A conceptual model and hydrogeological atlas for sustainable groundwater management in Faryab, northern Afghanistan

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Ministry of Rural Rehabilitation & Development
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HolyMoor

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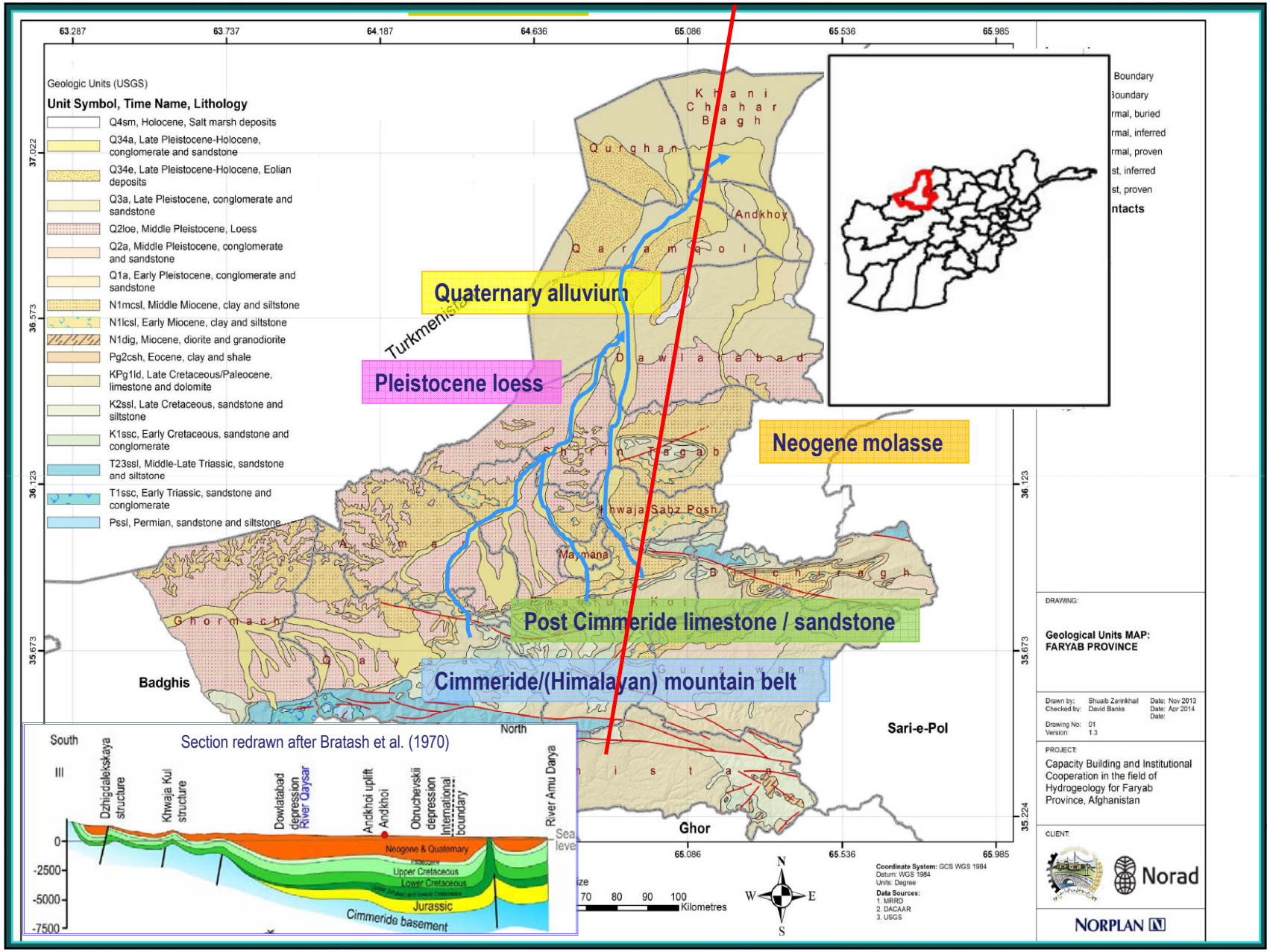
A 4-year project to develop hydrogeological mapping in Afghanistan via a pilot mapping in one province: Faryab

1. Desk study of existing data
2. Field surveys of
   - groundwater,
   - rivers,
   - rain/snowfall,
   - soil chemistry
3. Development of hydrogeological map and explanatory **Hydrogeological Atlas**
4. Development of GIS/MIS systems for data
   - an interactive **WebGIS** hydrogeological mapping portal
5. Extensive program of training
6. Detailed investigation/ drilling of one area (Maimana Airport)


Quaternary alluvium
Pleistocene loess
Neogene molasse
Post Cimmeride limestone / sandstone
Cimmeride/(Himalayan) mountain belt
Geologic Units (USGS)
Unit Symbol, Time Name, Lithology
Q4sm, Holocene, Salt marsh deposits
Q34a, Late Pleistocene-Holocene, conglomerate and sandstone
Q34e, Late Pleistocene-Holocene, Eolian deposits
Q3a, Late Pleistocene, conglomerate and sandstone
Q2loe, Middle Pleistocene, Loess
Q2a, Middle Pleistocene, conglomerate and sandstone
Q1a, Early Pleistocene, conglomerate and sandstone
N1mcsl, Middle Miocene, clay and siltstone
N1lcsl, Early Miocene, clay and siltstone
N1dig, Miocene, diorite and granodiorite
Pg2csh, Eocene, clay and shale
KPg1ld, Late Cretaceous/Paleocene, limestone and dolomite
K2ssl, Late Cretaceous, sandstone and siltstone
K1ssc, Early Cretaceous, sandstone and conglomerate
T23ssl, Middle-Late Triassic, sandstone and siltstone
T1ssc, Early Triassic, sandstone and conglomerate
Pssl, Permian, sandstone and siltstone
Section redrawn after Bratash et al. (1970)
South
North
Dzhigdalekskaya structure
Khwaja Kul structure
Dowlatabad depression
River Qaysar
Andkhoi uplift
Andkhoi
Obruchevskii depression
International boundary
River Amu Darya
Sea level
Neogene & Quaternary
Upper Cretaceous
Lower Cretaceous
Jurassic
Cimmeride basement
0
-2500
-5000
-7500
Badghis
Sari-e-Pol
Ghor
Andkhoy
Maymana
Turkmenistan
Kilometres
DRAWING:
Geological Units MAP:
FARYAB PROVINCE
PROJECT:
Capacity Building and Institutional Cooperation in the field of Hydrogeology for Faryab Province, Afghanistan
CLIENT:
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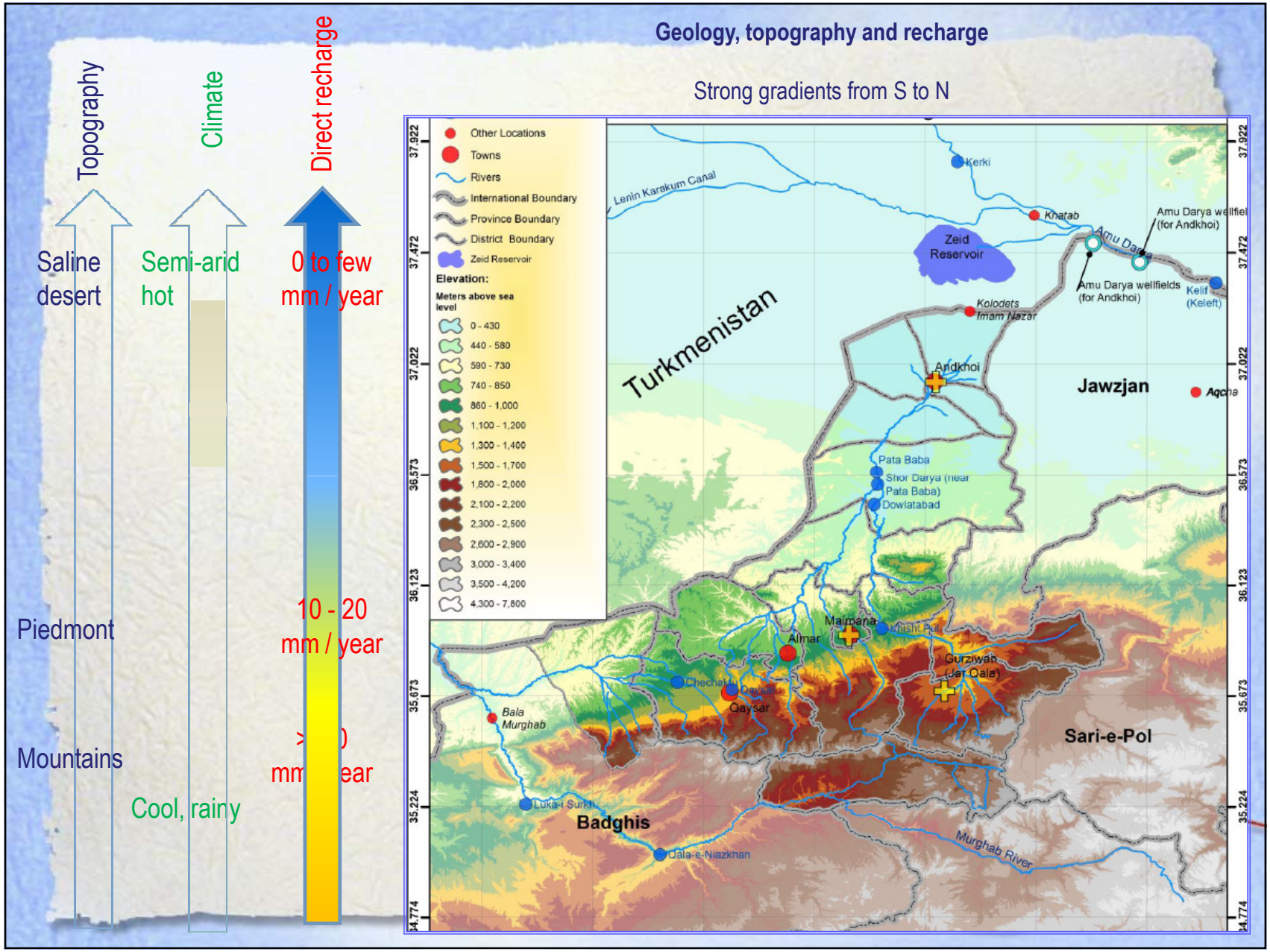
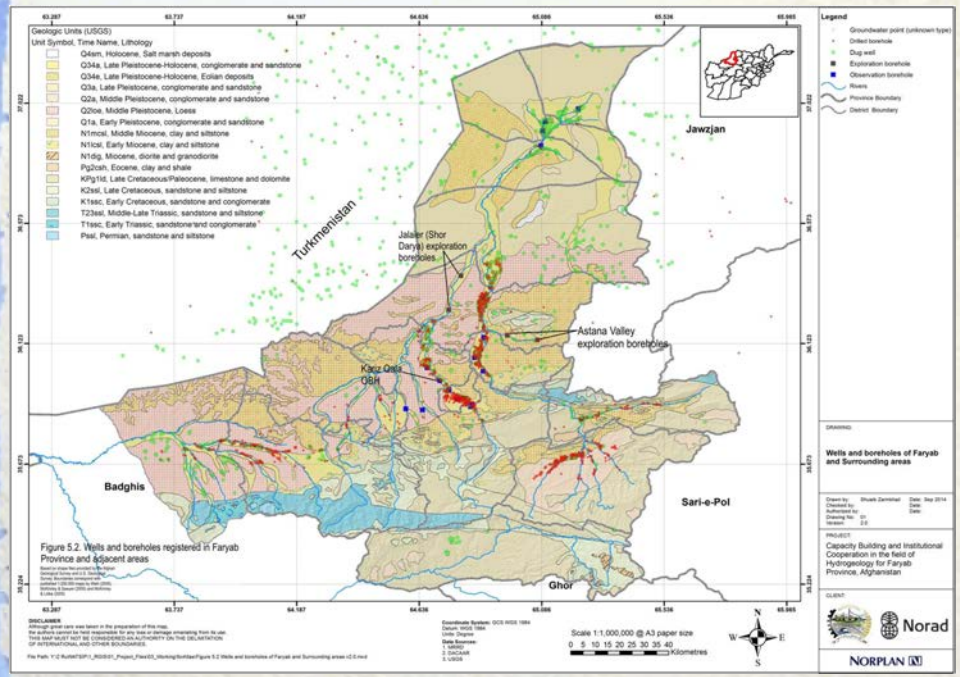

Geology, topography and recharge
Strong gradients from S to N
Topography
Climate
Direct recharge
Saline desert
Semi-arid hot
0 to few mm / year
Piedmont
10 - 20 mm / year
Mountains
Cool, rainy
Other Locations
Towns
Rivers
International Boundary
Province Boundary
District Boundary
Zeid Reservoir
Elevation:
Meters above sea level
0 - 430
440 - 580
590 - 730
740 - 850
860 - 1,000
1,100 - 1,200
1,300 - 1,400
1,500 - 1,700
1,800 - 2,000
2,100 - 2,200
2,300 - 2,500
2,600 - 2,900
3,000 - 3,400
3,500 - 4,200
4,300 - 7,800
Turkmenistan
Kerki
Lenin Karakum Canal
Khatab
Amu Darya
Amu Darya wellfield (for Andkhoi)
Zeid Reservoir
Amu Darya wellfields (for Andkhoi)
Kelif (Keleft)
Kolodets Imam Nazar
Andkhoi
Jawzjan
Aqcha
Pata Baba
Shor Darya (near Pata Baba)
Dowlatabad
Maimana
Almar
Gurziwan (Jer Qala)
Qaysar
Bala Murghab
Sari-e-Pol
Luka-i Surkh
Badghis
Qala-e-Niazkhan
Murghab River
37.922
37.472
37.022
36.573
36.123
35.673
35.224
34.774

1. Desk study


Jawzjan
Turkmenistan
Jalaier (Shor Darya) exploration boreholes
Astana Valley exploration boreholes
Kaoz Qala OBH
Badghis
Sari-e-Pol
Ghor
Figure 5.2: Wells and boreholes registered in Faryab Province and adjacent areas
Wells and boreholes of Faryab and Surrounding areas
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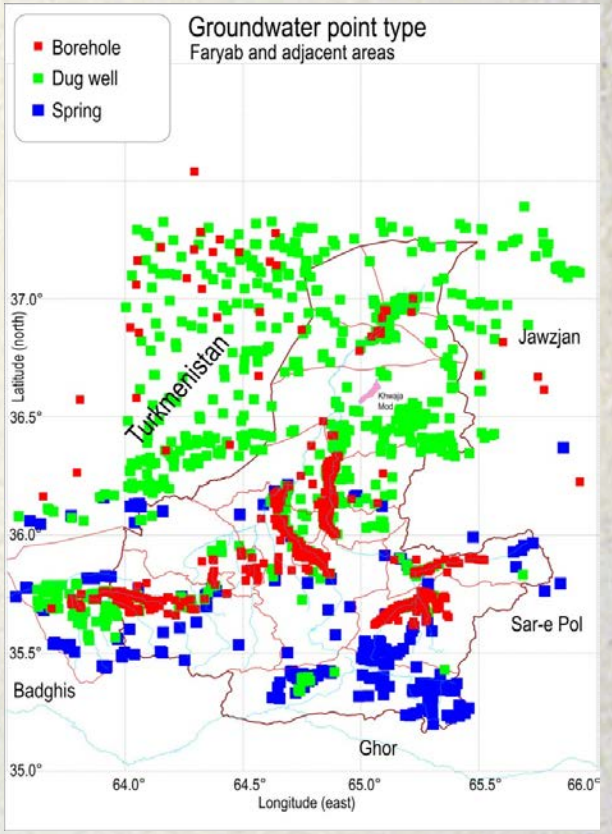
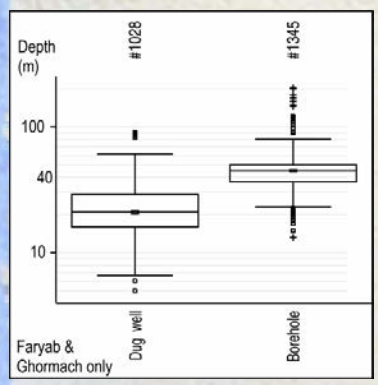
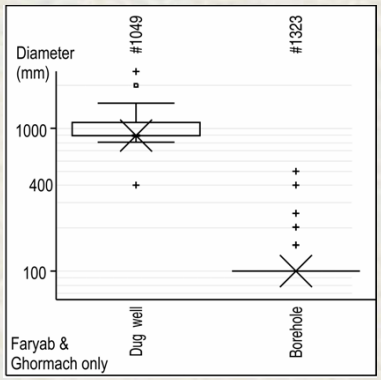

Groundwater point type
Faryab and adjacent areas
Borehole
Dug well
Spring
Latitude (north)
Longitude (east)
37.0°
36.5°
36.0°
35.5°
35.0°
64.0°
64.5°
65.0°
65.5°
66.0°
Turkmenistan
Jawzjan
Sar-e Pol
Badghis
Ghor


Depth (m)
#1028
#1345
100
40
10
Dug well
Borehole
Faryab & Ghormach only

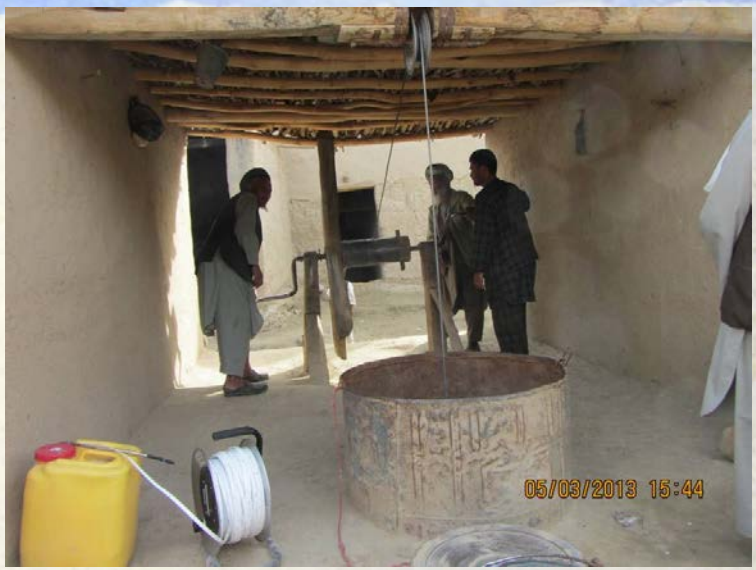

Diameter (mm)
#1049
#1323
1000
400
100
Dug well
Borehole
Faryab & Ghormach only

Hydrogeological parameters

Borehole	Aquifer	Depth	Diameter	Date	SWL	Yield *Q*	Yield *Q*	Drawdown *s*	Duration	*T* (high)	*T* (low)
		m	mm		m bwt	L/s	m3/d	m	hr	m^2/d	m^2/d
Qaysar area											
Arzolik borehole		145	152	05/03/2008	91.4	4	346	13.6	8	51	31
Qaysar Health Centre[$]		104	254	31/03/1979	78.72		86	3.5	8	49	30
Sar Asyab borehole		150	152	04/03/2008	27.5	5	432	15.2	4	57	35
Almar area											
Sarf Ali borehole		160	152	01/06/2010	134.2	2.77	239	Pump dry	0.22	*	*
Qara Tana borehole		150	152	01/06/2010	87.1	2.9	251	Pump dry	0.27	*	*
Nughayli Bala borehole		150	152	06/03/2008	101	3	259	19	6	27	17
Shoran Shikhan borehole		150	152	03/06/2010	105	1.85	160	25	5	13	8
Almar Markaz (Centre)[$]	Quaternary	66	152	Aug-75	52	0.7	60	6		20	12
Bish Qara / Noqholi Payan borehole		122	152	29/05/2010	83.7	3.5	302	15.3	15	40	24
Maimana area											
Jamshidy Bala borehole	Neogene	92	203	18/03/2012	26.8	3.5	302	34.3	6	18	11
Bakhshi Sayd Alli borehole	Neogene	118	203	16/07/2012	61.8	2.5	216	47.32	7	9	6
Maimana University borehole	Quaternary	90	203	30/11/2011	41	0.7	60	1.5	6	81	49
NCA Maimana (Koh-e Khana) test borehole	Quaternary	98	203	16/10/2011	20.3		864	6.7	24	258	157
Bibi Aina borehole	Quaternary (some Neogene)	204	254	30/06/2008	65	8	691	6	5	230	141
Toshkur Bibi Amina (Maimana District)[$]		74	254	24/06/1979	50		216	0.7	13	617	376
Further north											
Shirin Tagab Health Centre[$]		42	203	21/06/1978	21.5	1.6	138	3.8	20	73	44
Shirin Tagab Markaz (Centre)[$]	Quaternary	41	203	Feb-75	22.9	5	432	1.32	5	655	399
Astana 1 deep bore (Mahad)	Neogene	200	152	08/09/2009	10	2	173	13	7	27	16
Astana 2 deep bore (Gul Qudoq)	Neogene	200	152	09/11/2009	9	1.5	130	121	0.73	2.1	1.3
Jalaier 1 deep bore (Chokazie village)	Neogene	200	152	24/12/2009	23	4	346	11.1	8.5	62	38
Jalaier 2 deep bore (Atomchi village)	Neogene	200	152	07/02/2010	16.7	0.75	65	129.1	6	1.0	0.6
Dowlatabad Markaz (Centre), borehole 2[$]	Quaternary	42	152	1976	13	5	432	6	19	144	88

Data of such quality that only very approximate estimates of transmissivity could be derived (Logan Approximation)

Astana valley (DACAAR)



Qaysar (south-west part of Province)

Spring: Qaysar (south-west part of Province)

2. Field survey

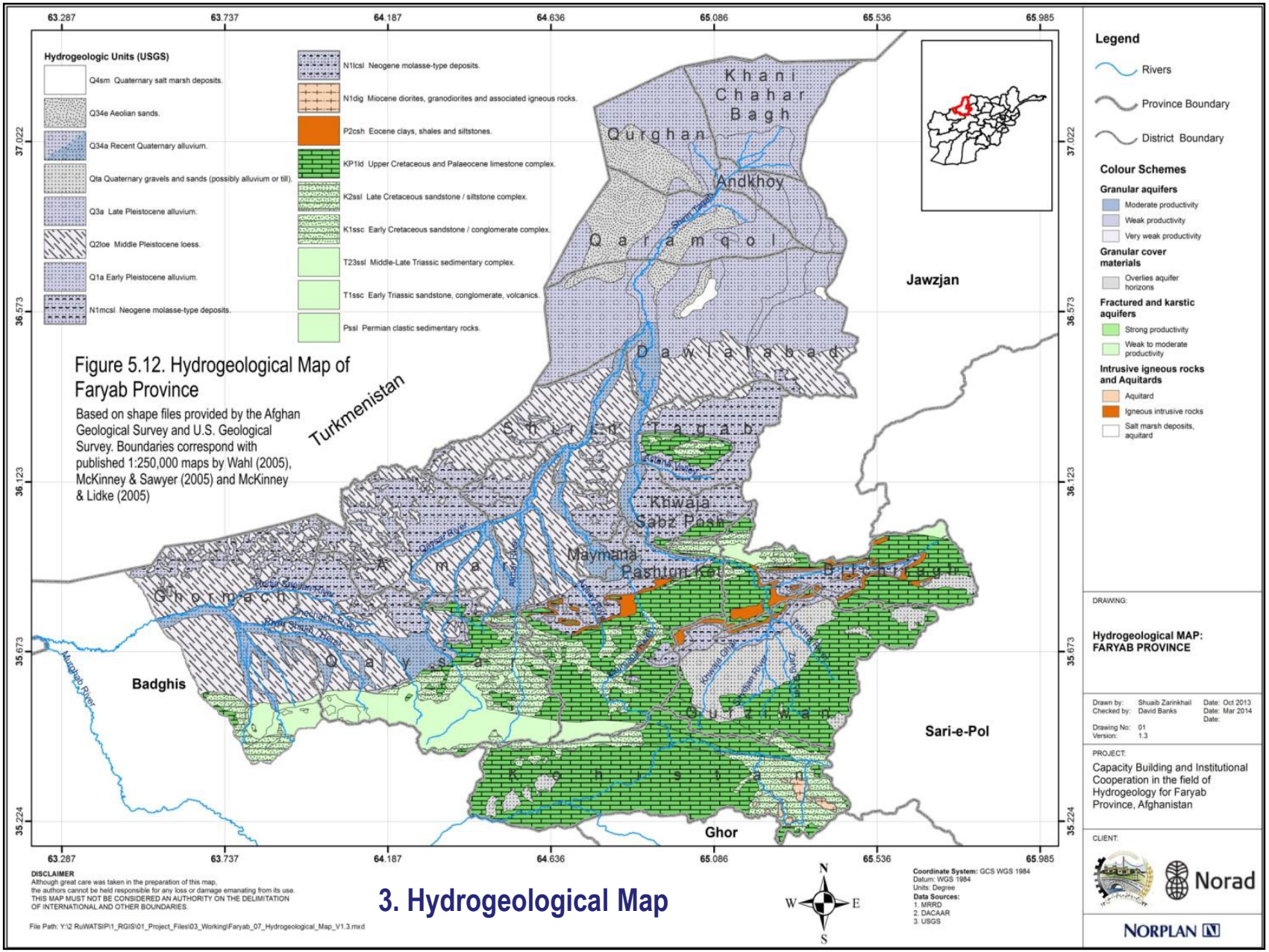
Dug wells / boreholes / springs

-Well details / registration

-Depth and water level

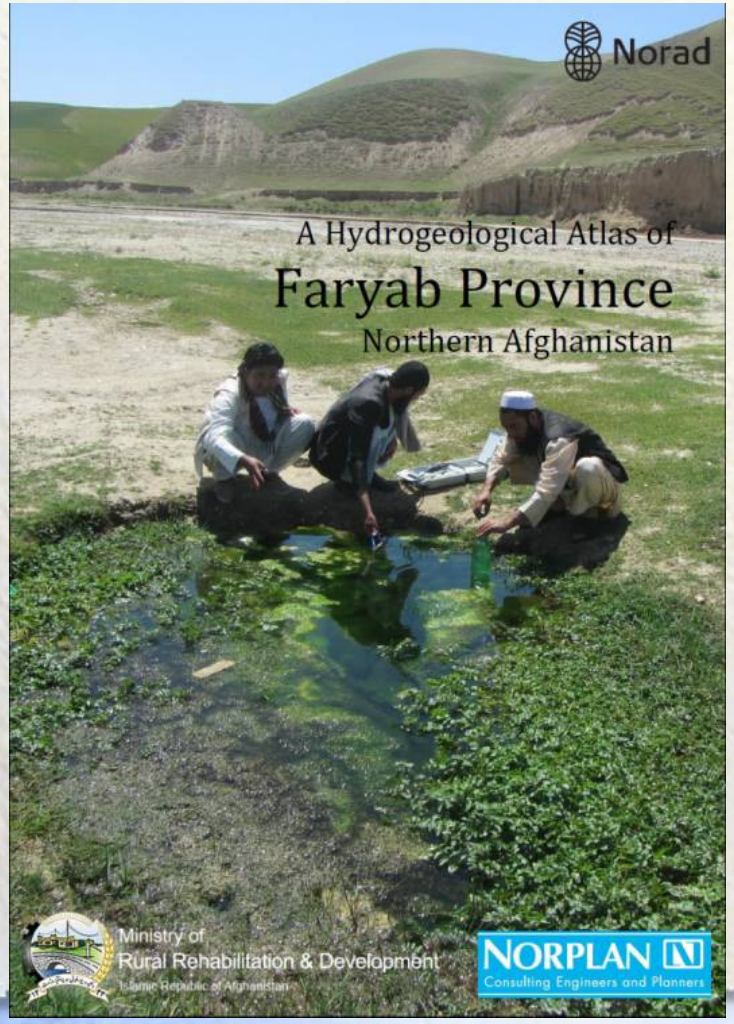
-Field EC, pH

-Samples

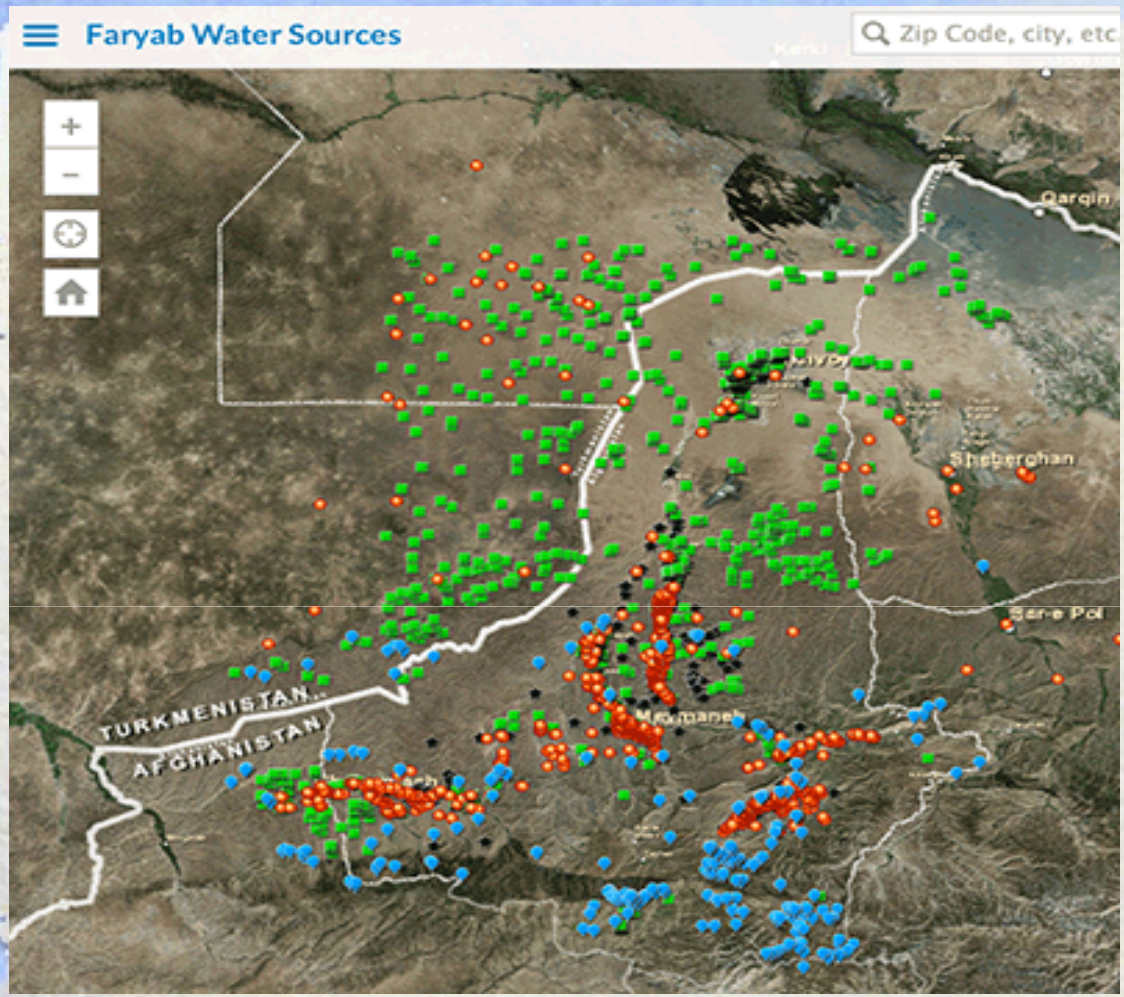


3. Hydrogeological Map

Hydrogeological Atlas



ATLAS: Available from
www.holymoor.co.uk/Faryabatlas/Atlas_Complete%20vF1.pdf



4. Data management and GIS

WebGIS interactive hydrogeological data service: Available from
http://www.arcgis.com/home/group.html?owner=AfghanMaps&title=Faryab%20Maps
http://www.norplan.af/Page_GIS_Web_maps.html

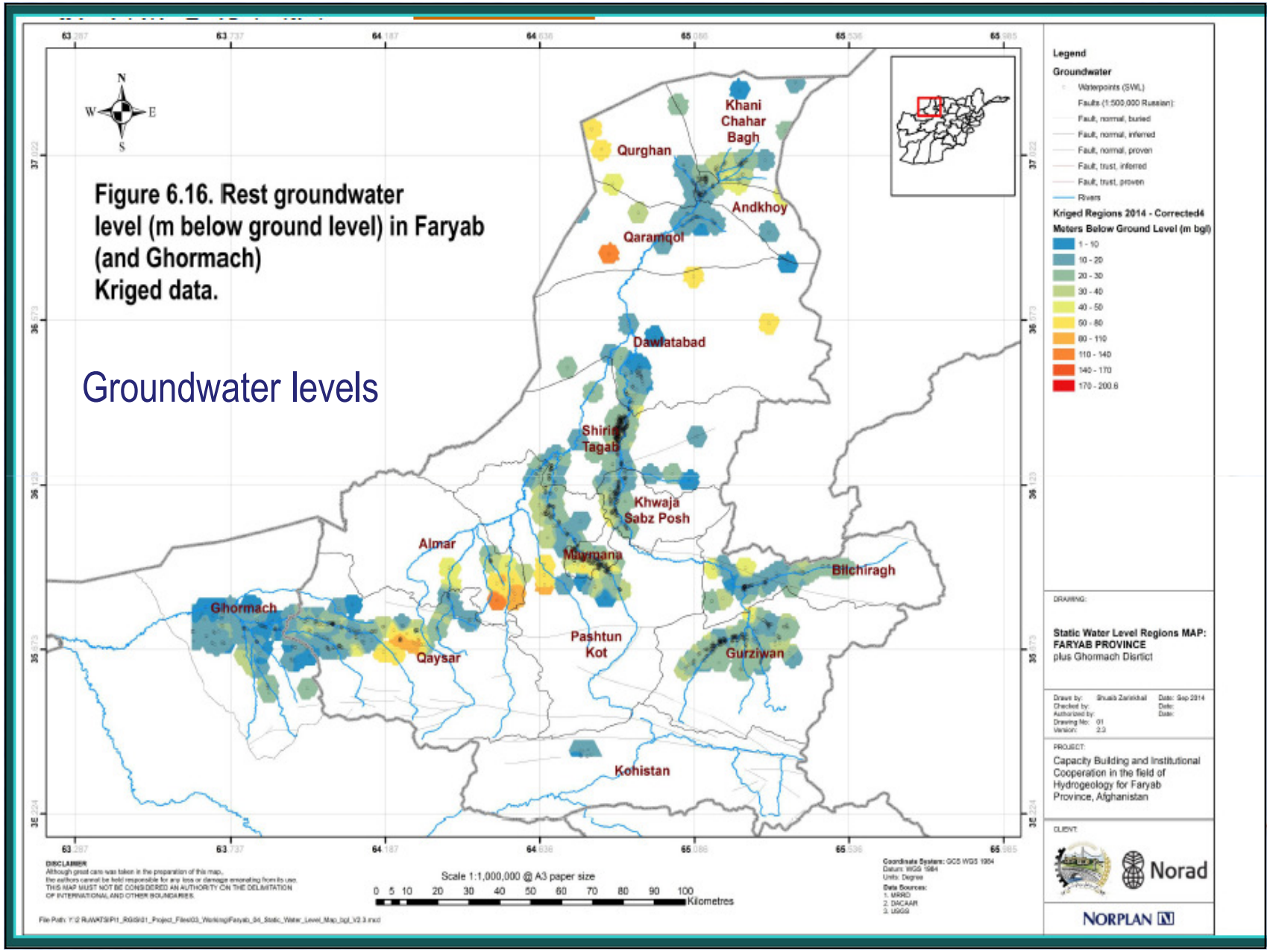


Figure 6.16. Rest groundwater level (m below ground level) in Faryab (and Ghormach) Kriged data.
Groundwater levels
Khani Chahar Bagh
Qurghan
Andkhoy
Qaramqol
Dawlatabad
Shirin Tagab
Khwaja Sabz Posh
Almar
Maymana
Bilchiragh
Ghormach
Qaysar
Pashtun Kot
Gurziwan
Kohistan
Legend
Groundwater
Kriged Regions 2014 - Corrected4
Meters Below Ground Level (m bgl)
1 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 80
80 - 110
110 - 140
140 - 170
170 - 200.6
Static Water Level Regions MAP: FARYAB PROVINCE plus Ghormach District
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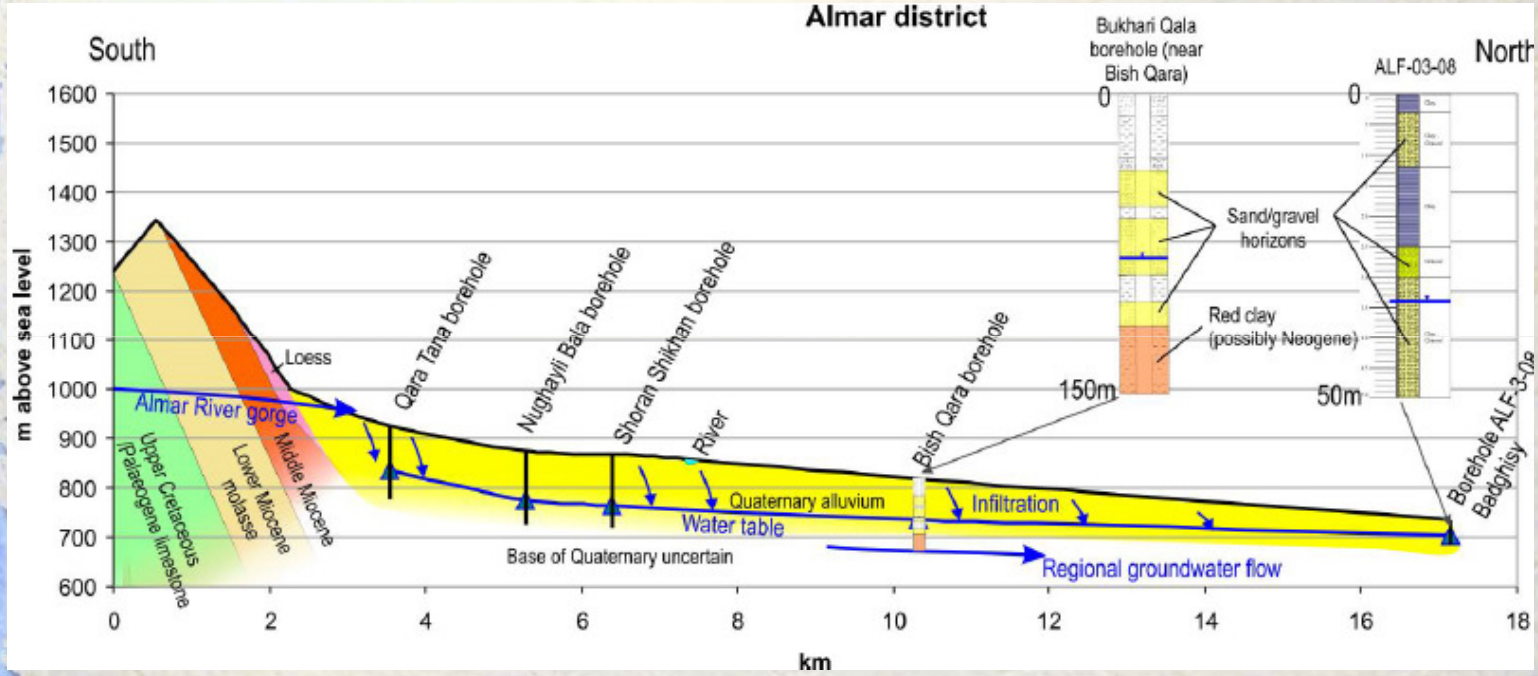
Scale 1:1,000,000 @ A3 paper size
0 5 10 20 30 40 50 60 70 80 90 100 Kilometres

As rivers emerge from mountain areas.....

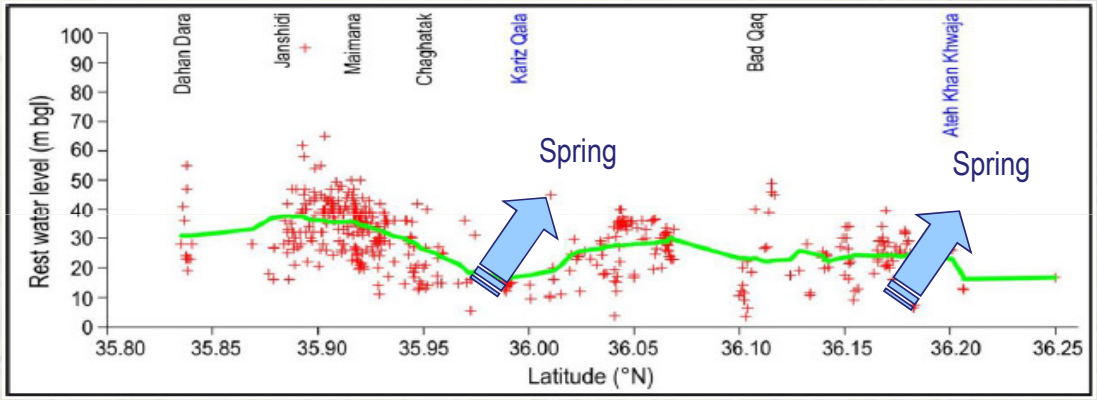


.....they start to infiltrate into alluvial fan and valley deposits.....

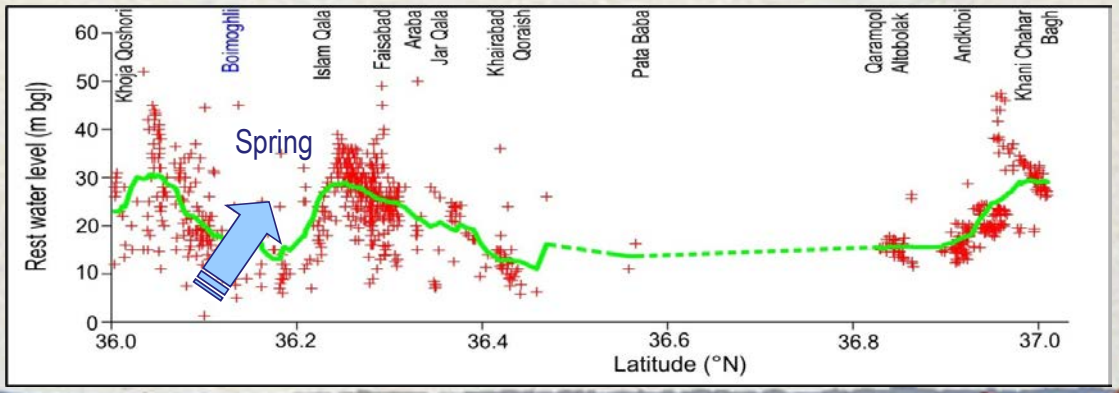
Groundwater levels

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

Maimana River



Shirin Tagab River



Key findings

- Direct groundwater recharge occurs in mountainous areas to the south. This generates baseflow for the main northward-flowing rivers.
- As the rivers flow north into the piedmont “molasse” areas and alluvial northern plains, direct recharge diminishes rapidly and indirect (river infiltration) recharge dominates
- Towards the north groundwater salinity rapidly increases and fresh water resources diminish.
- Zones of fresher groundwater occur along river corridors
- Groundwater and river chemistry and stable isotopic evidence suggest that evapotranspiration is a strong driving factor for groundwater salinity evolution
- **We are able to give good prognoses for groundwater depth, salinity and aquifer productivity at most inhabited locations**