PRELIMINARY: DESK STUDY - MAIMANA AIRPORT STUDY SITE v1.2 July 2013

Location

The proposed study area is located immediately NW of Maimana city.

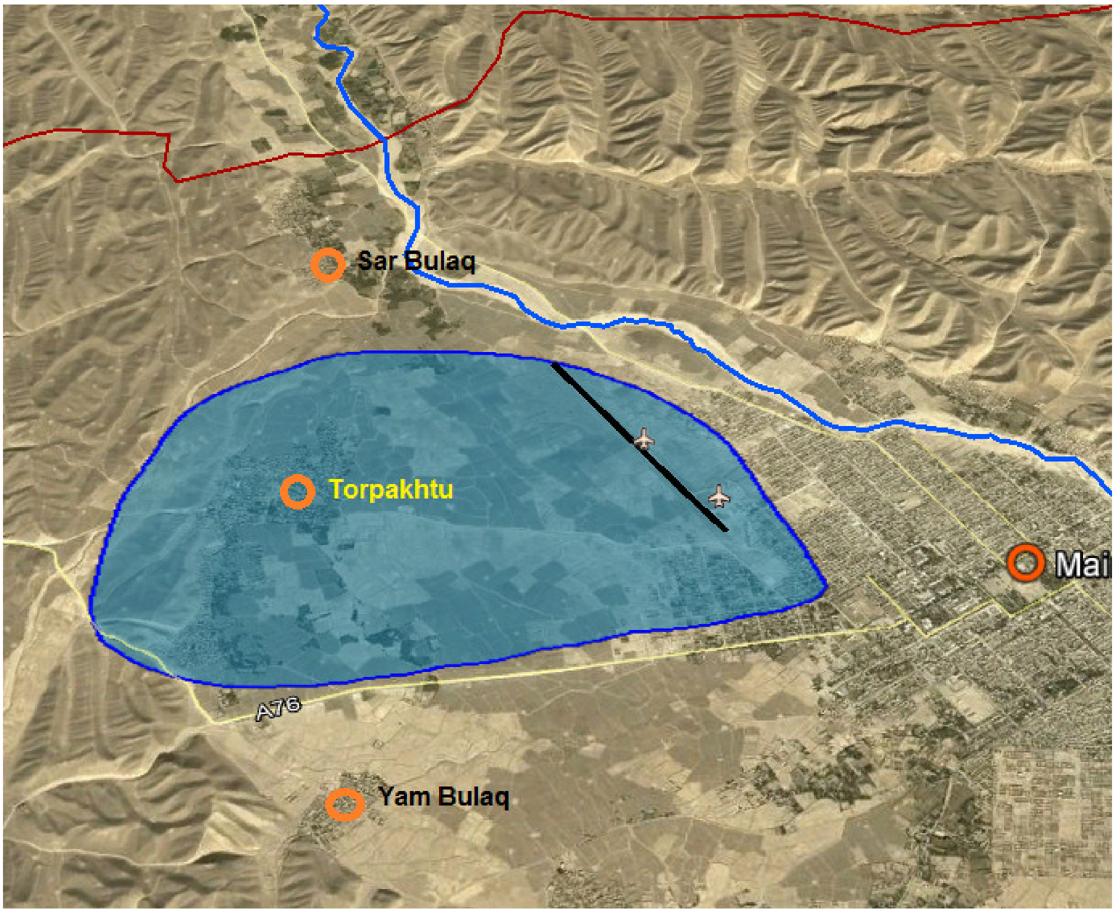

Figure 1. Location of Maimana study area (Google Earth). (Airport runway shown as black line and is c. 1.65 km long). The blue line shows the Maimana River, flowing north.

The study area occupies a flat plain, sloping gently from around 850 m asl in the west to around 830 m asl in the east, towards the Maimana River.

The southern end of the airport runway lies around 1.5 km NW of Maimana city centre.

The study area contains several inhabited villages, especially in the west, of which the largest is Torpakhtu. The study area is largely occupied by agricultural land.

Geology

The published Afghan Geological Survey / USGS maps show that the plain is underlain by Quaternary alluvial deposits of the Maimana River. These are described as:

Q_{34}a - Conglomerate and sandstone (Holocene and late Pleistocene) - Alluvium: shingly and detrital sediments, gravel, sand more abundant than silt and clay.

These alluvial deposits are underlain at unknown depth by Neogene sediments, described as

N_{1m}csl - Clay and siltstone (middle Miocene) - Brown clay, siltstone more abundant than sandstone, conglomerate, limestone.

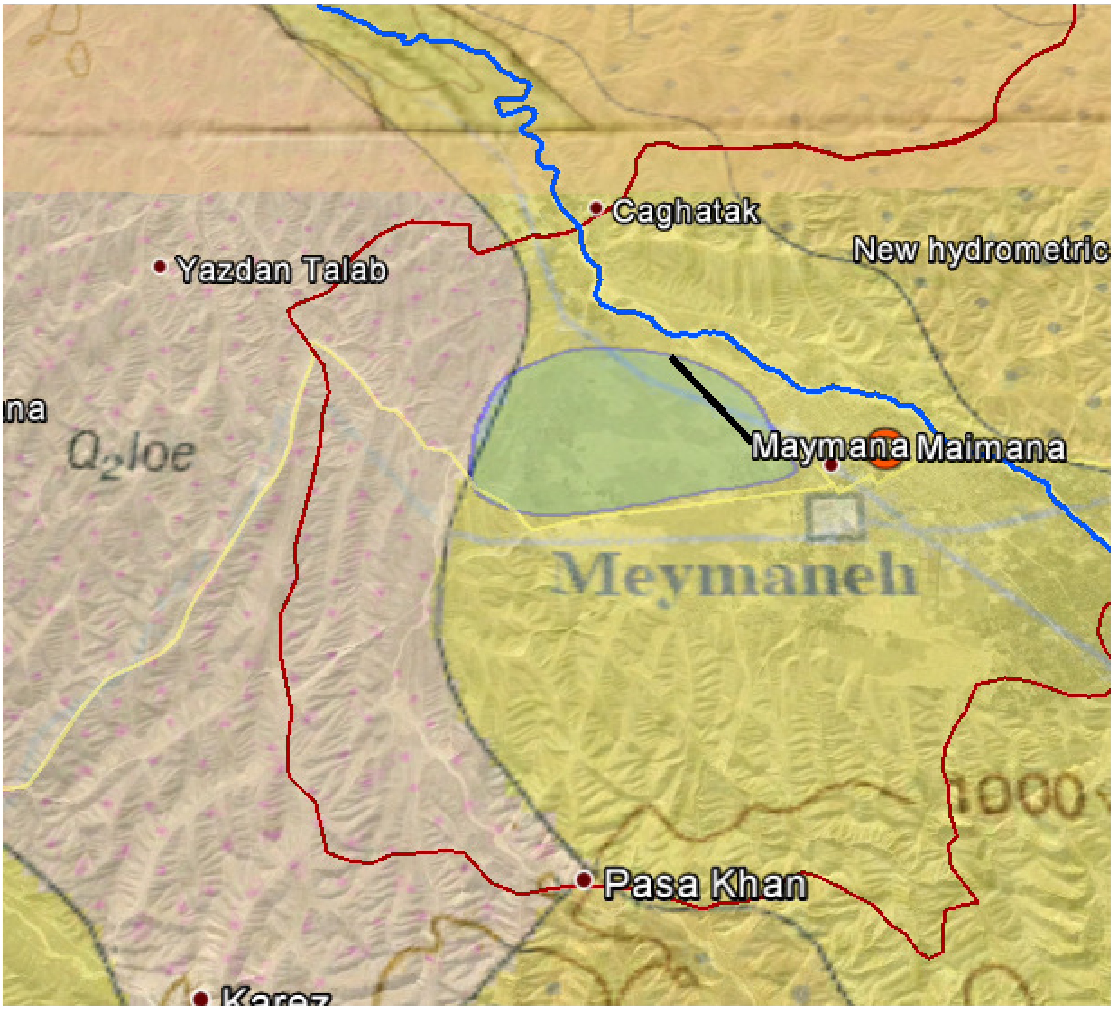

Figure 2. Geology of Maimana study area (Google Earth). AGS / USGS geological maps overlaid. See key below.

Q_{34}a	Conglomerate and sandstone (Holocene and late Pleistocene)—Alluvium: shingly and detrital sediments, gravel, sand more abundant than silt and clay	
Q_2loe	Loess (middle Pleistocene)—Loess more abundant than sand, clay	Q_2loe
N_{1m}csl	Clay and siltstone (middle Miocene)—Brown clay, siltstone more abundant than sandstone, conglomerate, limestone	N_{1m}csl

Registered Wells

Dug Wells

No dug wells are registered in the study area. Several are however registered in the valley of the Maimana River (Figure 3)

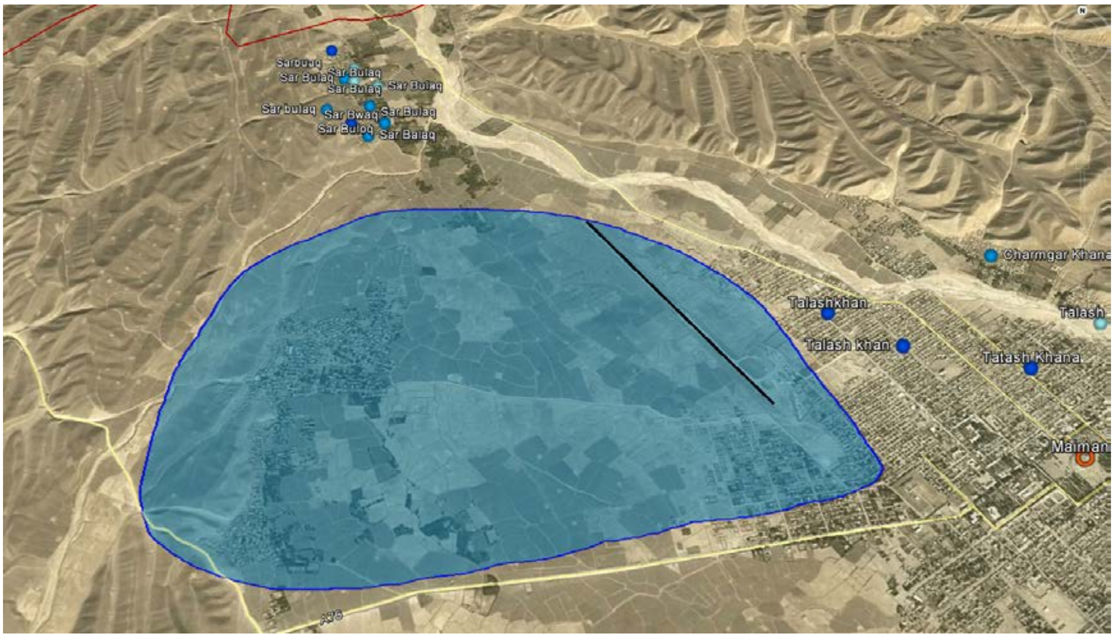

Figure 3. Registered dug wells in the Maimana study area (Google Earth).

There are, however, a number of drilled boreholes registered in and around the study area.

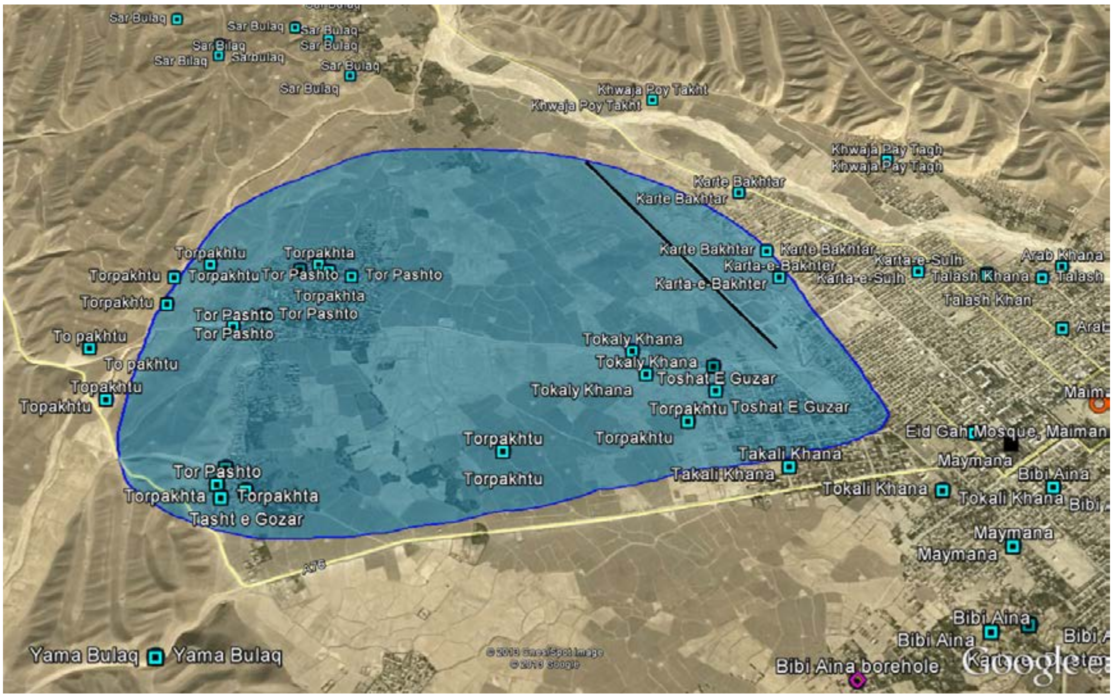

Figure 4. Registered drilled boreholes in the Maimana study area (Google Earth).

Groundwater levels typically range from 40 m below ground level in the extreme west of the study area to around 30 m bgl in the east.. It should be noted that this appears to be **below** the level of the Maimana River, suggesting:

1) There is a degree of discontinuity between river and aquifer
2) The River is likely to be infiltrating water into the ground.

There are two groundwater monitoring wells in the near vicinity of the study area:

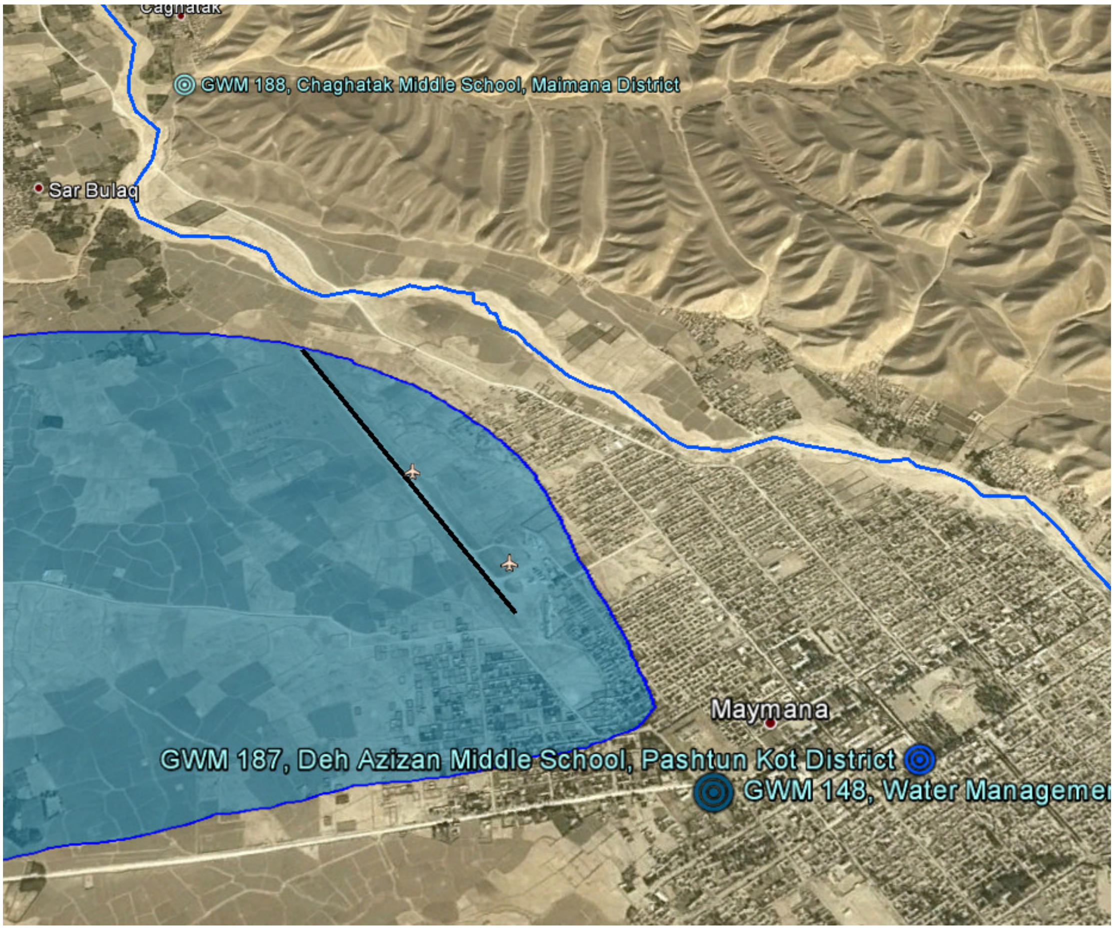

Figure 5. Registered groundwater monitoring boreholes near the Maimana study area (Google Earth).

GWM 148: Water Management Department, Maimana District is 52.5 m deep and has a typical water level of 38 m bgl.

GWM 187: Deh Azizan Middle School is 63 m deep and has a typical water level of 32 m bgl, and an electrical conductivity of 2030 µS/cm.

GWM 188: Chaghatak Middle School is 63 m deep and has a typical water level of 14 m bgl, and an electrical conductivity of 2300 µS/cm.

Water quality

There is a considerable amount of data on electrical conductivity within the study area (Figure 6).

The majority of boreholes have are colour coded green (1203 - 1517 µS/cm) or yellow (1517 to 1996 µS/cm), implying a slightly brackish water quality, with conductivity in the range 1200 - 2000 µS/cm. In the extreme SW of the area, higher conductivities of 2300-3600 µS/cm occur, maybe associated with the boreholes penetrating to the underlying Neogene sediments, at the edge of the Quaternary alluvial plain.

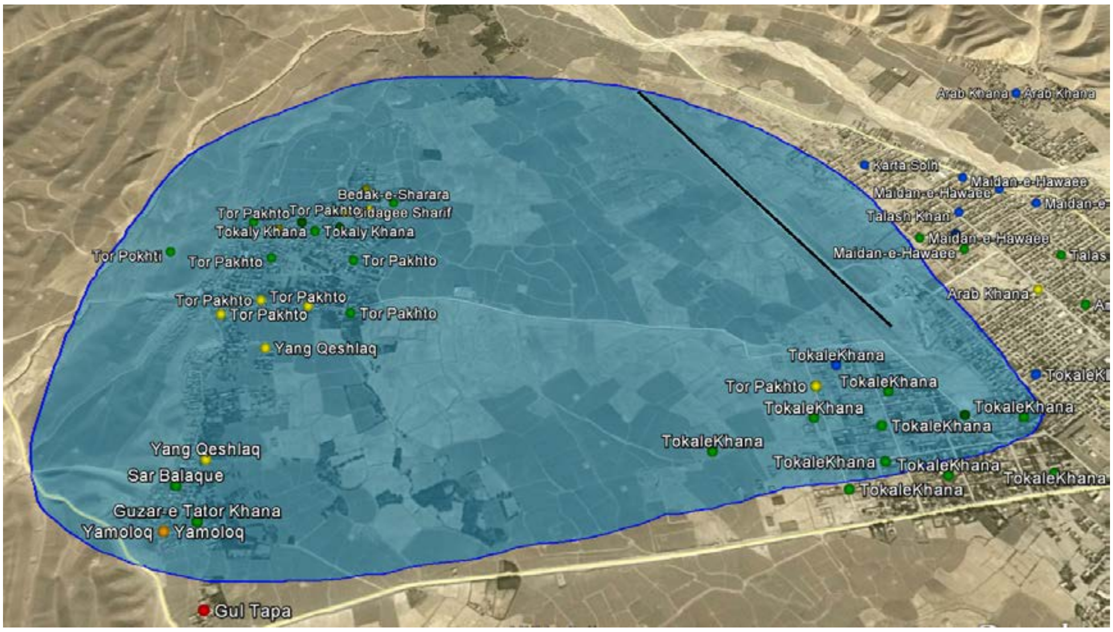

Figure 6. DACAAR groundwater electrical conductivity observations in the Maimana study area (Google Earth).

- Blue = <1203 µS/cm
- Green = 1203 - 1517 µS/cm
- Yellow = 1517 to 1996 µS/cm
- Orange = 1996 - 2950 µS/cm
- Red = 2950 - 5000 µS/cm

Meteorology

A considerable amount of data exists on the meteorology of Maimana. The World Meteorological Office data from 1959-83 result in the following graphs:

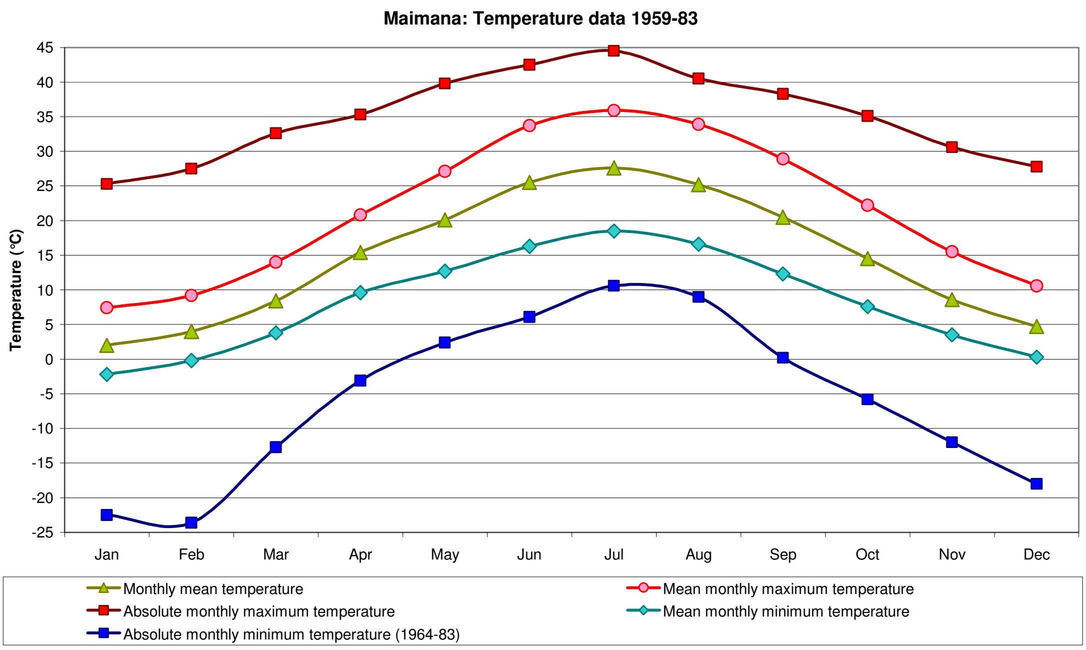

Figure 7. Monthly mean temperature data 1959-83 for WMO station 40922 Maimana.

Mean annual precipitation is around 356 mm and temperature around 14.7°C. The low precipitation and arid climate suggest that opportunities for direct recharge of groundwater systems are very limited. Some opportunities for small amounts of direct recharge may exist in the wettest, coolest months (January and February) or during snowmelt. The other potential source for groundwater recharge is infiltration from the Maimana River.

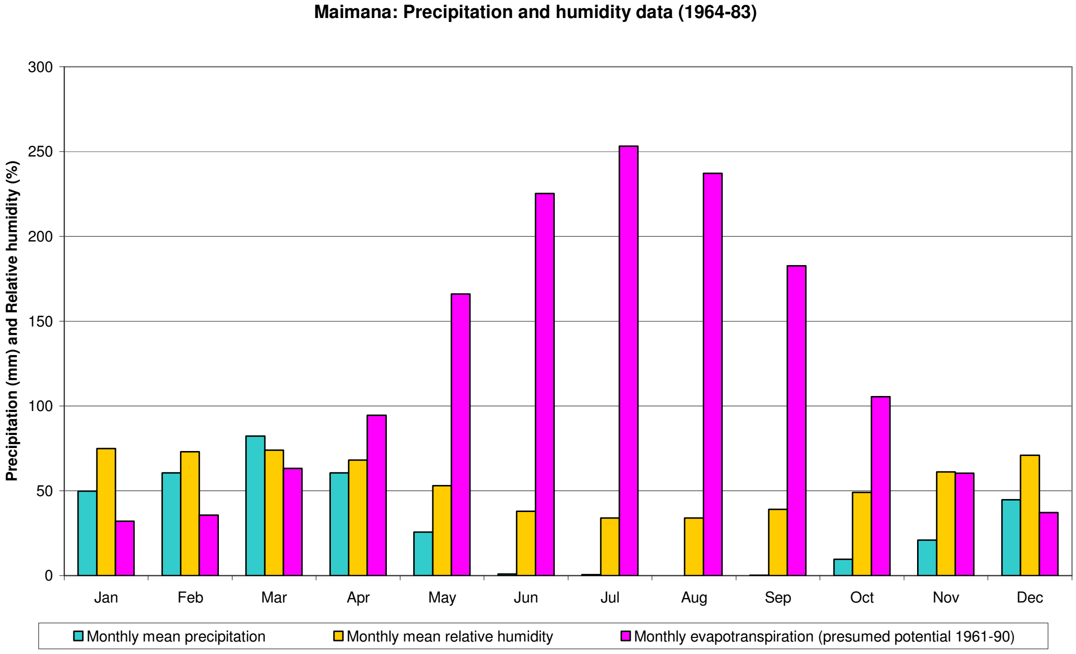

Figure 8. Monthly mean precipitation data 1964-1983 for WMO station 40922 Maimana.

Cross sections

Three geological cross-sections have been constructed as follows:

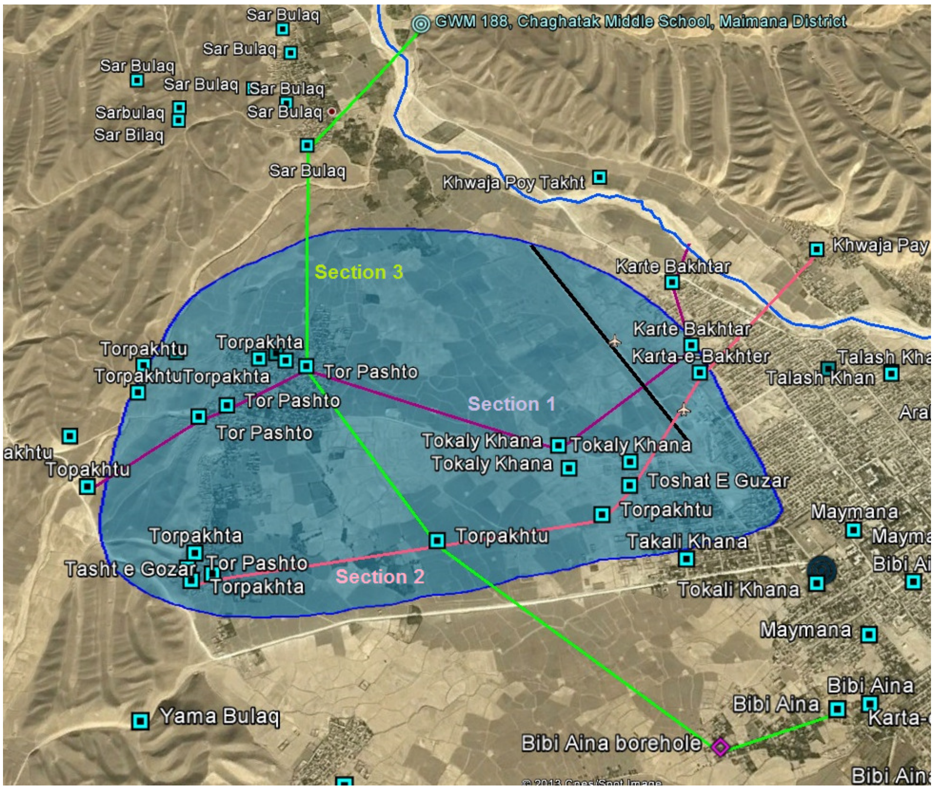

Figure 9. Locations of cross-sections 1-3 in study area Maimana.

Cross section 1

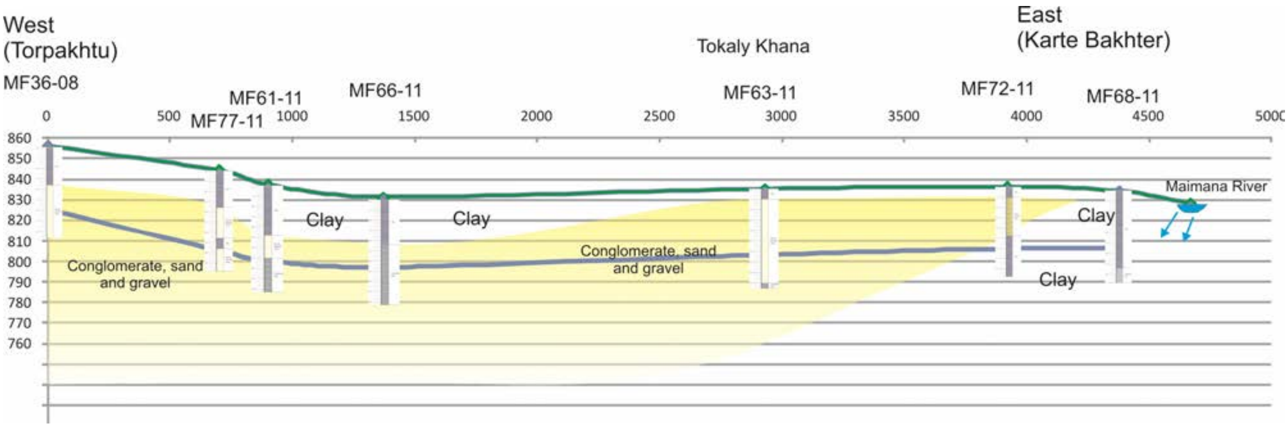

Figure 10. Cross section 1 of study area Maimana. *Elevation in m asl, horizontal distance in m.*

Cross section 1 suggests that, below the study area there is an initial clayey layer of thickness < 20 m, underlain by a substantial gravelly aquifer unit, whose base has not been proved but which appears to be at least 30-40 m thick (saturated and unsaturated total thickness). This appears to disappear towards the east, to be replaced by clayey sediments (at least within the depth range of 50-60 m penetrated by the boreholes).

The groundwater level is around 30 m below ground level and appears to be below the elevation of the Maimana River, suggesting:

1) There is a degree of discontinuity between river and aquifer
2) The River is likely to be infiltrating water into the ground.

However, the sediments in the vicinity of the river are generally clayey, so the degree of river infiltration to the aquifer is likely to be rather limited.

Lack of good terrain elevation data renders the following observation very tentative, but it appears there is a slight slope of the groundwater level surface *away* from the Maimana River, again suggesting an infiltrating river regime.

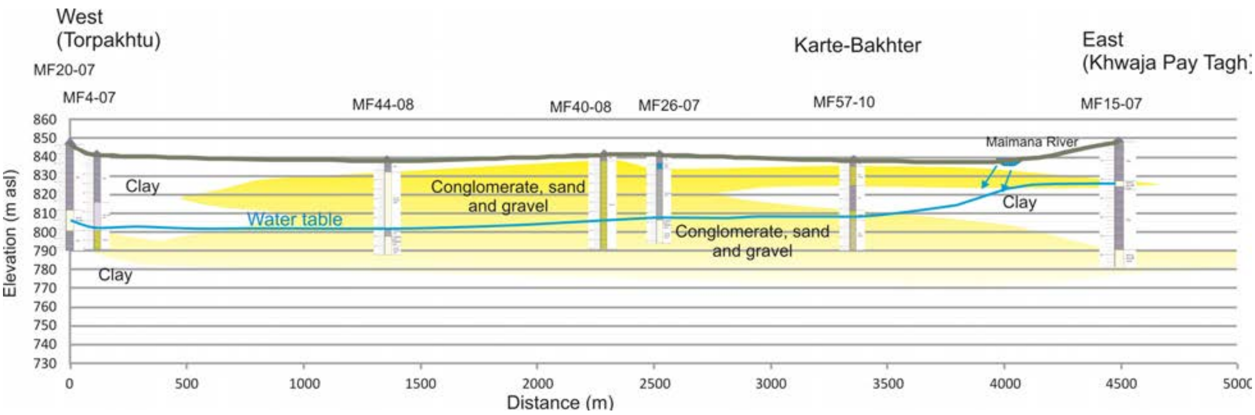

Figure 11. Cross section 2 of study area Maimana. *Elevation in m asl, horizontal distance in m.*

The second east-west cross-section, cross-section 2 (Figure 11) broadly supports the findings of cross-section 1.

The third cross section (Figure 12) is north-south, and incorporates the 200 m deep Bibi Aina production borehole, supplying water to a piped network in Maimana, and test pumped at 8 L/s with only 6 m

drawdown (specific capacity 115 m^2/d, likely transmissivity = 200 m^2/d, average hydraulic conductivity based on 129 m aquifer thickness = 1.6 m/d).

The Bibi Aina borehole encountered clayey dominated strata with some gravels to 56 m depth, then gravel aquifer to 185 m (at least 129 m good aquifer thickness). At 185 m depth, the borehole encountered lower permeability Neogene deposits.

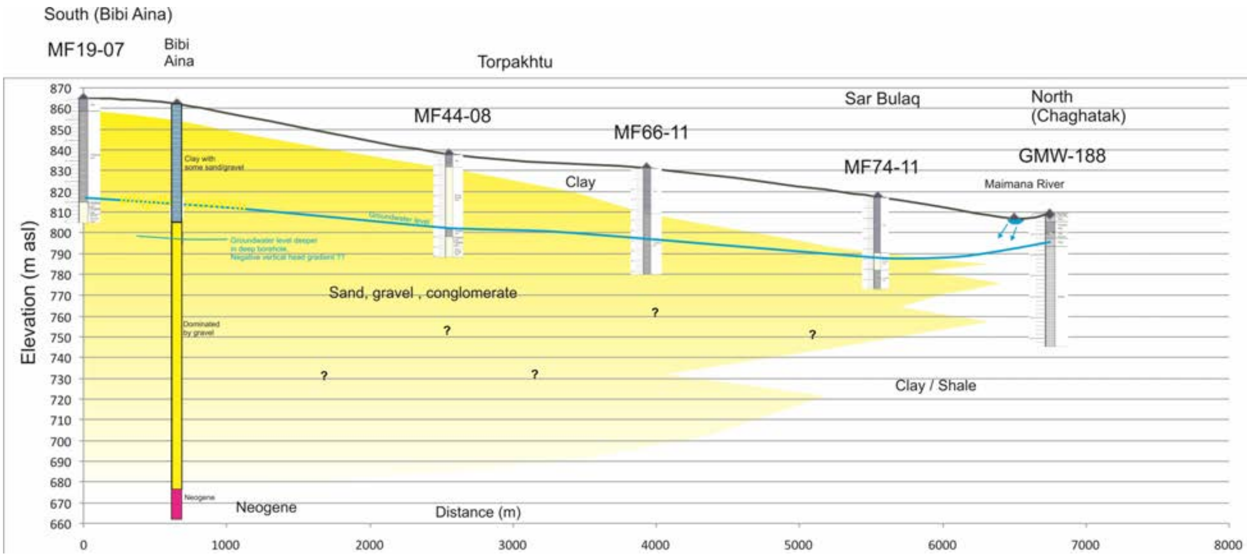

Figure 12. Cross section 3 of study area Maimana. *Elevation in m asl, horizontal distance in m.*

Cross section 3 also confirms that groundwater levels are below the level of the River Maimana.

Furthermore, the water level in the 200 m deep Bibi Aina borehole was deeper (65 m bgl) than in the shallower boreholes, again confirming a predominant downwards head gradient in the aquifer system.

Finally, the gravel aquifer seems to peter out (at least, at shallow depth) towards the River, being replaced by clayey / shaley strata. The aquifer does not seem to extend, at shallow depth, to the eastern bank of the Maimana River.

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 the source of recharge to the aquifer is not clear.

- 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.

Proposed Investigatory Programme

Summer 2013

Send a field hydrogeological and geophysical team to Maimana to

1) Interview locals about possible deep motorised boreholes constructed recently in the area, possibly by Norwegian occupying forces based around Maimana Airport. NORPLAN to make enquiries regarding this in Norway.
2) Field team to locate and sample any such boreholes for chemical and isotopic composition.
3) Field team to carry out Water Features Survey within 1 km radius around study focus area (study focus area = orange area in Figure 13) and to locate any springs or karezes within 2 km of study focus area. Electrical conductivity to be determined at all visited boreholes.
4) Field team collect chemical and isotopic samples from up to 15 boreholes in and around study area, and in the potential infiltration zone (green area in Figure 13) near to the Maimana River. Electrical conductivity to be determined at all visited boreholes. To include deep Bibi Aina borehole. Samples to be sent to BGS England for analysis.
5) Identification of geophysical lines within study focus area (orange area in Figure 13). Obtain permissions and consent for geophysical survey.

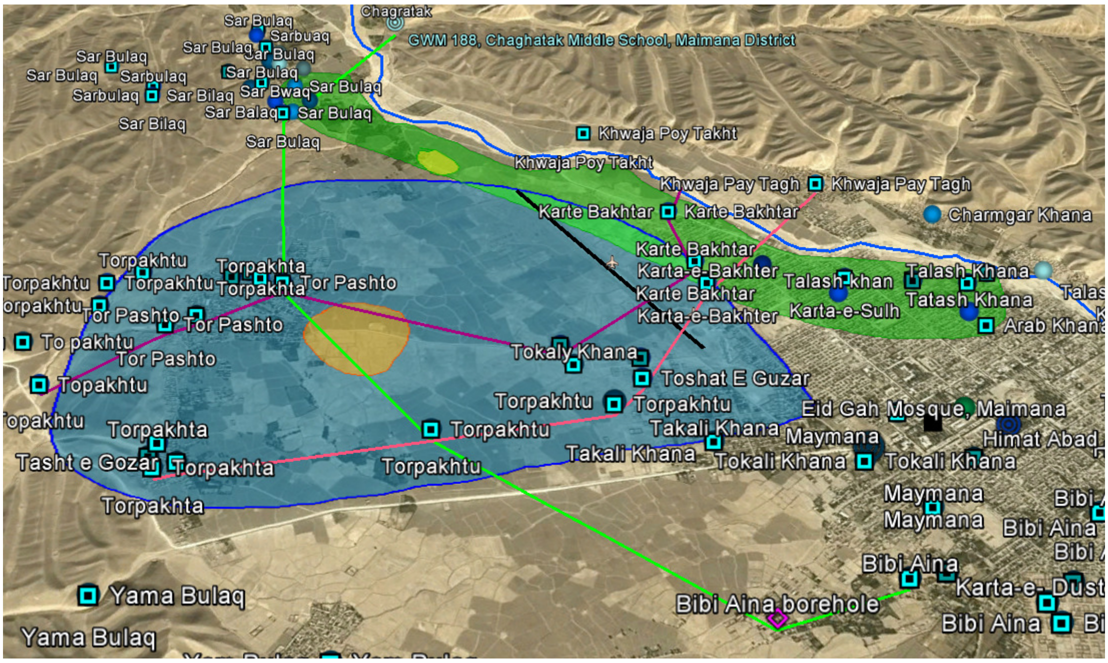

Figure 13. Orange area = proposed study focus area; green area = potential infiltration area from Maimana River; Yellow area = proposed area for observation borehole in infiltration area.

6) Identification of possible drilling sites for
   - 1 deep exploration borehole to up to 200 m within the study focus area (orange area in Figure 13).

- 1 observation borehole up to 120 m (depending on findings from deep exploration borehole), no more than 30 m distance from exploration borehole.
- 1 observation borehole to 50 m, no more than 30 m distance from exploration borehole.
- 1 observation borehole to 60 m in the zone of infiltration, in or near the yellow area in Figure 13.

Obtain permissions and consent for drilling

7) **August-September 2013.** Geophysical survey[1] of study area using identified geophysical lines (Step 5). **Eng. Jalil (MRRD), possibly assisted by DACAAR.**

Spring/Summer 2014

Drilling and test pumping program to commence

8) **April 2014.** Drilling of boreholes at study area. Tentatively:

- 1 x exploration well to c. 200 m depth at 200 mm final diameter
- 1 x Quaternary observation well up to 120 m (depending on findings from deep exploration borehole), at 150 mm final diameter.
- 2 x Quaternary observation wells (1 and 3) to c. 50-60 m depth at 150 mm final diameter.

Sampling and geophysical logging of all boreholes.

Installation of 4 water level divers in boreholes

Installation of 1 barometric diver

Installation of river level gauging post in Maimana River

Possible installation of 1 water level diver in Maimana river, within constructed, protected unit).

Accurate surveying (levelling) of all well-heads and Maimana gauging post.

9) **July 2014**. Test pumping and water sampling of all wells.

Clearance pumping.

Short term (6 hour) test of all 3 observation wells, with drawdown response being monitored.

Regular monitoring of electrical conductivity during test pumping.

Water sample from all 3 wells after 1 hour pumping and after 6 hours pumping.

10) **August 2014.** Test pumping of exploration well

Step testing of exploration well at 4 different rates

Constant rate testing of exploration well for at least 7 days (and possibly longer), with regular water sampling.

Recovery test of production well.

11) **August-September 2014.** Securement of all well heads and conversion to permanent monitoring facilities.

[1] At present, it is envisaged that the geophysical survey will comprise a systematic series of VES soundings along pre-agreed lines. Following the recommendations of Eng. Jalil and Dr de Jong, these may be upgraded to full 2-D resistivity profiles.

Necessary purchases

- Surveying equipment (presumably already available from MRRD??) with 1 cm accuracy.
- Geophysical equipment and teams from MRRD or DACAAR
- Drilling rigs from MRRD capable of constructing 8" completed diameter holes to 200 m.
- Geophysical logging equipment
- 5-6 SWS water level divers with appropriate ranges.
- Flow meter gauging kit
- River gauging post
- Water sampling bailer / Waterra type hand sampling pump.
- Appropriate pumps (possibly two different types required, depending on well yield characteristics)
- Generator.

AFTER THE STUDIES

It will be problematic to prevent the wells being utilised following the study. This would be especially difficult if private farmers take them into use for motorised irrigation. While the short term capacity of the aquifer may be high, we know nothing about the long-term capacity or sustainability. NORPLAN needs to develop a strategy to limit the unauthorised use of the wells following the study (e.g. restricting the diameter at the headworks and installing monitoring equipment).