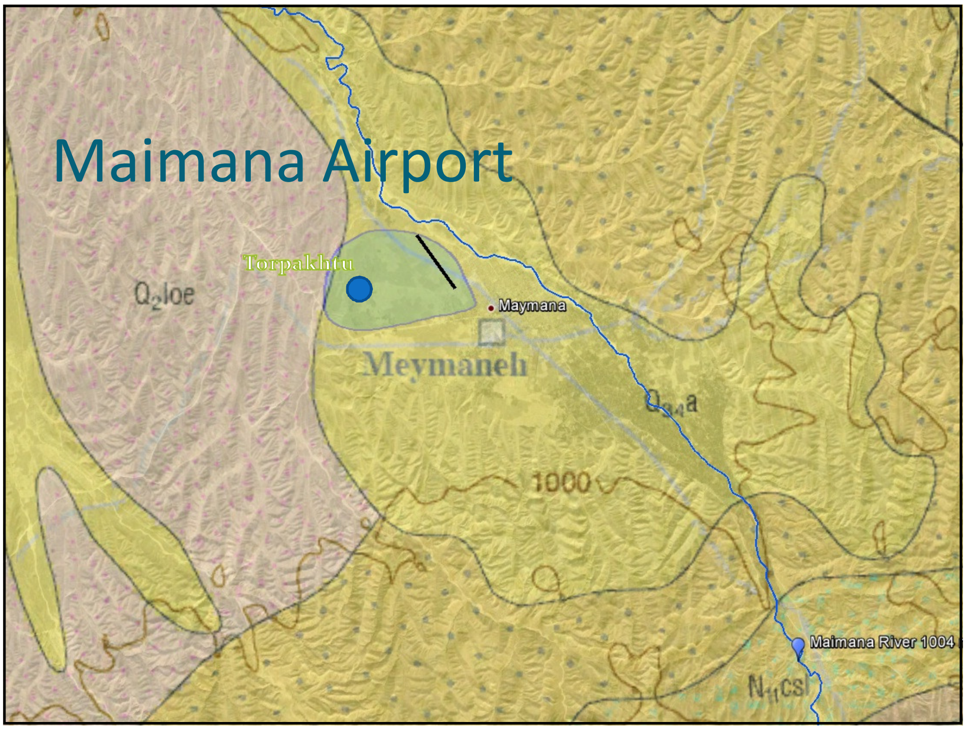
Sustainability and Recharge

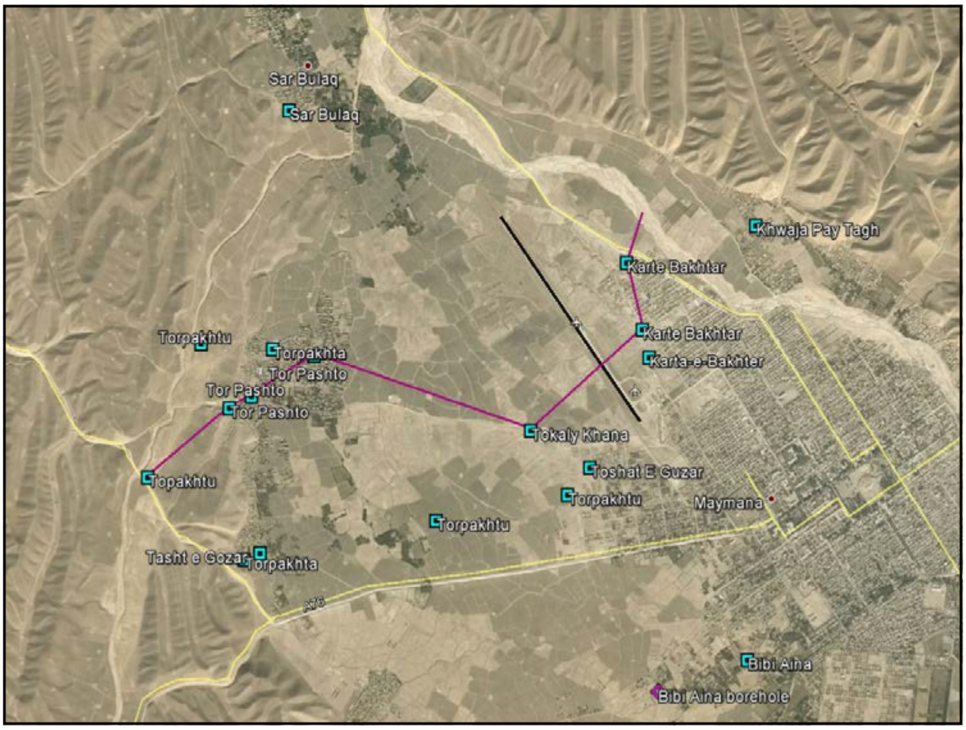
by: David Banks
Hydrogeologist and thermogeologist

Aral Sea 1989 2008

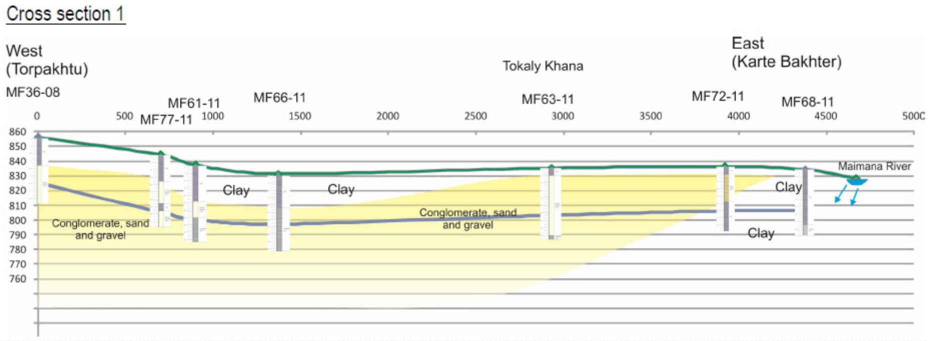
NORAD supported project in MRRD:
Capacity Building and Institutional Cooperation in the field of Hydrogeology for Faryab Province, Afghanistan

NORPLAN

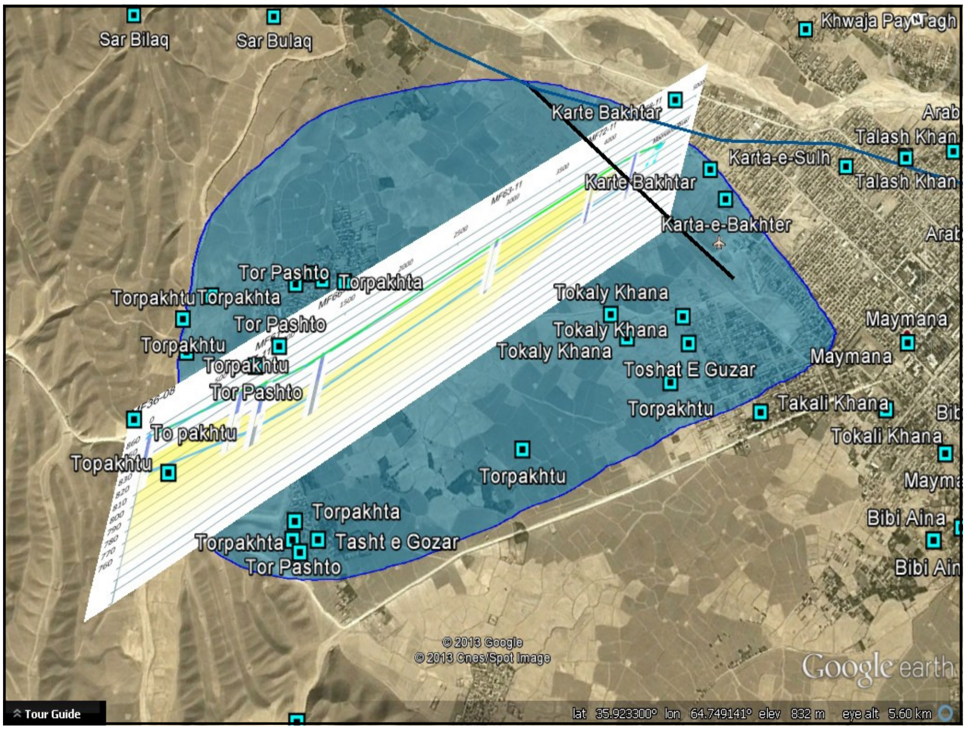




Maimana Airport (section 1)



Groundwater level is below river level....


Sar Bilaq
Sar Bulaq
Khwaja Pay Tagh
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Tasht e Gozar
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Bibi Aina
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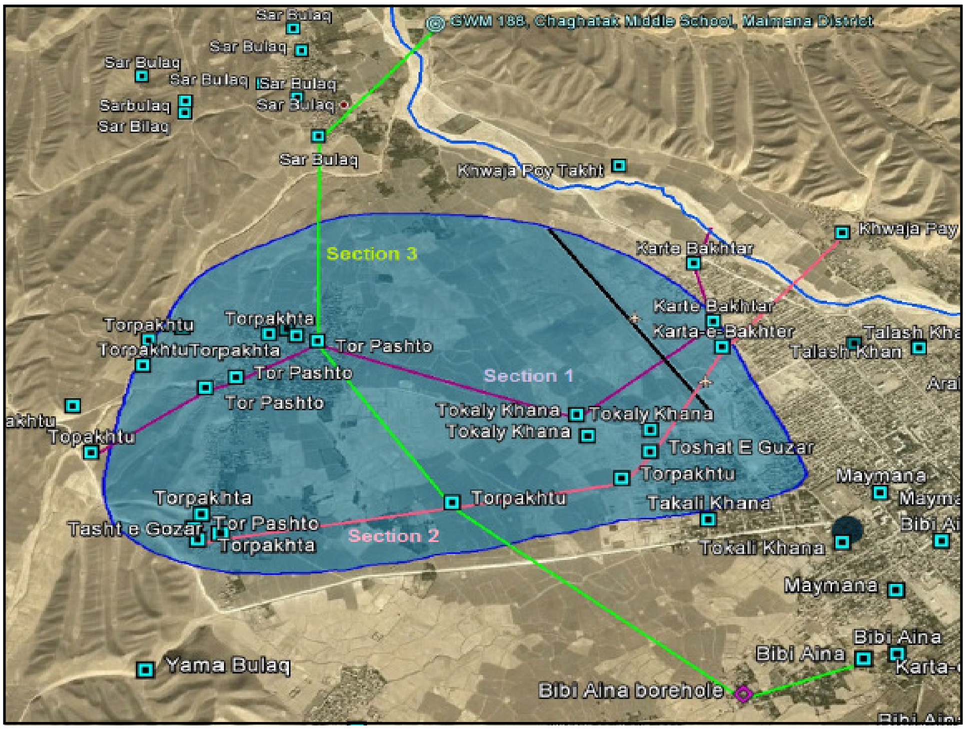
Tour Guide
lat 35.923300° lon 64.749141° elev 832 m eye alt 5.60 km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GWM 188, Chaghatak Middle School, Maimana District
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Tor Pashto
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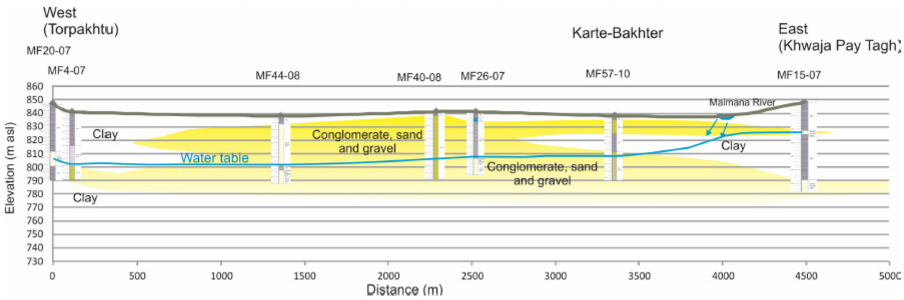
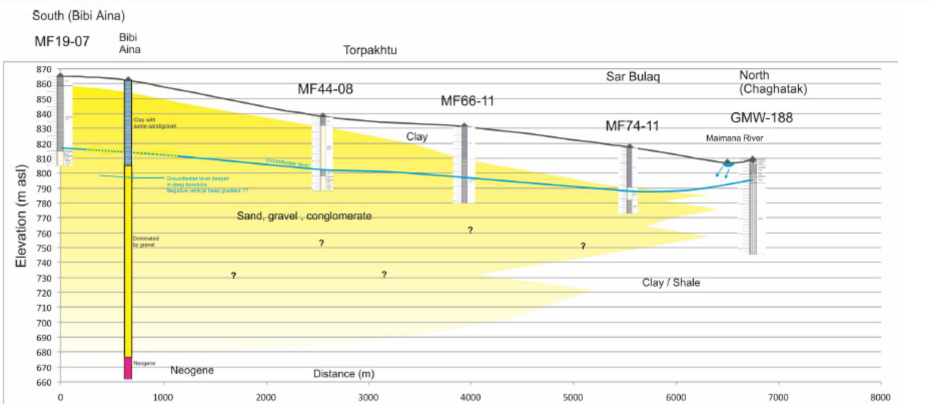
Section 2
Tokali Khana
Maymana
Bibi Aina
Yama Bulaq
Bibi Aina
Bibi Aina borehole

Maimana Airport (section 2)



Maimana Airport (section 3)



Conclusions

Conclusions

There appears to exist a substantial aquifer storage of moderately fresh to brackish groundwater below the study area in a Quaternary alluvial sand/gravel/conglomerate unit of thickness at least 30-40 m.

If the Bibi Aina borehole is representative of the depth of the Neogene beneath the study area, then the aquifer thickness could be in excess of 100 m. The aquifer's indicative transmissivity at Bibi Aina is around 200 m^2/d, with hydraulic conductivity between 1 and 2 m/d on average.

The aquifer is overlain by clayey sediments ranging in thickness from a few metres to around 20 m.

The aquifer is underlain by Neogene lower permeability materials at 185 m bgl at Bibi Aina. The Neogene may be encountered at shallower depths beneath the study area depending on the basement topography.

The aquifer is generally unconfined with groundwater levels typically a little over 30 m bgl in shallow boreholes.

The aquifer systems seems to be characterised by downward vertical head gradients, with the Maimana River seemingly disconnected from regional groundwater heads and presumably with a tendency to infiltrate river water into the ground.

But.....

Where does the groundwater come from....?

•The climate (and the clayey overburden) means that opportunities for direct recharge are very limited.
•The aquifer tends to be separated from the Maimana River by lower permeability clayey materials.

Thus, a large question mark must be placed over the ultimately sustainability of a major groundwater abstraction from this aquifer.

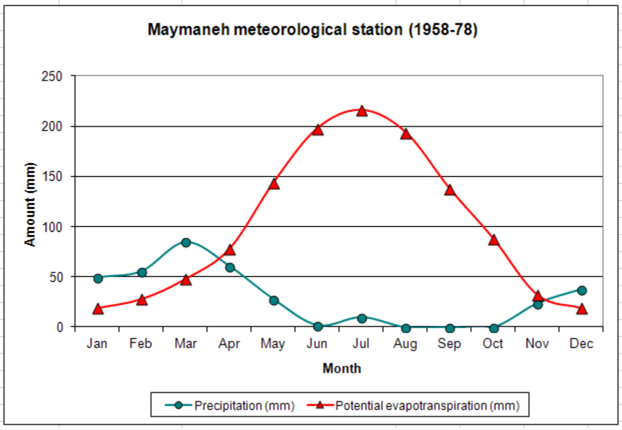
How do we estimate recharge? 1. From meteorological data....

Require:

- Daily data for precipitation
- Daily data for evapotranspiration
- Data on crop / vegetation cover
- Some data on soil moisture deficit

Even in Maymaneh....

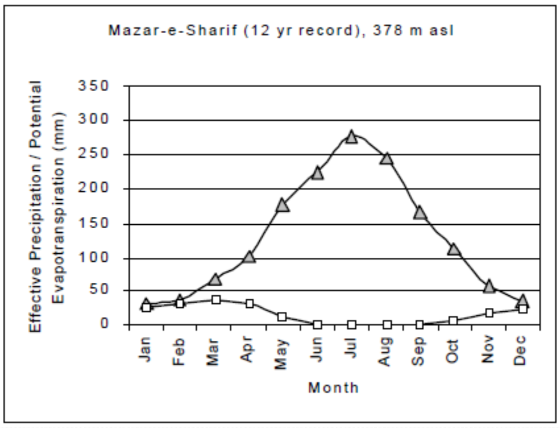
Potential evapotranspiration is much greater than precipitation for most months of the year



Precipitation = 354 mm (annual), potential evapotranspiration = 1202 mm

...and the further north you go

- The worse it gets....



Very unlikely to be any direct recharge

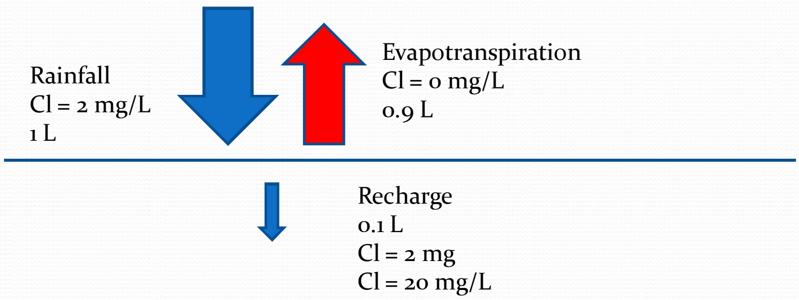
How do we estimate recharge? 2. From water chemistry....

Require:

- Concentration of a conservative ion (chloride) in rainfall
- Concentration of a conservative ion in groundwater
- A lot of assumptions

- that rainfall is the main source of recharge
- that there is no source of chloride in the aquifer
- that there is no human source of chloride

Evapo-concentration of rainfall



Chemistry

- Precipitation (mg/L)

		Cl^-	$SO_4^{=}$	NO_3^-
Maimana	snow	0.10	0.58	0.46
Maimana	Rain	0.48	3.25	1.67
Maimana	Rain	1.74	2.46	0.64
Gurziwan	Snow	0.60	0.75	0.38
Gurziwan	Rain	0.56	0.88	0.49
Andkhoi	Snow	15.6	25.1	16.4
Andkhoi	Rain	2.04	6.94	6.76
Andkhoi	Rain	1.36	3.91	1.04

- Groundwater (mg/L)

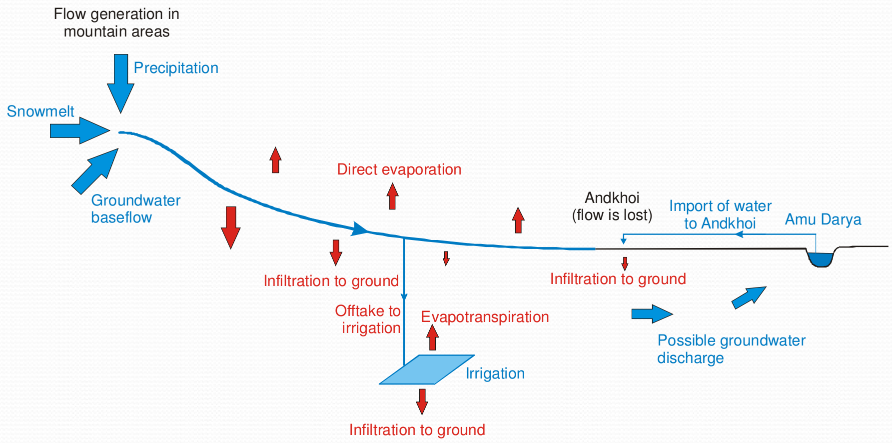
		Cl^-	Up-concentration
Kohistan	Groundwater	Typically 2-5	4-9
Gurziwan	Groundwater	Typically around 20	30-40
Andkhoi	Groundwater	Typically 600-1000	300-500

If taken at face value....this could imply that:
Rainfall recharge in Kohistan is 50-100 mm/a
Rainfall recharge in Gurziwan is c. 10 mm/a
Rainfall recharge in Andkhoi is < 1 mm/a

Groundwater chemistry - Andkhoi

	Ca	Mg	Na	K	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-
	meq l^{-1}	meq l^{-1}	meq l^{-1}	meq l^{-1}	meq l^{-1}	meq l^{-1}	meq l^{-1}	meq l^{-1}
NOR-QQ-01 F	11.532	12.831	29.561	0.517	10.538	17.800	23.967	0.125
NOR-QQ-02 F	13.668	16.024	35.846	0.472	11.835	24.584	30.304	0.146
NOR-QQ-03 F	8.568	20.501	39.361	0.495	12.703	21.036	35.425	
NOR-Qg-04 F	18.104	21.910	28.538	0.373	6.921	13.438	55.144	0.136
NOR-Qg-05 F	24.746	27.456	29.187	0.443	6.501	10.780	70.971	0.029
NOR-Qg-06 F	24.481	39.601	69.300	1.843	9.406	49.833	86.959	0.960
NOR-KB-07 F	7.221	12.159	22.053	0.606	9.067	12.873	18.233	0.360
NOR-KB-08 F	13.468	12.428	13.027	0.238	6.717	7.636	24.776	0.178
NOR-KB-09 F	11.033	14.667	26.429	0.501	4.866	18.817	27.978	0.022
NOR-KB-10 F	6.083	11.152	16.185	0.481	11.247	10.016	10.802	0.156
NOR-AK-11 F	20.120	16.592	26.894	0.675	5.862	26.932	30.870	0.809
NOR-AK-12 F	26.876	31.642	61.675	4.384	6.122	59.750	41.908	16.669
NOR-AK-13 F	11.417	22.475	30.261	0.656	8.990	27.751	25.237	0.625

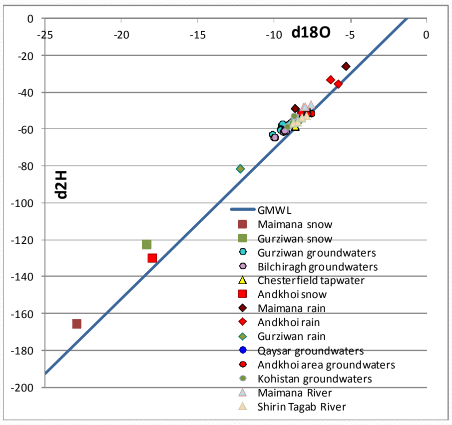
How do we estimate recharge? 2. Water balance and tracers

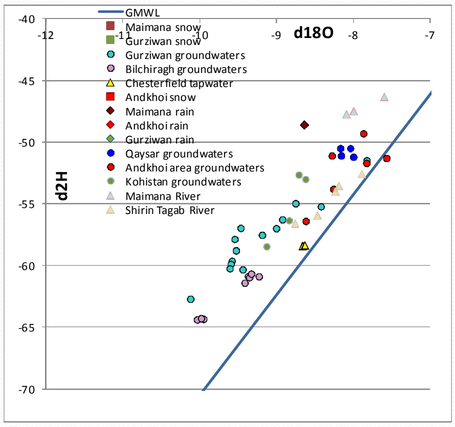


Possible tracers

- Stable ions, such as chloride, may be able to track evapotranspiration
- Stable isotopes (^{2}H, ^{18}O). These "heavy" isotopes become enriched by evaporation processes

Stable isotopes





All this is jolly interesting, Dave, but....what does it all mean?

- These studies give us a way into really understanding
  - - recharge mechanisms
  - - salt accumulation in groundwater
- In much of Faryab (Maimana and northwards), recharge is very limited (or non-existent!)
- Sustainability is not guaranteed!
- Be careful about planning large groundwater extraction schemes, you may be mining groundwater
- You may not be very popular with your descendants!

Thanks for your attention