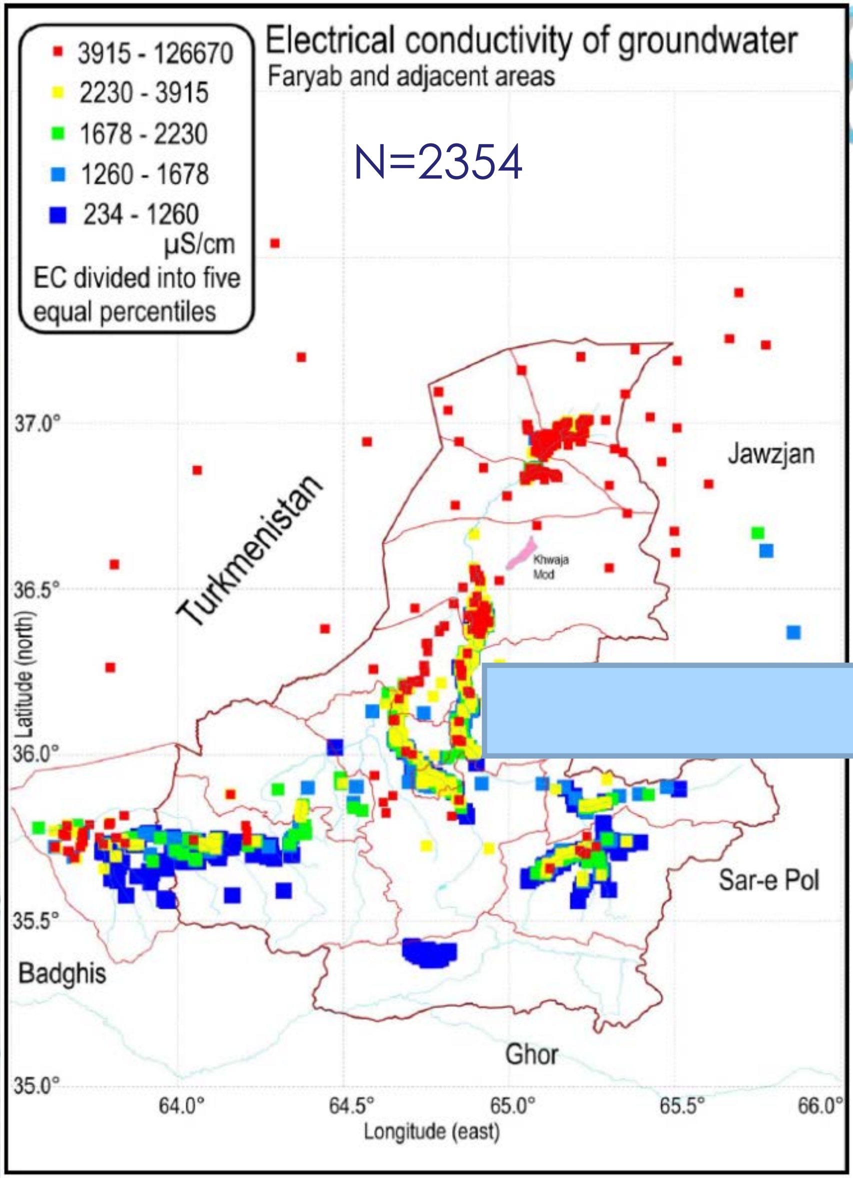


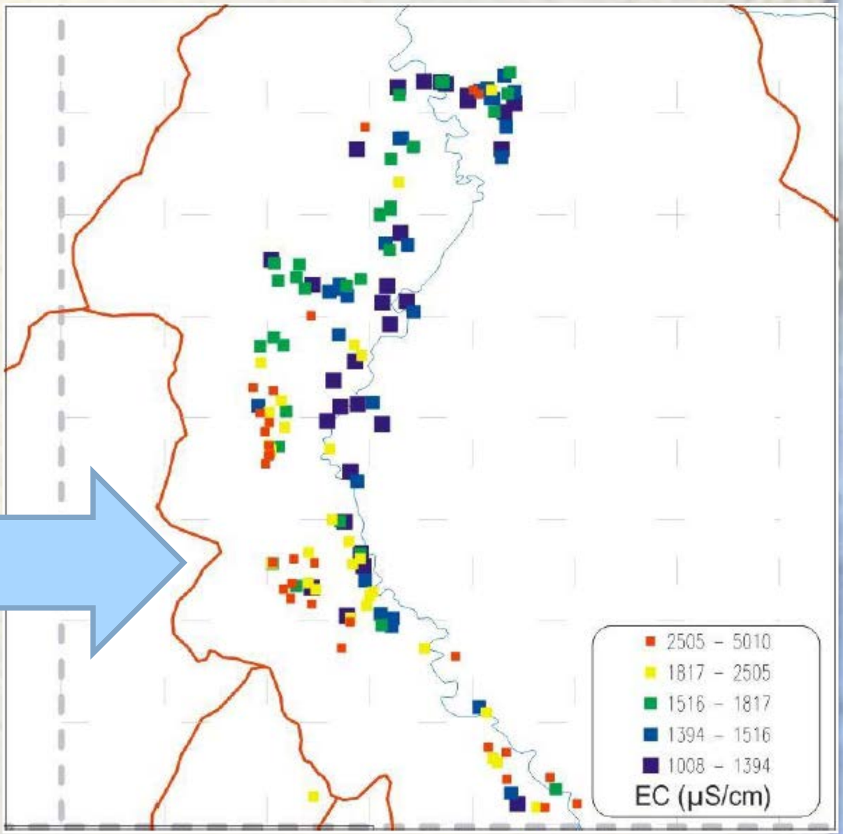
Salinity



Dahan Dara
Janshidi
Maimana
Chagnatak
Kariz Qala
Bad Qaq
Aten Khan Khwaja
Electrical conductivity (µS/cm)
30,000
20,000
10,000
5000
3000
2000
1000
500
300
Maimana river surface water May 2013
35.80
35.85
35.90
35.95
36.00
36.05
36.10
36.15
36.20
36.25
Latitude (°N)
Maimana River
Khoja Qoshori
Boimghli
Astana valley
Islam Qala
Faisabad
Araba
Jar Qala
Khairabad
Qoraish
Qaramqol
Altobolak
Andkhoi
Khani Chahar Bagh
Electrical conductivity (µS/cm)
50,000
30,000
20,000
10,000
5000
3000
2000
1000
Shirin Tagab surface water May 2013
Pata Baba
36.0
36.2
36.4
36.6
36.8
37.0
Latitude (°N)
Shirin Tagab River

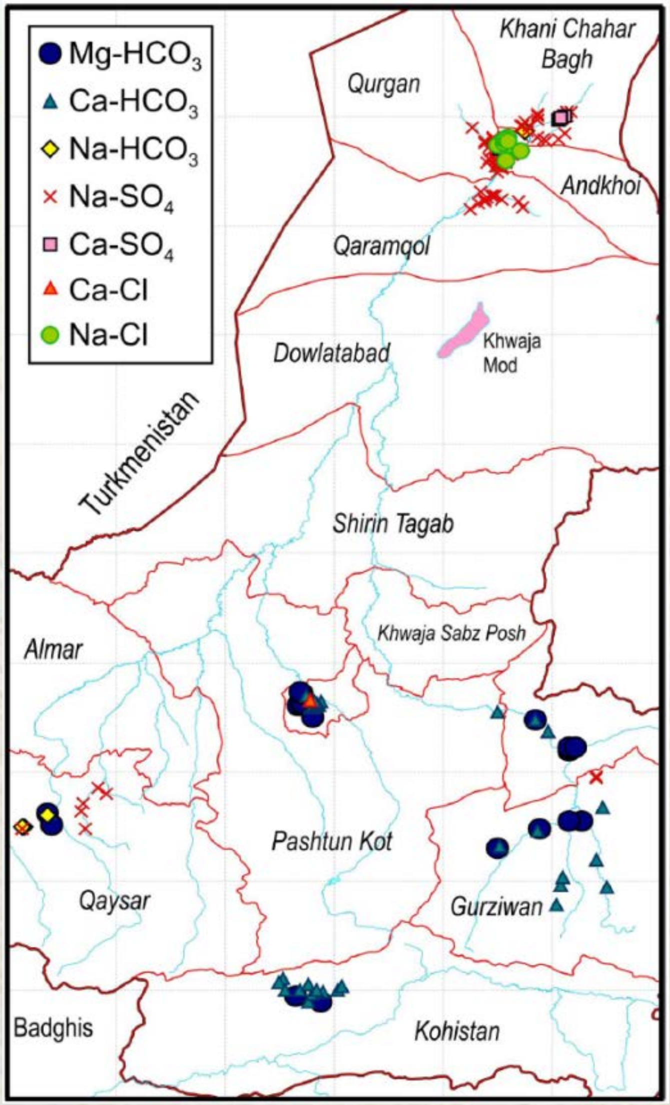
Salinity



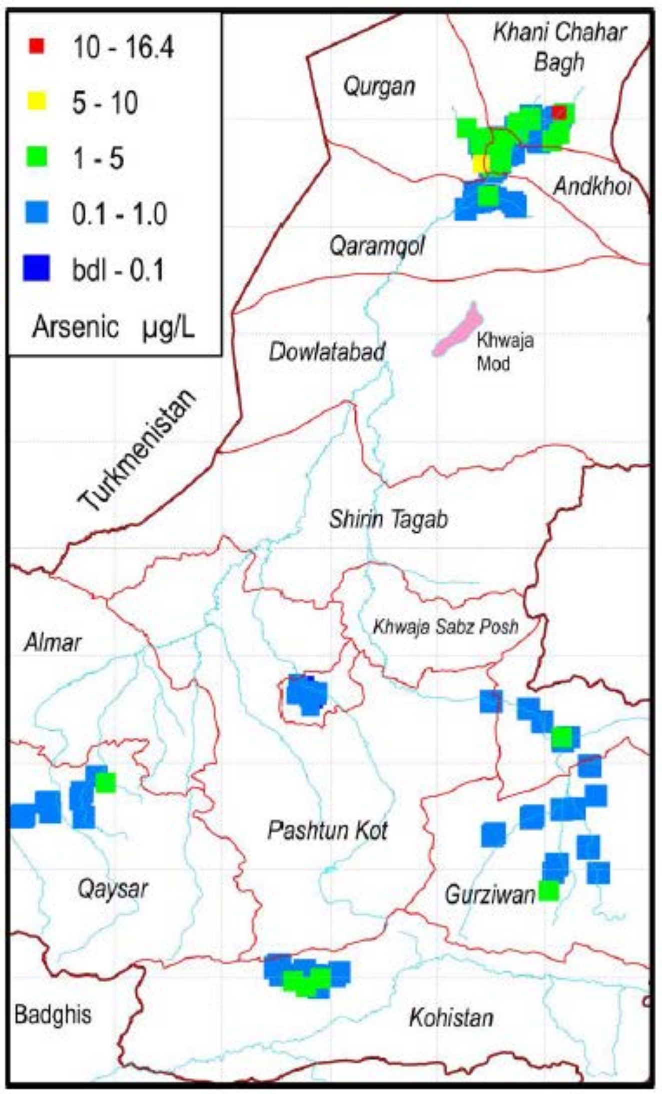


Islam Qala, Shirin Tagab

Water chemistry



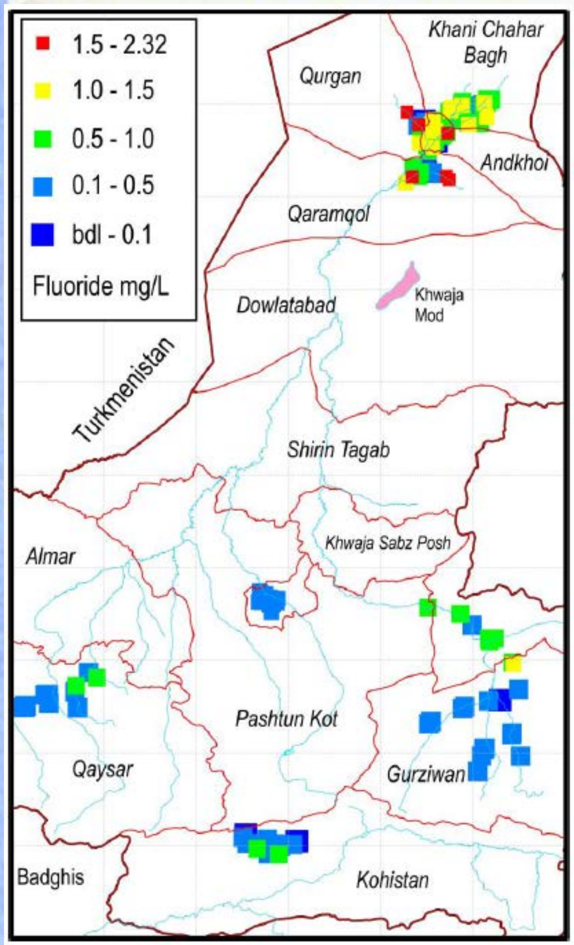
Major ion chemistry (N=148)



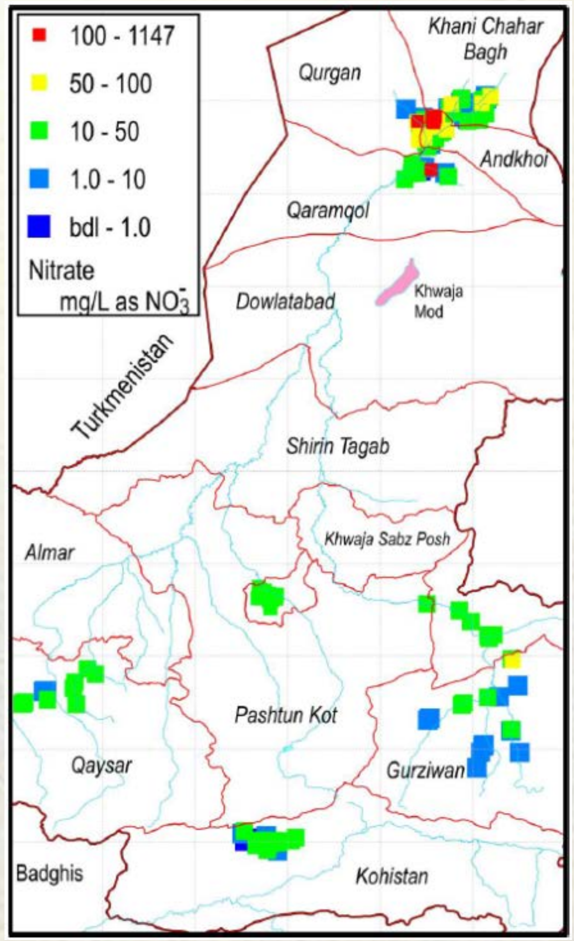
Arsenic (should be <10 µg/L)

Water chemistry

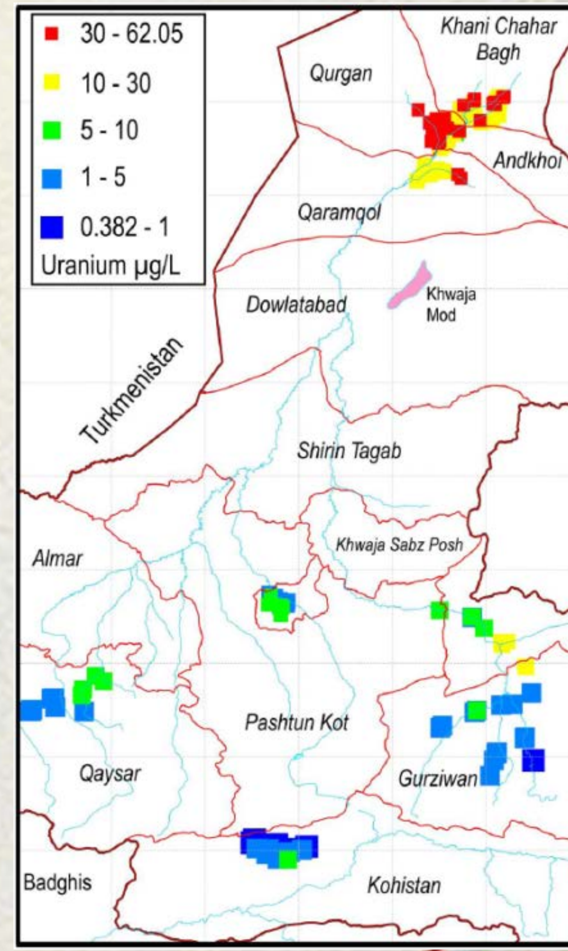
(N=148)



Fluoride
(should be <1.5 mg/L)



Nitrate
(should be < 50 mg/L)



Uranium
(should be < 30 μg/L)

Stable isotopes

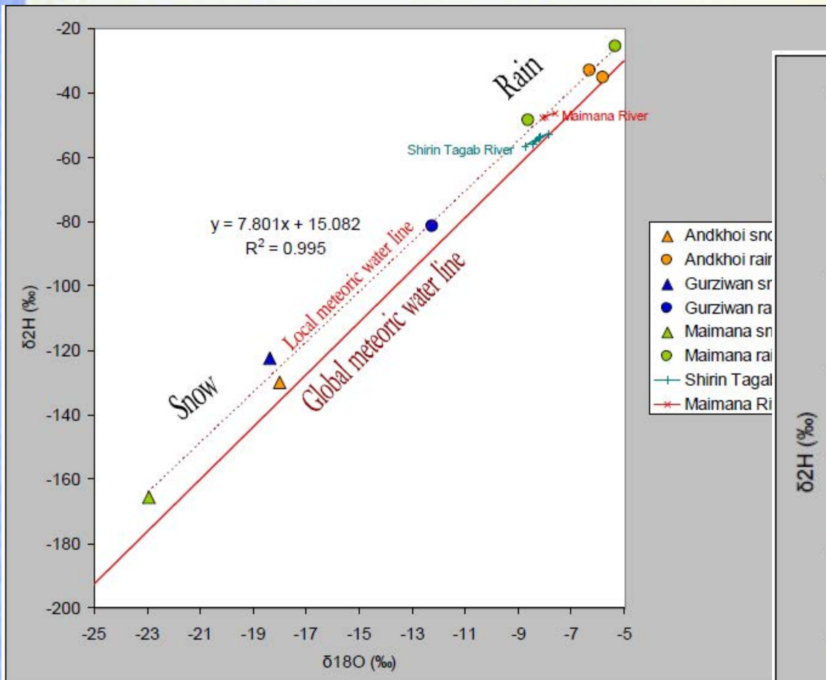


Figure 11.2. Stable isotope diagram comparing the isotopic composition of precipitation samples (from Figure 2.8) with river water samples from May 2013, described in Chapter 3. The GMWL is taken as $\delta^2H = (8.13 \times \delta^{18}O) + 10.8$ (Clark & Fritz 1997). The local meteoric water line is the linear best fit through all precipitation points and is defined by equation (11.2)

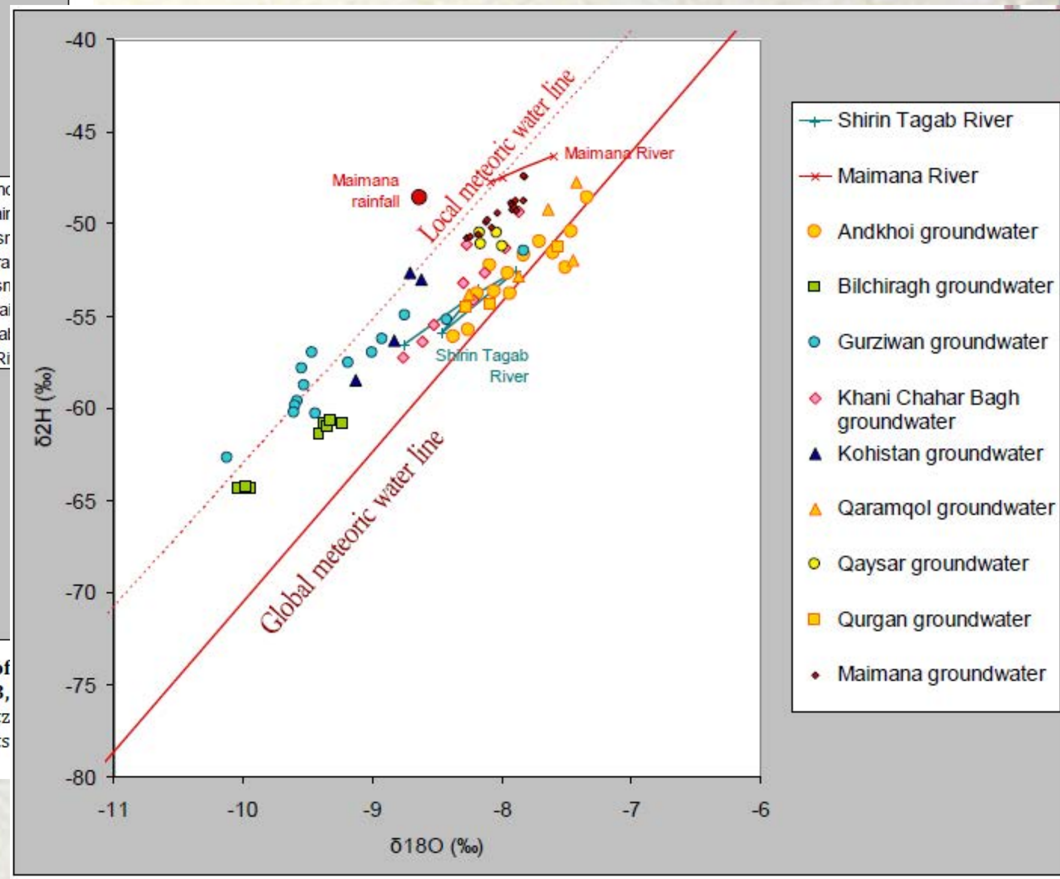
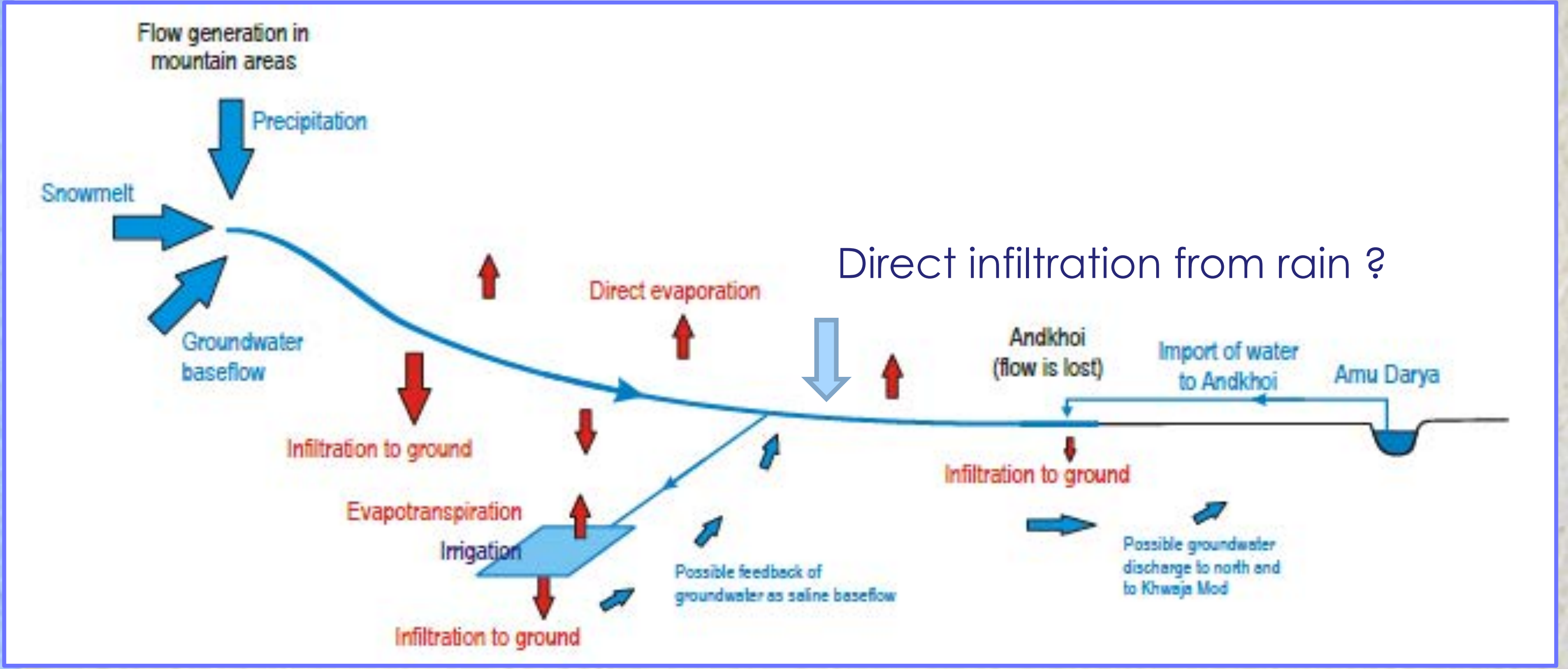


Figure 11.4. Stable isotope diagram comparing the isotopic composition of groundwater samples with river water samples from May 2013 and Maimana rainfall. The GMWL is taken as $\delta^2H = (8.13 \times \delta^{18}O) + 10.8$ (Clark & Fritz 1997). The local meteoric water line is taken from Figure 11.1 and equation 11.2.

Evapotranspiration is a powerful driving factor for groundwater chemistry

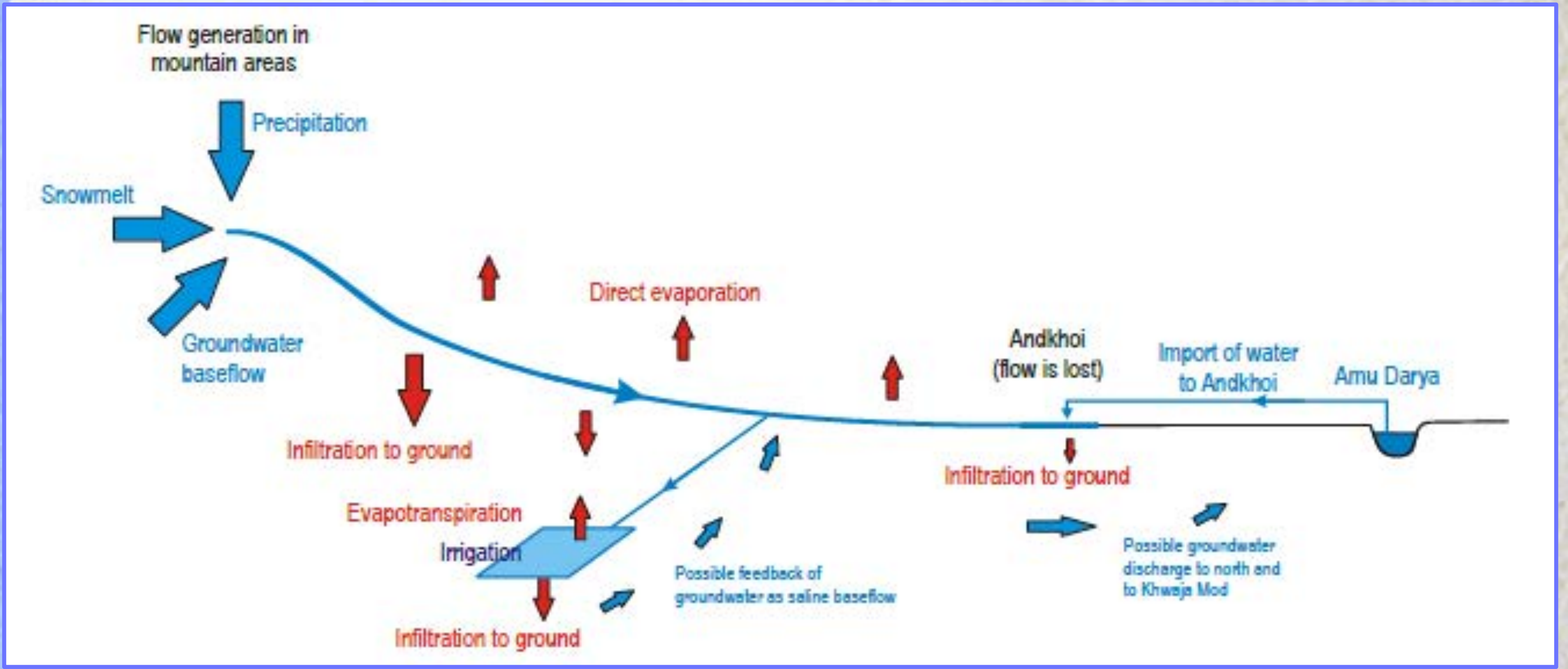
Water balance



Direct recharge of precipitation:
Almost 0 mm in northern districts
Around 10-20 mm per year in Maimana / Gurziwan
Maybe > 100-200 mm in Kohistan (mountains in south)

Water balance

Indirect recharge of river water is very important for groundwater resources



Major uncertainties in water balance
Offtake to irrigation
Evapotranspiration losses to irrigation
Quantification of indirect infiltration from rivers