

Survey of Infiltration Karez in Northern Iraq: History and Current Status of Underground Aqueducts

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Executive Summary

Subterranean aqueducts, known as *karez* in Iraq, were identified, mapped and placed in historical context to document this important part of Iraq's cultural heritage and to provide guidance for plans to rehabilitate karez systems in Iraq. Information was collected from existing karez inventories held by the Federal Government of Iraq (GOI) and the Kurdistan Regional Government of Iraq (KRG), historic cadastral maps which recorded the location of many karez, and through interviews and personal observation during several weeks of fieldwork conducted across northern Iraq. This work has documented 683 infiltration karez throughout the northern governorates (Dohuk, Ninewah, Erbil, Kirkuk, and Sulaymaniyah). The karez in this region have been adversely impacted by drought and excessive well pumping. Almost 40% of karez documented—and 70% of those that were still flowing five years ago—have been abandoned since the onset of drought in 2005. As a result of this decline, over 100,000 people have been forced to evacuate their homes since 2005. The study identified 116 karez that were still being used in summer 2009, but all have diminished flow, placing an estimated 36,000 people at risk of displacement. The recent decline of karez and the resulting migration can be considered to be an early warning signal for other serious problems concerning the future water supply in the area. The study recommends urgent intervention to restore the karez in 50 communities. Water managers in Iraq now have a more comprehensive list of karez for water resource inventories and UNESCO plans to refurbish karez can be guided by the information now available on the configuration, condition, ownership, and use of infiltration karez in the region. Information on the distribution and use of these historic systems also helps to situate the karez of Iraq as part of the wider story of karez or qanat technology across the eastern hemisphere. This effort represents the first systematic survey of karez in the northern region of Iraq and fills an awkward gap in the international academic literature for these historic systems of water supply.

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1. Karez and qanats: Infiltration well and tunnel technology

Karez (subterranean aqueducts; *kahrez* in Persian)—also known as *qanats*, *aflaj*, *foggara*, *khattara* and other names in other places—are engineered to collect groundwater and direct it, through a subsurface tunnel with a gradual slope, to surface canals that provide water to settlements and agricultural fields (Figure 1). Karez are found in 38 countries worldwide (39 including Palestine/West Bank), in both western and eastern hemispheres, though most are concentrated in the Middle East region and the frequency of karez increases in proximity to Iran, where the greatest number and variety of karez are found. Only Iran and Oman (and possibly Afghanistan and Pakistan) have more infiltration karez than are found in Iraq.

The karez that still function often compete with pumped wells for limited groundwater resources and they are frequently abandoned as the water table falls. Karez are also abandoned as social systems change following the proliferation of privately owned tube wells (not managed by the village labor network), or the migration of young men away from villages. Either change renders village labor networks less capable of supporting the proper maintenance of karez. Karez must be periodically cleaned and reinforced to repair collapsed wells and keep the tunnel clear of debris to ensure unobstructed flow of water through the underground channel. Many of the karez in northern Iraq have also been abandoned since a protracted drought began to lower water tables in 2005-2006.

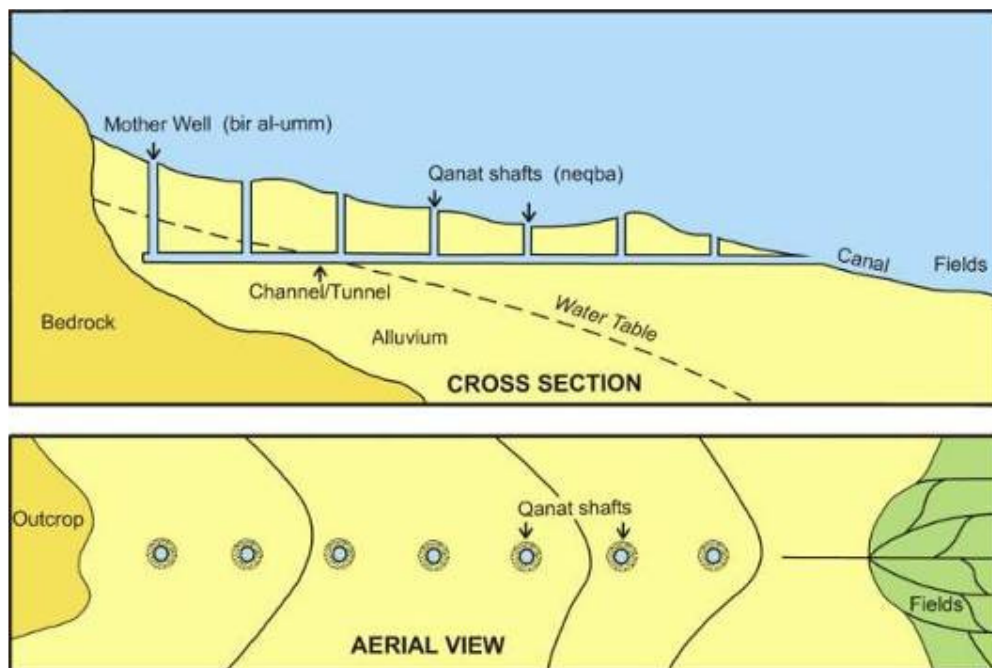


Figure 1. Diagram of a karez (qanat) in cross section and aerial view.

Karez exhibit a great variety of configurations, lengths, and tunnel forms, though all are variations of the same technique of boring a tunnel and wells into water-bearing bedrock, alluvium or conglomerate and conducting—through the tunnel to the surface by gravity flow—the water that infiltrates into the wells and tunnel. The water exits into a surface canal and often collects in a pool or basin before being distributed for drinking, washing, ablution, watering livestock, and irrigating fields, orchards, and gardens. More numerous than infiltration karez are the other water sources and channels known colloquially as “karez” that do not collect water through infiltration. These other “karez” deliver natural spring water to a collection spigot or pool, or use tunnels (a.k.a. spring tunnels) to carry spring water

from its source to a distant location through a surface canal or a shallow subsurface canal that has been cut into the soil, covered with stones, and buried so that water flows under the surface (a.k.a. cut-and-cover canal). An infiltration karez may also incorporate a cut-and-cover canal (rather than a surface canal) to carry the karez water from the tunnel exit to its destination (Figure 2). Some water sources known locally as “karez” collect water through infiltration by excavating a surface trench into a shallow aquifer and direct the water that flows from the exposed aquifer through an open channel. These simple surface-cut spring channels, though they rely on infiltration from an aquifer, are not subterranean systems, do not involve the tunnel and well system of a true karez or qanat, and are not included in this survey.



Figure 2. Cut-and-cover section of canal at the outflow of a karez at Basak. (Photo by Dale Lightfoot)

The 683 karez counted in this survey are all of the infiltration tunnel variety and function in the same way that karez function in Iran, or Aflaj flow in Oman, or Qanat Romani in Syria or khattara tunnels flow in Morocco. Most of these karez (84%) are in Sulaymaniyah governorate. A large number are also found in Erbil governorate (13%), especially on the broad plain around and in Erbil city. Only five karez are located in Dohuk governorate. Adjacent governorates—Ninewah and Kirkuk—also contain a few karez (Figure 3).

All of these karez operate on the same principals, regardless of the aquifer geology being tapped, and regardless of how long or short the tunnels may be, how many wells are found along the channel, or how deep the mother or source well. Many infiltration karez collect water from aquifers at the base of hills or low mountains (see Figure 1). Others tap into alluvial or conglomerate aquifers perched in alluvial fans. Some of the longest karez, in Iraq and elsewhere, are found running for several kilometers across broad alluvial plains, and others run along stream valleys or wadis where they tap the shallow water tables adjacent to intermittent or ephemeral streams. All karez are excavated into porous, water-bearing materials like alluvium, conglomerate, limestone and sandstone. Karez in Iraq are found in alluvium, conglomerate and limestone.

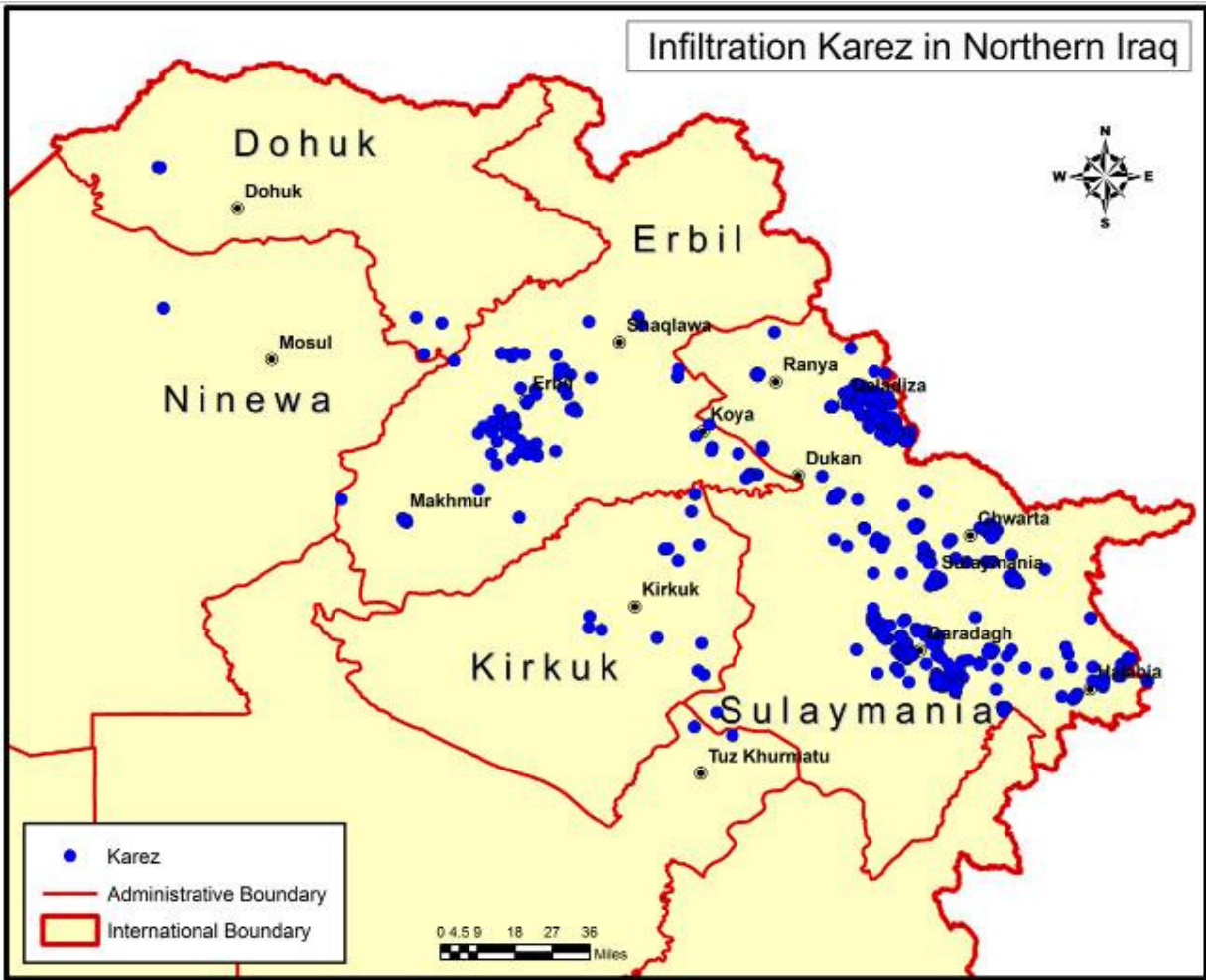


Figure 3. Distribution of infiltration karez in northern Iraq (683 in total)

2. The need to study karez

Karez technology is one of the most labor intensive yet environmentally-suitable and sustainable systems for delivering water ever devised by humans. It has given birth to thousands of settlements over the past 3,000 years and helped to sustain many more. Karez waters have been used for drinking, flushing public toilets, bathing and washing clothes, watering livestock, irrigating orchard and vegetable crops, and ritualistic cleansing before prayer; all of the needs of life in places that lack good surface water sources. Small wetland habitats supporting aquatic vegetation and birdlife have sometimes developed in outflow areas where excess water runs through surface channels (sometimes from continued seepage after abandonment of a karez). Though karez do not contribute as much to a country's total daily needs as do other water supplies, they are significant in communities that derive most of their water from karez. The fact that they exist and most of us know little about them requires that we learn all that we can before the use of this traditional technology is lost and before the vestiges of abandoned karez have disappeared from the landscape.

This research follows a theme I have pursued since 1992 in developing countries across the semi-arid and arid regions of North Africa, the Near and Middle East, and Central Asia. Field studies targeted countries where karez were known to exist but where systematic surveys of a comprehensive nature were absent from the scholarly literature and from water and irrigation inventories. In the quest to fill in these missing details, I have completed country-wide studies of the history, ecology and contemporary use of karez in Morocco, Syria, Jordan, Yemen, Uzbekistan, Cyprus, and Tunisia. The multi-country, cross-cultural nature of these many field studies has allowed me to consider the commonalities and variations on karez technology, and the broader story of technology diffusion and contemporary use of historic irrigation systems across the drier realms of the eastern hemisphere. A few notable gaps still remained in this story of diffusion and adaptation, and the most egregious gap was in Iraq. The research reported here was conducted in 2009 to produce this missing survey, under contract with the United Nations Educational, Scientific, and Cultural Organization (UNESCO).

UNESCO has an interest in the cultural heritage of karez systems and has begun a new program to revitalize some of the karez in northern Iraq to enhance local water supplies, make villages with karez more self-sufficient, and improve conditions of development and productivity in karez-watered places. Some information helpful to this cause was maintained by GOI and KRG ministries, though water managers in Iraq did not have a comprehensive list of karez in their water resource inventories.

There are many papers and books that discuss the origins and use of karez in other regions. A few details on the karez in Iraq exist in scientific reports and graduate theses in Arabic and Kurdish, but details on karez in this region are lacking in any Western-language publication and no comprehensive inventory exists in any language. The few sources that mention Iraq's karez are either dated, simplistically brief, or relate to only one area (e.g. Erbil and vicinity). A comprehensive, field-based, systematic study of the karez of Iraqi Kurdistan, their place in Middle Eastern history, and their relationship to other water technologies has never been completed. Guided by the up-to-date information from this survey, UNESCO and its contractors may now make better decisions regarding where and how to direct resources to refurbish karez, to benefit the villages that have them, and to aid regional development objectives for the region.

3. Research Questions and Methods

This research was designed to locate all infiltration karez in the three governorates of Iraqi Kurdistan (and adjacent Ninewah and Kirkuk governorates) in northern Iraq, illustrate the history and contemporary use of karez in the region, and consider the possibilities for karez renewal. Karez have also been referenced at Samarra in central Iraq, Rutbah in western Iraq, and Ukhaidir in southern Iraq, but they have not been included in this survey. How many karez, or their relic traces, are located in northern Iraq? Where are these features, and why are they found where they are? What roles have been played by the Persians, Kurds, and Arabs in the adoption and modification of these systems? If they no longer function, when and why were they abandoned? Do karez systems still have a role to play in delivering water? What impact have pumped wells had on karez, and will groundwater resources be adequate to meet future needs if present trends continue? These questions were addressed during fieldwork to understand the history, ecological conditions, and contemporary story of karez water use.

Specifically, the following details (1-6) were recorded for each karez throughout the Iraqi Kurdistan region (as far as cadastral maps, ministry records, and interviewees could provide at each site) and added to a comprehensive database for analysis and mapping within a geographic information system (GIS). Functional and relic karez were included in the survey and database. Only infiltration karez (qanats), were included; not springs, spring tunnels, or surface-cut spring channels, which are also called “karez” by local informants.

- (1) **Terminology:** Terms used for karez, mother well, vertical shafts, exit tunnel, etc.
- (2) **Location:** The village associated with the karez, location on the landscape and GPS coordinates
- (3) **Characteristics:** The number of karez at each site, karez lengths, number of wells/surface shafts, water source, geology/rock type associated with the infiltration source, tunnel height/width and current condition of the tunnels, channel exits, and outflow basins and canals
- (4) **Oral History:** Which culture or empire originally introduced or constructed the karez and which groups maintained or reopened them
- (5) **Social Use:** How often karez were cleaned, how work was funded, who owns/uses water and is ownership clear, number of families supported with the karez water, what is/was water used for (drinking, irrigation), how much land is/was irrigated, when was a karez abandoned and why, how is the land used today that was formerly irrigated with a karez, the perceived importance of the karez, and the willingness of local residents to refurbish the karez)
- (6) **Physical Use:** Volume of flow, seasonal variation in flow, depth to the water table currently and in recent past decades

Primary data sources for this survey included (1) lists of karez maintained by the KRG and Government of Iraq ministries of water (Surface Water and Irrigation Directorates), (2) a series of historic cadastral (land ownership) maps—which depict the name, length, and location of the chain-of-wells for many karez; production of the maps was supervised by a Dutch survey/cartography team and produced at the scale of 1:10,000 for the entire study region during the period 1939-1958, and (3) knowledgeable informants in the field. Each of these sources contributed something to the enterprise.

Many karez found on historic maps were not included in ministry lists and some were not recovered on the ground because they had been obliterated in recent decades (built over or covered through

cultivation). Some karez recorded in ministry lists were not seen on cadastral maps, and ministry-recorded details were not always known by village informants. Likewise, visits to villages and karez sites in the field confirmed the existence of karez previously mapped or listed, allowed precise locations to be fixed with the aid of GPS, recovered a great amount of detail not available from other sources, and revealed the existence of many additional karez not recorded in any other source.

Interviews in the field included conversations with *agas* (landowners), *mukhtars* (village administrators), *wastas* (well and karez maintenance experts) and farmers and others familiar with the location and use of local karez. Interviews were conducted with the assistance of a field coordinator and interpreter (Hawta Khayyat). Interviews did not involve questionnaires and were not formally structured. Questions were informally posed during many “conversations with a purpose” during which key details were elicited to recover desired information. Additional information on the history and environmental context of karez was gathered from books and articles collected before, during, and after fieldwork. Locally produced works in Arabic and Kurdish have been read and key passages translated to English.

Fieldwork was completed in six weeks during June and July 2009; most days involved 12-13 hours in the field plus additional days for researching historic cadastral maps and compiling details from existing ministry lists. Some of these ministry karez lists proved accurate (all sites were checked in the field); others offered general guidance but information was dated and errors were noted and corrected during fieldwork. Ministry lists and cadastral maps did not distinguish infiltration karez from springs and spring tunnels; these systems were sorted out during fieldwork. The final compilation of field notes, GIS database and cartographic work, and writing occupied the month following fieldwork. Several attributes were recorded in the GIS database for each karez (where detail was available). Additional information and stories for many karez were recorded in field notes (see Appendix C for example). These field note compilations were used to discern many of the trends noted in this report and may be of interest where future plans are made to refurbish a karez.

4. Karez construction and terminology in Iraq

Karez construction

The specialists who construct and maintain karez are known in Iraq as *wastas* (a.k.a. *oustas* in Turkish). They typically have experience installing pumped wells in addition to karez, and may have first learned the well-digging craft this way. Therefore, the Iraqi *wastas* are not the equivalent of Iranian *moghanni*, who are an expert class of karez specialists, usually from an extended family of karez specialists, who have been responsible for constructing and maintaining the many thousands of karez in Iran for centuries. The term *moghanni* is not used in Iraq and very few people—including many of Iraq's *wastas*—have ever heard of the term. *Wastas* in Iraq are mostly involved in cleaning existing karez, as few tunnels or branch galleries have been added since the early 20th century. The British governor of Erbil from 1918-1920, Captain High, wrote a book titled “Two years in Kurdistan” in which he discussed karez and *wastas*. He described the best *wasta* in Erbil (at that time) and said “there is an old man named *wasta* Fatah; this man was well known as an expert *wasta* of karez. For example, he was able to identify those places which are rich in groundwater and digging karez will be necessary in those places. He learned this specialty from his father” (reported in Haji 1985, 90). Modern *wastas* have retained this specialist knowledge and, until the mid-20th century, continued to build new karez.

With 380 karez still active in northern Iraq as recently as 2004, and 116 of these still being used in summer 2009, there are still several *wastas* who practice the karez craft—especially in Sulaymaniyah governorate—and a few who specialize in karez maintenance. A few (mostly aging) *wastas* may be found around Erbil. Ramadan of Nawroz district has worked on many of the karez around Erbil since he was a child in the 1960s and has experience adding branch galleries on some of them. Like many *wastas*, he mostly installs and cleans tube wells now, because most karez in the Erbil area have fallen out of use. More *wastas* can be found in the area between Shaqlawa and Koya, and many active *wastas* can be found in parts of Sulaymaniyah governorate, where most of Iraq's karez are found. Among the most active and expert *wastas* in the karez-rich Qaradagh region is Hama Rashid Ahmed. He has worked 12 years as a *wasta* (learning the craft from his *wasta* father), has been inside most of the karez in the Qaradagh area and Dukon district of Sulaymaniyah, and is typical of other active *wastas* who are willing to relocate to any job site to work on karez. There is no formal training or organized apprentice system for *wastas* in Iraq; training is learned informally from fathers and friends.

The work of cleaning and maintaining karez typically involves at least three people (and maybe more), with at least one working in the tunnel, another working the windlass above a surface shaft (to lower and raise equipment, casing materials, and any debris removed), and another to move supplies on the surface and oversee the work flow (Figure 4). When a karez is flowing they must pump water to the surface to dry the karez in order to perform cleaning operations. Sections of the tunnel in good condition are, generally, merely inspected; only damaged or collapsed sections are carefully repaired. Each meter of tunnel repaired typically requires about two hours of labor (and possibly materials like cinder block and concrete pipe rings for support casing) and will typically cost 85,000 Iraqi dinars per meter (2009 cost) for all materials and labor.



Figure 4. Working a windlass over the mother well of karez Barzawan Saru at Sewsenan.
(Photo by Dale Lightfoot)

Karez tunnels and wells have been incrementally excavated into the landscape of Iraq over a wide span of time—2,500 to 30 years ago—and added by a combination of local and foreign agency. For much of this time, specialists have come from Iran, where many more thousands of karez exist than have ever been installed in Iraq. Wastas, mukhtars and agas in northern Iraq sometimes mention these Iranian connections, and many people in Sulaymaniyah governorate with expert knowledge of karez have clear memories of Iranian involvement in both the construction and maintenance of their karez at least since the early 20th century. Several karez owners and active wastas around Kharaba (Koya area), Basak (Barzinja area), Goradem (Chwarta area), and Sewsenan (Qaradagh area) have either paid or remember their fathers or grandfathers hiring Iranian wastas from Isfahan, Bana, Bukan, and Meriwan to build new karez in the 1920s through 1950s (with a few new ones added by Iranian wastas in the 1960s-1970s around Goradem). These and other villages report hiring local wastas and Iranian wastas (with work permits) to repair and clean their karez in recent years.

Karez tunnels were excavated in a variety of profile shapes, including rectangular, round-arch, and pointed-arch ceilings (Figure 5). Some tunnels (though not most) have a narrower water channel excavated along the length of the tunnel floor to allow one to walk through the tunnel straddling the water flow and to reduce the likelihood of lateral erosion of the main tunnel walls.



Figure 5. (A) Round arch karez tunnel in limestone at Zimzimuk; (B) Pitched and pointed arch Sarsula karez at Girdashekhal (in limestone). (Photos by Dale Lightfoot)

The tunnel height may range between three meters and as low as 60 centimeters (0.6 m). Tunnel widths vary between two meters and 50 centimeters (0.5 m). An average tunnel is 1.5 meters high by 80 centimeters (0.8 m) wide. Many tunnels have burn marks along the walls where oil lamps have been placed for interior lighting during past cleaning operation. Traditional lamps used for light in karez tunnels (during construction and maintenance) use sesame oil rather than petroleum oil because it produces much less smoke (Haji 1985). They call these lamps “shirbaq” light. Flashlights are also used for lighting in the tunnels today. Surface wells, which provide light, ventilation and access to the tunnels, are usually no wider than 70-90 centimeters and are typically 20-30 meters apart (though there may be less than 10 m or more than 100 m distance between wells). These wells are usually aligned in a (more or less) straight path (Figure 6). Some wells—and the tunnels they mirror—follow a zigzag pattern (e.g. at Arabkand-Kasim Aga, Sewsenan-Suraban Saru, and Gawilan), reportedly to increase the speed of water flow.



Figure 6. Alignment of wells at an abandoned karez at Qushtapai Gichka.
(Photo by Dale Lightfoot)

Karez may experience reduced flow because (1) the water table has dropped (because of drought and/or over-pumping from tube wells), (2) heavy rains have washed debris into wells and tunnels and/or a section of a tunnel or well has collapsed (in either case leading to tunnel constriction or blockage), or (3) because nearby tree roots have grown into the tunnel to create debris dams that restrict flow. Special knowledge (*wastas*) and tools are required to repair these tunnel restrictions and return a karez to healthy flow. Sometimes a simple cleaning of debris and/or removal of plant roots is all that is needed. Sometimes more complicated repairs are required and casing may be added to provide strength to the walls of tunnels and wells. Historically, casing materials were natural stone, cut stone, or bricks. Most casing installed today is cinder block, concrete rings (which can be connected together to form an interior concrete pipe), or form-poured concrete. The openings of karez wells that have had such maintenance performed will typically have raised casings (to prevent debris from easily entering the wells) and hatches to cover the well openings.

Karez terminology

Karez are known by many other names in other countries (sometimes by different names within a single country) but are known only as *karez* in Iraq. This Persian word also has meaning in Kurdish—“working in one line” or something similar which recalls works along a path. The karez channel or tunnel is most commonly called a *lagham* in Iraq; a Kurdish word meaning “underground tunnel.” This term is most commonly heard in Sulaymaniyah governorate but is also used elsewhere. Alternate terms used around Erbil may include *loyin*, a word of unknown origin that refers to a section of tunnel between one well and the next, and *kuna kotor* (Kurdish *kun* = hall and *kotor* = a type of bird that goes into karez channels for water; i.e. “hall of the kotor bird”). The source well or mother well of a karez is known in Iraqi Kurdistan as the *kala bir* (“big well” in Kurdish), *bira gumana* (“checking well” in Kurdish; the well where you check to see if there is enough water to dig a karez), or *biri sarachawa* (“source well” in Kurdish). The first part or section of the karez is called the *tayan*. This is the beginning of the underground channel from the source. The *manjal* is the last well before the exit. The terminus or exit of a karez is known locally as the *killil* (“key” in Kurdish), *miftah* (“key” in Arabic), or *zari karez* (“mouth of the karez” in Kurdish). At the end of the karez, the basin or cistern is called *astelik*.

The word *wasta* is widely used in Iraq for the specialist who builds or maintains karez. *Wasta* is understood in Kurdish to mean “builder” or “expert” and may be used to refer to any type of expert in any field, not just karez specialists. The word is derived from the ancient Avesta word *ostâd*, meaning “professional” (any professional). Avesta is a 2,500 year old language from Persia that pre-dates the widespread use of Persian in the area.

5. History of karez in Iraq

There is a shortage of published information on the history of karez of Iraq; an unusual gap given the amount of historical detail available on the karez in adjacent countries like Syria, Jordan, and Iran. Likewise, there are no corroborating details available from archaeological reports—no material evidence—to help support the dating of karez in Iraq. The dating of karez anywhere is notoriously difficult, even where material evidence is plentiful, and must rely on circumstantial evidence around a karez or historical details from an adjacent settlement clearly linked to a karez through its exit tunnel, cistern, or distribution canal. Even these lines of evidence are scarce or non-existent for the karez of northern Iraq and only general inferences can be made regarding their historical introduction, diffusion, and use. This story must be pieced together from the general sweep of history, from what we know from more detailed historical studies of karez in adjacent regions, and stories from the local oral history.

Oral histories often report local karez to be 100-350 years old. In many cases this is contemporary with the age of the village. For example, 22 karez lie around the village of Goradem in the Sharbazher district of Sulaymaniyah, a village that has existed for 280 years (since about 1730). The oldest karez here are presumed to be this age, but others were built new in the 1920s-1930s (and 2 or 3 added in the 1960s-1970s) by Iranian wastas brought to the area from Mariwan, Bana, and Bukan. Many karez in Iraq are just reported to be “very old,” meaning before living memory or the stories of fathers and grandfathers. The modern Iraqi historian Abdul Razzak Al-Hassani reports that the karez in Kurdistan are “very old” and in very ancient times they allowed Erbil to continue developing and thriving, because invaders could not control Erbil or destroy the karez like invaders had done with water sources in the past in Babylon, Ur and other southern cities of Iraq (Al-Hassani 1956, 239).

It is clear that most karez in Iraq were constructed “long ago” but not much more can be said with any accuracy when speaking about a specific karez. A few can be dated more precisely using old documents that mention the karez. Several owners of karez reported that they have documents that attest ownership, and some of these documents (mostly 19th-20th century papers) record new construction. Many owners have karez documents in ministries in Erbil and Sulaymaniyah (Chawshli 1985, Kargachi 2003).

Many karez are said to come from the “Gaurkare” period; a reference to the Christian era, meaning pre-Islamic. “Gaur” means “Christian” here (people in Iraqi Kurdistan call Jews, “Jews,” but call Christians, “Gaur”). “Kare” means “work,” so Gaurkare refers to Christian works, or simply to the Christian and pre-Islamic era of AD 1 to 632. The Parthian and Sassanid Persians were not Christians, but their works were added to the landscape during this period and may be referred to as Gaurkare. Regardless of religious affiliation, it is clear that Kurdish people, before Islam, knew how to dig karez and constructed them for different purposes (Kargachi 2003).

The karez in northern Iraq could be associated with any past empire or cultural influence along the continuum of Iraq’s history (at least since 800 BC when karez are known to have existed in neighboring Iran). Karez might possibly have been an independent and local adaptive response to the increasing aridity that has been documented in the Middle East for the late second and early first millennium BC, so we might not want to overplay the diffusionist argument in every instance. However, independent invention is more difficult to argue for several areas of the Middle East where there is enough material, archaeological evidence to clearly draw connections between the karez of one place and another (Magee 2005). There is not enough material evidence to confidently connect karez in northern Iraq to those in surrounding areas, but nearby correlates—in Iran, Azerbaijan, and Syria, for example—where the diffusion model can be supported, is enough to compel us to consider the role of diffusion in bringing karez to northern Iraq.

Origins of karez in Iraq: Median and Achaemenid Empires

Some of the oldest karez in the world are found in the Azeri and Kurdish regions of northwest Iran. Excavation and material evidence obtained through several decades of intense scholarly study in northwest Iran has stimulated debate concerning chronology and the impact of the Median and Achaemenid Empires (Magee 2005), but the western (or Iraq) side of the Zagros has been less thoroughly examined. By the 8th century BC the Median Empire was flourishing, contemporary with the earliest reference to a karez—the Sargon II tablet that (possibly) refers to a Urartian karez near Lake Urmia in 714 BC—and in the same region of northwest Iran. These early ancestors of the Kurdish people may have been the first to carry karez technology into what is now northern Iraq.

By the 7th century BC the Medians had moved to the western side (Iraq side) of the Zagros Mountains, expanding their settlements throughout the region of Kurdistan and as far west as the central Anatolian Plateau (Turkey) by 575-550 BC (Brown 1986; Summers 2000). It is possible these migrations were part of a planned resettlement of Median people in order to enhance economic production and to extend their control over the region. This migration carried them into an area that served as a source of tribute, tax, plunder and labor for the Assyrians; it also brought them closer to the center of Assyrian territory, where there is clear evidence in the archaeological record for such a dramatic, state-sponsored resettlement program to expand (in this case) Assyrian control over a wider area and ensure that the land was agriculturally productive (Brown 1986; Wilkinson et al. 2005, 25). In 612 BC the Medians destroyed the Assyrian capital at Nineveh (across the Tigris from modern day Mosul). The Medians inherited the famous Sennacherib canal that had been built by the Assyrians (and is sometimes misrepresented as a karez) and continued developing the water and agricultural resources of the region. There is no direct evidence that the Medians ever built a karez, but their co-existence with karez east of the Zagros, where karez were likely in use by the Median period, and their later movement west of the Zagros, makes an early Median connection to the karez of Iraq very plausible.

By 559 BC the descendants of the Achaemenes dynasty of Persian monarchs defeated the Medians and united the broader Persian realm into the Achaemenid Persian Empire. During the era of Achaemenid supremacy (559 to 330 BC) the Persians constructed karez across much of their large empire, which ranged from the Indus valley to the Mediterranean and included the region that is today northern Iraq. It is likely that the Achaemenids either introduced karez in Iraq at this time or fostered the building of additional karez in an area already familiar with the technology. What we know is that the Achaemenid Persians were well acquainted with karez systems and played a role in building many of them not only in the Persian heartland but farther west in the empire; archaeological and historical evidence ties the first karez in Egypt, Palestine, and possibly Syria to Achaemenid agency (Caton-Thompson 1952; English 1968; Forbes 1964; Goblot 1979; Honari 1989; Kobori 1982, 1990; Lightfoot 1996, 1997; Ron 1989; Safadi 1990; Wuttmann 2001). Achaemenid Persians used karez to supply water to the Kharga Oasis (Egypt) by about 525 BC (Caton-Thompson 1952; Forbes 1964; Salibi 1980; Wuttmann 2001). Ancient Persian potsherds have been found inside karez in the Arava valley, in the Israeli Negev, suggesting that they were first constructed during the Persian rule of the Holy Land (537-332 BC) (Evenari et al. 1971; Ron 1989). The Achaemenid Empire consolidated control over Babylon and Mesopotamia (Iraq) after 539 BC, at about the time that Syria was incorporated as a province within their empire (Lightfoot 1996; Salibi 1980).

The Achaemenid monarchs actively encouraged the construction of karez by granting the profit for five generations to the people who dug them (Potts 1990). The carefully planned and well-managed systems of this Persian Empire, its method of land and water distribution, tax collection, communication and post provided the opportunity to establish thousands of farms and villages throughout Persia and the conquered lands of empire (Honari 1989).

Other Persian, Roman, and early Islamic Empires

The Parthian Persian Empire (250 BC to AD 229) continued the work begun by the Achaemenids, and controlled Mesopotamia by the mid-second century BC. The Sassanid Persians (AD 229-637) are noted for their investments in hydrological works like fountains, gardens, aqueducts and wells, and they generally improved irrigation techniques and expanded arable land in the region. Both of these historic Persian empires are associated with karez building and maintenance in Iran and can be assumed to have used karez in the Kurdish region of their empire, but are not affirmatively tied to any karez in Iraq.

The Romans and Byzantines added most of the karez found nearby in Syria and Jordan, and the Romans, especially, were active karez builders all around the Mediterranean (Butzer et al. 1985; Glick 1970; Lightfoot 1996, 2004, 2009). However, most of northern Iraq lies beyond the eastern frontier of these empires—the boundary between Romano-Byzantine and Persian empires—and was never invested with significant construction or settlement efforts by these Mediterranean powers, though the Romans did build some public works in the area (e.g. the bridge at Eski Mosul, 35 km north of Mosul). There is a confirmed karez at Sinjar (northwest Iraq), which lays near the eastern extremity of the area that “was for a time protected by Rome as an outlying section of its Mesopotamian Limes” (Stein 1941, 310), the Roman frontier that stretched to the town of Eski Mosul (Old Mosul) on the Tigris River, another settlement where a karez has been reported. Though Roman connections to the two karez in northwest Iraq cannot be affirmed at this time, the Roman bridge at Eski Mosul—one of two eastern most bridges in the empire—does show some investment in public works at this eastern limit of the Roman Empire. The Romans built several karez around military posts and on land settled by former soldiers along the Roman frontier in southern Tunisia (Lightfoot 2009). Even if the Romans could be connected to the karez at Sinjar and Eski Mosul, all other karez in Iraq lay well to the east, beyond the Roman limit of control.

In 636 an Arab Islamic army defeated Sassanid Persian forces in a battle south of Baghdad and moved quickly to the capital of the Sassanid Empire where, in 637, the Sassanids were defeated and the Abbasid Islamic state added what is now much of Iraq and Iran to their rapidly growing empire. This Persian-influenced Arab empire had its capital in Baghdad, and Mesopotamia had once again risen to center stage in an empire. Until their control of the region ended in 1258, the Abbasids probably expanded or at least continued regular use of the karez in Iraq. Karez are known to have been used (and probably new ones built) in Syria during the long period of Abbasid administration (Lightfoot 1996) and the history of karez in Iraq goes back (at least) to the Abbasid period (637-1258). Captain High, the first English governor in Erbil city (1918-1920), reported that there were 365 karez in Erbil city and environs in the Abbasid period (reported in Al-Gaznaiy 1997, 34). Presumably, this number includes springs and spring tunnels in addition to infiltration karez. The use of karez in the medieval era is confirmed by Yaqut al-Hamawi, a famous Syrian geographer and historian who twice visited Erbil during this period, discussed water and karez in Erbil city in the first edition of his book *Mu'jam al-Buldan*, and reported that in the Atabiki (Atabegi) kingdom in Erbil (between 1128-1233 AD, after the Abbasids lost control of the area to the Seljuk Turks and the Atabegs of Azerbaijan), agriculture “depends on rain and karez and the water in those karez is the same as the Tigris River.” (i.e. karez had strong flow) (Haji 1985, 89; Husayn 1976).

The Ottoman and modern periods

It is clear that many karez were in use in Iraq in the medieval period of the Abbasids and Atabegs, and the continued use and new construction of karez is also associated with the Ottoman period of administration in Iraq (1534-1623 and 1638-1918). The city of Sulaymaniyah has used a number of karez for its primary water supply for hundreds of years, even before the modern city (with this name) was founded in 1784. Sulaymaniyah used to be the village of Mulkany, which is now the oldest district of the city. Mulkany had karez at least 450 years ago (i.e. around 1550; in the Ottoman era), before the modern city was established, and at least one of these old Mulkany karez

is described in a document dating to the mid-16th century (Kargachi 2003). There were likely other karez in and around Mulkany around the same time, and possibly older karez, but they are not accompanied by documentation.

Karez were still used as the primary water resource in Sulaymaniyah city in the 19th century because spring flow was insufficient to meet the needs of the city at that time. Sulaymaniyah city continued using karez as a main source of water until completion of the Serchnar water project (the old city reservoir completed in 1955) (Kargachi 2003, 22). Portions of 17 karez can still be seen in the city and its environs (along with an even greater number of springs and spring tunnels), and nine of these were still flowing and used in summer 2009 for drinking (1), ablution (4), and irrigating city parks and gardens (4). Though the city still uses the karez that flow, they now account for a small percentage of the city water supply. Since 1955 the Sulaymaniyah municipal authority has primarily depended on reservoirs and is increasing the city supply with surface water piped from mountain catchments and reservoirs constructed around Azmir Mountain, northeast of the city.

In addition to the oldest karez around Erbil—which may include some of the oldest in Iraq—new karez were dug around Erbil city in the decades before WWI and many owners have documents for these karez in the ministries in Erbil (Chawshli 1985, 54). Captain High, the first post-Ottoman governor in Erbil city, reported that the main source of water for Erbil during 1918-1920 was karez; they didn't have any other water projects for supplying water. "During my stay," said Capt. High, "people were using 60 karez in Erbil and surrounding areas." (reported in Al-Gaznai 1997: 34).

Most of the karez around Jafaron (west of Qaradagh in Sulaymaniyah governorate) are reportedly 100-200 years old, built by local wastas who are thought to have learned their craft from Iranian-trained wastas in the Sewsenan area, south of Qaradagh. If this is true, then the first introduction of karez in the karez-heavy Qaradagh region of southwest Sulaymaniyah governorate would have been from Iranian wastas from Isfahan, which oral history reports were the first to build karez in the area (in the 1800s). After Iranians built the first karez around Sewsenan they are believed to have trained Sewsenan-based wastas, who added more karez in the area. The Sewsenan wastas then helped to spread karez systems to the northwest, where they reportedly introduced the first karez around Jafaron and trained local people as wastas. The Jafaron wastas, in turn, added more karez around Jafaron; so many that Jafaron now has the greatest number of infiltration karez (52) of any village in northern Iraq.

Living history reports that 40 karez in Iraqi Kurdistan were constructed between 1900 and the 1950s; some of them built by Iranian wastas. Most of these are in Sulaymaniyah governorate, which shares a long border with Iran. One karez at Surdash (one of two karez there) was newly constructed in 1980 by a local wasta, the most recently built karez recorded in this survey. Most of the constructing and building of karez appears to have been done by local wastas. Some wastas, long ago, learned the trade from Iranian wastas who were brought from cities like Isfahan, Bana, Bukan, and Meriwan to construct and clean karez. Importing Iranian wastas to build new karez continued through the 1970s in some places, and the use of Iranians to clean and maintain karez continued for many years after that.

Wheat grinding mills

The surface flow of many karez was diverted to wheat grinding mills. Twenty-six grinding mill ruins and former mill sites associated with 16 different villages were recorded during this survey. Each of these water-powered mills received its flow from a karez, which channeled water along high ground to a siphon that was elevated above the mill. Water dropping through the funnel shaft of the siphon would speed up (*a la* the Venturi effect) and turn the paddle blades of a horizontal water wheel placed at the siphon exit, at the bottom of an embankment below the channel and siphon entrance. The horizontal water wheel was attached to a grinding stone that was rotated by the movement of the water wheel. These mills are similar to horizontal-wheel grinding mills powered by karez found in nearby countries such as Iran, Syria, and Cyprus.

A high stone tower was sometimes built on the site (with access to the tower stairs from inside the mill room). A mill worker would climb stairs to the top of the tower to announce (by yelling) when the mill was open for business and accepting wheat. Most of the karez-powered wheat grinding mills noted in this survey still have visible ruins, and some mill ruin/tower combinations are still seen. An excellent example is found near the Haji Elias karez at Sardar. The karez-fed channel and siphon of this ruin are still intact, as are portions of the mill room. The original tower was destroyed by lightening and a new circular stone tower built in 1962.

No one knows when wheat grinding mills first came to be associated with karez in Iraq. Also unknown is the age of any individual mill. All mills are “very old”—at least older than living memory. Wheat mills on the Erbil plain fell out of use around 1957-1960 and the last one was used in the early 1960s. Most of these mill ruins (24) are located on the Erbil plain. One is at Bakhakon village in the Halabja area and another is on the outskirts of Piskandi, in Dukon district (Sulaymaniyah). More mill ruins likely exist in northern Iraq than were uncovered by this survey. The wheat grinding mills mentioned here were found by circumstance; we were not systematically searching for them.

6. Regional patterns: Environmental context and configuration

Rainfall

In most countries, karez are found in arid and semi-arid environments that receive less than 300 mm average annual precipitation, and very few are found outside of areas exceeding 500 mm. People in wetter areas—where perennial stream flow is adequate—rarely built karez. Drier regions were inhabited by nomadic Bedouin herdsman who were not invested in labor-intensive irrigation systems. Most areas in Iraq that receive less than 500 mm annual rainfall are either hyper-arid and not inhabited or cultivated, or else well provisioned by extensive surface canals fed by the large Tigris and Euphrates rivers (i.e. surface water is plentiful; tapping groundwater with karez is not likely to be supported). It is the lack of natural surface water supplies in northern Iraq that makes karez an attractive option for water supply there, even though 90% of the three governorates receive 500-750 mm (20-30 inches) average annual rainfall. Many of the karez in central and eastern Sulaymaniyah governorate lie within areas receiving more than 750 mm precipitation and snowfall per year. Less than 4% of the karez in northern Iraq are found in places that receive less than 500 mm average annual precipitation. This is uncharacteristic for the world of karez, but not unexpected given the historic reliance on groundwater in Kurdistan and the proximity of this region to Iran, where thousands of infiltration karez are in daily use.

Hydrogeology

To ensure long-term, continuous flow from a karez, they are constructed in aquifers that are seasonally recharged. These aquifers are usually shallow—a few meters to tens of meters deep—and located in areas of permeable rock, thus allowing regular recharge to the aquifer below. Most karez in Iraq have been excavated into porous, water-bearing beds of alluvium (26%), conglomerate (10%), and limestone (63%). Some karez originate in limestone (the infiltration source) but their tunnels flow partly through alluvium. Some of the karez around Basak are found in bituminous limestone and several others (e.g. Kani Bardina and many of the Sulaymaniyah city karez) run through the marly-lime Tangelo formation. Two of the karez around Girdashekhhal are in loosely-cemented, friable breccia. Several karez, classified in the database as alluvial sources, were found in gravelly or cobbly alluvium, though more alluvium than conglomerate. Sandstone is not common in northern Iraq and is not associated with karez there, though karez are found in sandstone aquifers in other countries. The deepest mother well (source well) identified in this survey was 45 meters (at Grid Mala) and the shallowest was Piskandi (3 meters). Most karez in Iraq have mother wells 7-12 meters below the surface (the mode is 10 meters).

The type and depth of geological materials, together with the configuration of the landscape and available rainfall, all conspire to produce variable hydrogeological conditions that affect the suitability of karez as a resource strategy. For example, one of the most dense concentrations of karez in Iraq is found in the Qaradagh region of the Sulaymaniyah district in southern Sulaymaniyah governorate. Along the eastern side of the Qara Dagh range, that separates the Sulaymaniyah district (east) from the Chamchamal district (west), there are numerous villages with many karez. The lands of Sewsenan village, alone, contain 35 infiltration karez (plus 20 spring tunnels) and 10 of these karez were still being used in 2009. In other villages around Sewsenan, another 27 karez are found (10 were flowing in 2009). Dozens more are scattered around Qaradagh (in southwestern Sulaymaniyah district) and one village alone—Jafaron—has 52 karez; eight of these were still flowing in 2009 and 40 have only recently dried up since 2008-2009. These are all on the eastern side of the Qara Dagh range. On the western side of this mountain range, in Chamchamal district, there is less rainfall and aquifers are less accessible or less well supplied with recharge in the mountains. As a result, the eastern side of this dividing range developed an agricultural tradition and karez irrigation. The western side has more of a pastoral tradition, though the dry farming of wheat (without irrigation) is common. While 175 karez can be found scattered along the eastern flank of this mountain range, only six karez are located within a

similarly sized area along the western flank. Within all of northern Iraq, 84% of the karez are found within the Sulaymaniyah governorate. Thirteen percent (87 karez) are located in the Erbil governorate, and only 5 are in Dohuk governorate. A few are also found in the adjacent Kirkuk and Ninewah governorates.

Configurations

The longest karez in Iraq is reported to be in Sinjar, in northwest Iraq, not far from the border with Syria. It begins in Sinjar Mountain (the infiltration source area). It flows toward the desert to the south and was reportedly followed by a British scientific team that found it extending as far as Tharthar Lake (see Kariz in Sinjar/Mosul n.d.), an account that must be viewed skeptically as this is a distance of more than 200 km. The longest karez in the fieldwork study area exceed eight kilometers (the Miri karez that once delivered water to the Erbil citadel and the Asad Afundi karez at Bagluminara). Most of the karez on the Erbil plain are long tunnels in alluvium; there are 17 karez channels in the area that exceed 4 kilometers in length. All of the longer karez in Iraqi Kurdistan are found in the broad alluvial plains around Erbil, Koya, and Qaradagh. The shortest karez are 10-20 meters in length, usually in limestone, and may have no surface well because of their short run, though their tunnels are bored into an aquifer and deliver water that infiltrates into the tunnel from the aquifer. There are many short karez in the mountainous areas of Sulaymaniyah governorate, typically in limestone with one to four wells along a 20-100 meter long infiltration tunnel. They discharge into a surface canal or underground cut-and-cover canal that often empties into a basin or cistern. Shorter karez (80-100 meters) in limestone are also found in Erbil governorate (at Kunaflusa) and Dohuk governorate (at Zimzimuk).

Most karez in Iraq have a single gallery that collects the infiltration water and carries it to its destination. Karez with a second or third branch in the collection area (aquifer zone) are common, and a fourth or fifth branch was noted on a few karez. These branch infiltration galleries extend outward from the main channel and are designed to gather additional water and direct it to the main tunnel, much like tributary streams contribute to the flow of a larger order river channel.

7. Contemporary use of karez in Iraq

Ownership of karez

Karez may be privately owned by a single *aga* (big landowner), a group of landholding family members with defined water shares, a group of unrelated people who have varying interests or water shares in the karez, or a village committee. If owned by a village committee, all of the people of a village will benefit and receive water from the karez, but even privately owned karez may benefit other families in the village; families that do not own water shares and typically pay for their use of the water. If a karez is privately owned, the owners are responsible for paying for repairs, in proportion to the water shares they own in the karez. If owned by a village committee, the committee arranges for maintenance either by coordinating labor contributed by families in the village, or by collecting money from everyone in the village to pay someone (e.g. a *wasta*) to perform the work.

Uses of karez and changes in use

The karez of northern Iraq have been used for drinking water and other household needs (e.g. washing clothes and bathing), flushing out toilets, watering livestock, ritual cleansing or ablution at mosques, and irrigating rice, tobacco, summer vegetables, orchard crops, and many other needs involved in daily life and economy. Land irrigated will vary according to the flow of the karez and ranges from a half donum to a few hundred donums (1 donum = 0.15 hectare). The area irrigated with karez has drastically diminished in recent years as karez dry up in the face of over-pumping and drought all across northern Iraq. Even where karez still flow, they are now irrigating less land than was irrigated in 2004.

Many karez flow into towns and villages and some of these were primarily or exclusively maintained for municipal drinking water. The city of Erbil has many karez on the plain around it and a few that are buried under city foundations. These karez, now all abandoned and mostly covered by city foundations and streets, used to supply the central city with water for drinking and household use (also for irrigation, animals, and mosque ablution). The city of Sulaymaniyah also has many karez under the city. Nine karez still flow in Sulaymaniyah and are used for mosques, irrigation of municipal parks and gardens, and drinking water (with chlorination units installed at the karez exit). The city of Arbat, southeast of Sulaymaniyah, piped its karez water into the city water system until karez flow became insufficient in 2008. Another 20 villages in northern Iraq maintain (or recently maintained) karez primarily or exclusively for village drinking water.

The Kunaflusa karez is still this village's preferred source of drinking water. The exit tunnel is an important focal point of daily village life. The karez now barely flows (Figure 7). The Nowdeh karez at Piskandi is the only source of drinking water for the village. It has been dwindling since the onset of drought. Its use as ablution water for the mosque ended in 2009. Its use as drinking water is about to cease (Figure 8). Many families have already moved from this village. The village of Hargena had three flowing karez. It lost all three to drought in 2006-2007. It now relies on a hand pumped well for drinking water. Many families have already sold their livestock and migrated away from the village.



Figure 7. Exit tunnel at the public ablution and drinking water basin, Kunafusa.
(Photo by Dale Lightfoot)



Figure 8. Water slowly trickles from the exit tunnel of karez Nowdeh at Piskandi.
(Photo by Dale Lightfoot)

Jafaron village, west of Qaradagh in Sulaymaniyah governorate, has more karez than any other village in northern Iraq but has a story much like any other karez-dependent village in the region. Forty-four of Jafaron's 52 karez became dry during the years 2008-2009; only eight still flow, but these have all experienced diminished flow since 2006. Some karez well sections have also collapsed and are not yet repaired, but many karez have not collapsed—the tunnels and wells are in good condition—and yet there is no water in the karez. Though local informants are not sure why their karez have dried up, the most likely culprits are drought and over-pumping. People in Jafaron used to earn a lot of money from crops irrigated with these many karez. They now rely on government salaries or look for jobs to earn money. There are few options for staying in the village and those without alternate employment have usually moved away. The village has already

experienced some displacement of people and is on the verge of losing many more. Irrigated crops were the main source of revenue for Jafaron and for nearby karez-dependent villages for generations. Karez in Jafaron collectively irrigated 846 donums (113 hectares) before 2008. This land is now dry farmed (mostly wheat) or unused, and productivity and profits have diminished.

8. The decline of the Iraqi karez

The Anfal effect

Many karez were destroyed or abandoned during the 1980s Anfal campaign (1986-1988) launched by the Iraqi government of Saddam Hussein to eradicate Kurdish villages as both a punishment to the Kurdish population that had resisted his government and to make it more difficult for the Kurdish Peshmerga (paramilitary forces) to operate. During the Anfal campaign more than 1,200 villages in the region were damaged or destroyed by aerial bombardment, ground attack, bulldozers, mass deportation and, in several cases, chemical warfare attacks aimed at killing and terrorizing the local population. The campaign, as predicted, led to the abandonment of many villages. Many karez were damaged or destroyed in the process and many of those still intact were abandoned along with the village and eventually became unusable from lack of maintenance. Some of the damaged and abandoned karez were eventually refurbished when villagers moved back to abandoned sites to rebuild. Some of these rejuvenated karez continue to function today, but most have, once again, fallen from use because of a declining water table or lack of regular maintenance.

The impact of pumped wells

Even more damaging to karez than this outside attempt to destroy the Kurdish infrastructure has been the home-grown promotion of pumped wells as a preferred system of water development in Iraqi Kurdistan. After the proliferation of pumped wells in northern Iraq (since about 1940) the water table in the most heavily pumped areas began to fall, and karez dried up, especially after 1960 when the rate of pumping increased and deeper wells were installed. This affected the karez in the Erbil plain sooner than most other places. A few karez on the Erbil plain dried up in the 1940s to 1960s, but almost 50 of them were abandoned in the 1970s to 1990s. Far more karez—more than 250 across northern Iraq—have dried up and been abandoned since 2005 (Figure 9).

The impact of drought

The stories of karez loss and pleas for assistance, heard after visiting so many drying villages, leave an impression of just how dependent some villages are on their karez, how serious their plight, and how many more karez were functioning only four or five years ago. The northern region of Iraq has received only half of its normal precipitation since 2007 (USDA 2009). Although the over-pumping of aquifers must also share the blame for falling water tables and karez death, such a drastic and sustained loss of incoming precipitation has greatly reduced aquifer recharge and placed the groundwater-dependent northern region at risk. Almost 40% of the karez in this region have died since the onset of drought in 2005 (most of those stopped in 2006-2008) but that is almost 40% of the total karez count of 683. If we consider only the 380 karez that were still active and used in 2004, before the drought, 70% of these have been lost since the onset of drought in 2005. And the ones that still flow have all diminished. Some that flow appear healthy still, but others in the “flowing” category include places like Piskandi, Kunafusa, and many others with an unhealthy and feeble karez for their water supply.

Generations of families, shared history, and connection to a place will be lost when the village dies. The displacement of people will then lead to additional social and economic problems (ripple effects). Saddam Hussein couldn't finish these villages off, even though he tried during the Anfal campaign (1986-1988). They just moved back and rebuilt in the early 1990s (after the first Gulf War). Karez death, in the case of some of these villages, will lead to a more permanent village death.

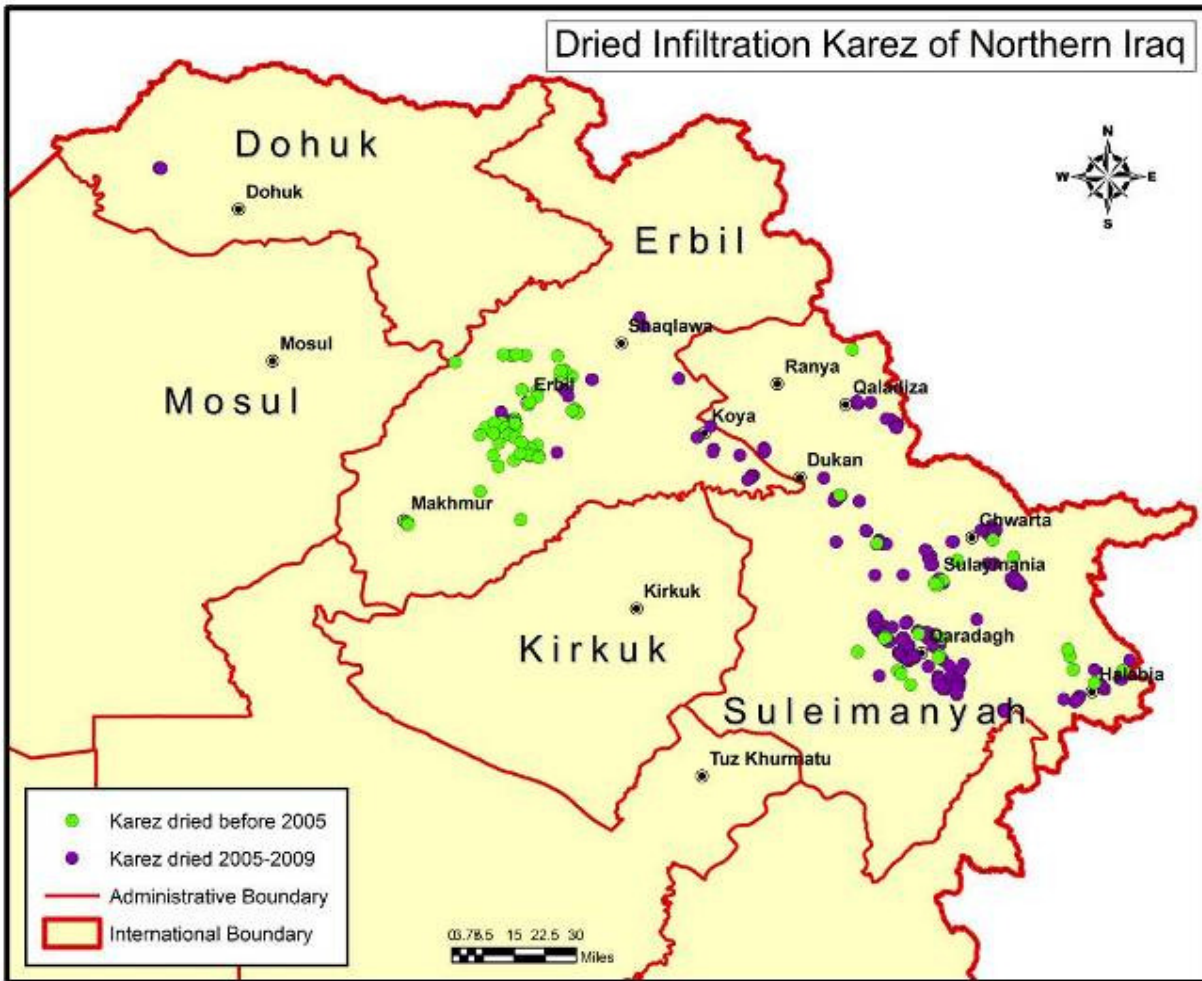


Figure 9. Karez that have dried before 2005 and since the onset of drought (2005-2009).

Karez still flowing

As of July 2009, 116 karez were still flowing and used for drinking, animals, mosque ablution, and/or irrigation around 49 different settlements in northern Iraq (Figure 10 and Appendix B). Most that still function report diminished flow since 2005. Many karez listed in the “flowing” category barely flow and are used only because no other local source is available. Almost 30 more are barely seeping but have a flow too feeble to be used at all.

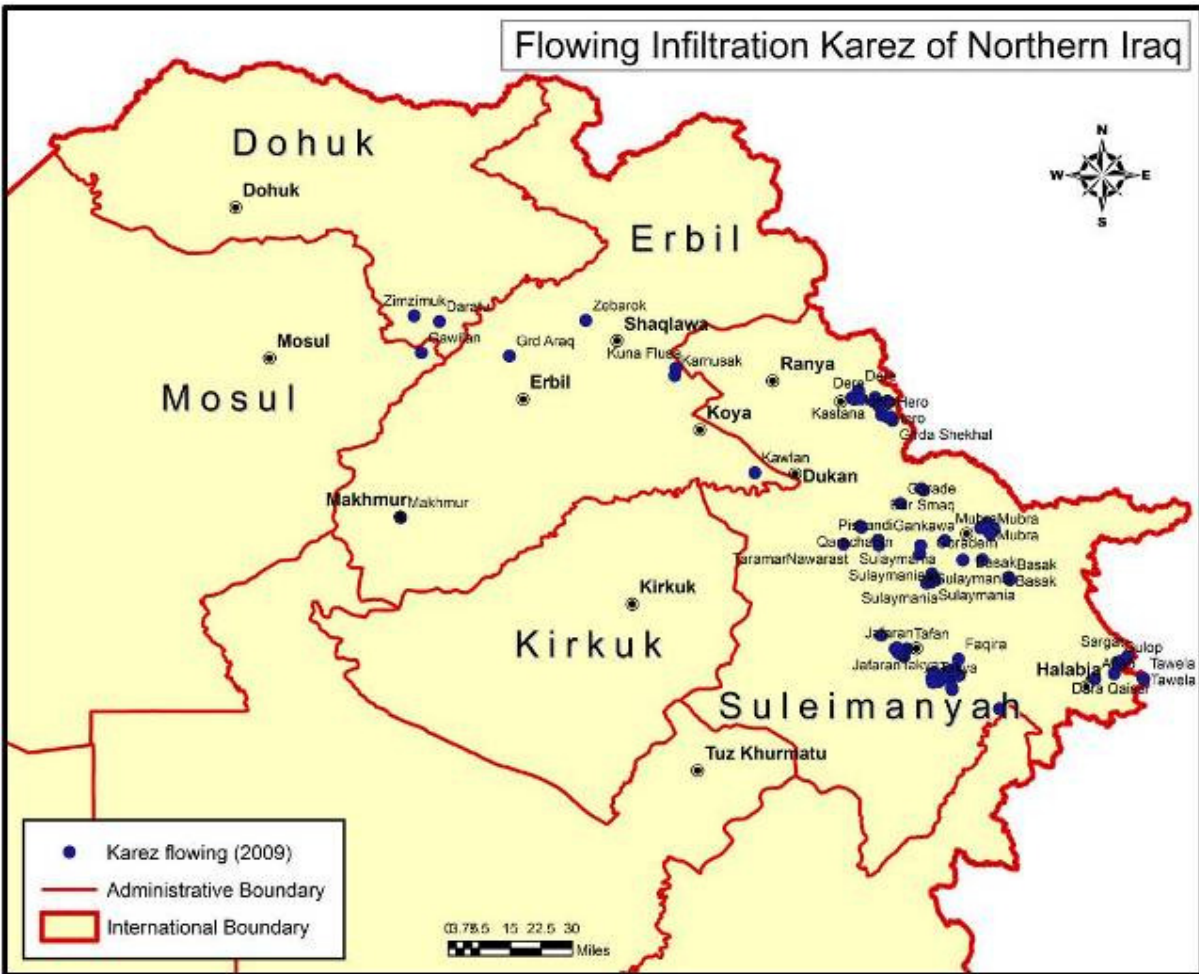


Figure 10. Karez that were still flowing in summer 2009.

The death and diminishing of so many karez since 2005 can be attributed to drought, but relaxed pumping regulations by the KRG beginning 2004 (a year before the onset of drought) has also contributed as the proliferation of pumped wells has drawn down the water table. Households near a karez tunnel sometimes draw water from one of the wells (Figure 11). This is more common where karez have begun to dry up; where wells retain water but little issues from the exit channel.



Figure 11. Household pumps drawing from the *manjal* well (last well before exit) of the Karamuchak karez. (Photo by Dale Lightfoot)

Responses to karez desiccation

Village committees and landowners once dependent on karez have exhibited a wide range of coping mechanisms and responses to karez death. In some cases, mechanized tube wells have been installed and have proved sufficient for irrigating all of their land and provisioning all household and mosque needs. In these cases, the villages or landowners seem not to miss the old karez and may have stopped using it, even if it continues to flow (e.g. at Zimzimuk). In most cases, local users express concern over the loss or impending death of their karez and employ a variety of stop-gap measures to deal with the crisis. Responses to the loss of irrigation water include irrigating less land, dry farming wheat on land formerly planted with higher value irrigated orchard crops and vegetables, and leaving some land unused. In more extreme cases, all land formerly irrigated with karez will be abandoned and unused, and drinking water (followed by ablution water) becomes the most pressing need. Responses to the loss of drinking and ablution water include switching to small wells or (if available) local spring sources, or petitioning the government to deliver water to the village by tanker truck (to supply house cisterns). Water delivery by truck is not a preferred or sustainable long-term solution.

In many cases, stop-gap measures have failed to supply the needs of everyone who used to live in a village and families have begun selling their livestock and moving away. In these cases, all or most land formerly irrigated sits unused, as daily survival and a focus on drinking water preoccupies activity and forces everyone who remains in the village to daily assess their options for staying or leaving.

9. Migration of communities dependent upon karez

Significantly, this survey has revealed a pattern of migration away from many villages that are still dependent on their karez, where families have made the painful decision to sell their livestock and leave their village for another location where water is not so scarce. Remaining families face the same decision every day as long as their karez remains dry or continues to dwindle. Some of these villages have arranged for stop-gap measures to keep the last few families from leaving the village; for example, relying on water trucks to deliver supplies to village cisterns, water gathering from nearby springs, or new wells that provide only drinking water while formerly irrigated lands that produced higher value crops are turned into lower value, rain-fed grain farms, or left unused and abandoned.

Population declines have averaged almost 70% among the villages adversely affected since drought and excessive pumping began drying up so many karez. Some villages have experienced no population loss since 2005, especially where pumped wells were already available for an alternate source of water. However, some of these villages report that people may soon begin moving away. Population loss in the most extreme cases has been 100% (vulnerable places that had very small populations and no other water options). Most communities have experienced a 50% to 90% loss as families sell their livestock and move to another village or to a city where there are family connections and water. In terms of real residents, this represents an average loss of 275 people per village in the places where karez have either stopped flowing or experienced reduced flow since 2005 (actual numbers vary with each village; this is an average for the villages that reported this information). There were 380 karez still flowing and used in 2004. Extrapolating these data for the whole of northern Iraq, it appears that more than 100,000 people—most of them in the eastern portion of northern Iraq (see Figure 9 and Appendix A)—have been forced to leave their homes as a result of karez loss.

In addition to the residents who have already moved, others remain in place and are on the verge of displacement. Many have reported that they assess the situation every day and talk about whether to stay or leave their village. The average number of residents that remain in villages “at risk” is 120 (the actual figures vary considerably; this is an average). The villages at risk include most—though not all—of the communities with actively flowing karez (a few karez remain healthy, and a handful of villages with flowing karez no longer rely on them). Communities at risk also include places where the karez have dried up within the past two to three years but they have been clinging to their place by drawing on other supplies of water in the area (e.g. a well, a local spring), or by accepting water delivered by trucks, generally supplied by the government. There are about 300 communities with flowing or recently dried karez that fit this characterization, which suggests a population of 36,000 at risk of displacement in the karez-dependent villages of northern Iraq.

But not every village and town in northern Iraq has a karez. Greater in number than the places with karez are the villages and towns that rely on natural springs, spring tunnels, surface cut spring channels, and pumped wells for their water needs. This survey did not account for these places. It can be assumed that the same desiccation of groundwater that has made karez-dependent communities vulnerable has also adversely affected other communities in the region. The total number of people already displaced, or at risk of displacement, can only be guessed. Interested agencies should target research to collect information from a large sample of villages in northern Iraq—and not just communities with karez—to better understand the magnitude and character of the drought-induced migration now underway.

A previous study of migration trends in the three northern governorates showed significant movement of internally displaced persons (IDPs) from the principal cities of each governorate (Dohuk, Erbil, and Sulaymaniyah) to home villages, or to communities other than places of origin (HIC 2003). The HIC graphic does not account for the movement away from villages. But movement away from villages is currently underway in northern Iraq, and this migration will continue until villages regain some control

over their water supplies and can again support their full compliment of families. The villages most at risk are small settlements where the lack of water has led to families selling their property and moving to other villages where they have extended families, where water is not so scarce or, usually, to nearby cities (e.g. Piskandi to Sulaymaniyah). This village-to-city migration is the reverse of movements depicted in the HIC study (2003).

Using information provided by this karez survey, the KRG, Government of Iraq, UNESCO and other interested organizations can target their drought mitigation efforts by intervening where karez death is real or imminent, in communities that are mostly or entirely dependent on one or more karez (Table 1). Recommendations have been made in this report to highlight the villages most at risk of losing population, and places where community development and intervention efforts are most likely to be successful at halting the most adverse effects of drought and over-pumping. However, before refurbishment is attempted at any recommended site, a hydrogeological survey is required to determine whether the tunnel needs to be repaired, and whether the aquifer may still be exploited by extending the tunnel deeper into the aquifer, or by adding another branch gallery to bring a moribund karez back to life and health.

	<u>Village Name</u>	<u>Governorate</u>	<u>District</u>	<u>Number of Karez</u>
1	Hanasura	Sulaymaniyah	Halabja	2
2	Saraw	Sulaymaniyah	Halabja	2
3	Chrustana	Sulaymaniyah	Halabja	1
4	Sitak-Pirmalak	Sulaymaniyah	Sharbazher	1
5	Barsmaq	Sulaymaniyah	Sharbazher	1
6	Gankawa	Sulaymaniyah	Sharbazher	3
7	Sewsenan	Sulaymaniyah	Sulaymaniyah	35
8	Hargena	Sulaymaniyah	Sulaymaniyah	3
	<u>Most Critical</u>			
9	Qasr Kharaba	Erbil	Koysinjaq	2
10	Kharaba	Erbil	Koysinjaq	3
11	Jelila	Sulaymaniyah	Halabja	1
12	Darakaisar	Sulaymaniyah	Halabja	3
13	Chinara Basak	Sulaymaniyah	Sharbazher	1
14	Kanipira	Sulaymaniyah	Sulaymaniyah	2
15	Piskandi	Sulaymaniyah	Sulaymaniyah	2
16	Chingyan-Awail	Sulaymaniyah	Sharbazher	1
17	Goradem	Sulaymaniyah	Sharbazher	22
18	Garade	Sulaymaniyah	Sharbazher	1
19	Jafaran	Sulaymaniyah	Sulaymaniyah	52
20	Tamar Nawarast	Sulaymaniyah	Sulaymaniyah	1
21	Kunafusa	Erbil	Shaqlaw	1
22	Shekh Mamudian	Erbil	Shaqlaw	1

10. Analysis

Complete record of infiltration karez

Early in this karez survey, before fieldwork began, we could account for about 80 karez using the lists provided by government ministries and UNESCO, together with a few karez recorded in academic sources collected prior to the survey. Most of these were confirmed in the field as infiltration karez. Research from historic cadastral maps revealed many additional karez sites, and many more were recovered through interviews/conversations with people in villages and towns. In the end, we recorded 683 infiltration karez. Using a combination of GPS, descriptive directions, and known village locations on a geo-referenced map, we mapped the locations of all of these infiltration karez in northern Iraq. Details at most karez sites were collected through interviews to learn specific facts about each karez (length, number of wells, geology, condition of the tunnel and outflow features, ownership, number of families supported, depth to water, and other details as available). Special attention was paid to whether the source of the “karez” was surface spring flow (not a karez) or subterranean infiltration from an aquifer (a karez), and whether the karez was still working or when the karez had been abandoned. The complete record of infiltration karez recorded by this study can be found in Appendix B.

Trends in karez health

Collecting these details for hundreds of karez revealed interesting trends in karez use and abandonment, most notably: (1) the impact that pumped wells have had on drawing down aquifers across northern Iraq, especially since 2004 when the KRG relaxed rules regulating the installation of new wells, and (2) the complimentary impact that drought has had since 2005 in desiccating aquifers, drying up 70% of the 380 karez that were still flowing in 2004, and diminishing the flow of the 116 karez that were still active in summer 2009.

Karez as early warning indicators

The loss of 70% of a country's active karez after four years of drought (combined with accelerated pumping here since 2004) demonstrates how karez can be used as barometers or early warning indicators of impending and serious groundwater problems (Lightfoot 2003). When so many karez die in such a concentrated area during such a short period of time, an unmistakable and alarming signal is being sent that the aquifers are being used unsustainably, and more serious problems lie ahead if current trends are not reversed. Beyond the general drying trend revealed by mapping karez losses, regional variations in groundwater loss (i.e. how far the water table has receded in a given region) can be revealed if additional detail on water table depths is elicited from people who use and maintain the karez. Interview-derived facts, if properly collected, can provide accurate data for groundwater mapping in places where monitoring wells do not exist, to reveal regional patterns that help water planners better target mitigation efforts (Lightfoot et al. 2009).

Cultural heritage

Beyond the immediate necessity of salvaging a few karez and stemming the tide of emigration, this survey provides a record of infiltration karez that helps to complete our knowledge of the diffusion and use of these systems. This information will be of great interest to scholars of water history and traditional resources, as well as those interested in contemporary conflicts between traditional and modern technology, and sustainable development. Therefore, this survey can be used to aid people currently living in drought-afflicted villages, while also contributing an important record for the cultural heritage of the region.

11. Recommendations

Recommendations for intervention

Villages recommended for community development and drought intervention efforts were selected from among all villages with functioning or recently-abandoned karez if they met the following criteria:

- (1) One or more karez that has been recently abandoned (since 2005), so the water table has not fallen so far that extending the channel or adding branch galleries would not likely produce results;
- (2) Tunnel and outflow area are in good condition and can be refurbished with minimal effort and expense;
- (3) Ownership of the karez and its water is clear and all in the settlement seem to know who (village committee, specific landowner or owners) have rights to the karez; and
- (4) There is a clear desire on the part of village inhabitants to refurbish the karez and, preferably, contribute labor and assistance for any cleaning efforts, provided that funding and tools (which they lack) are made available.

Preference is also given to karez owned by a village committee and/or privately-owned karez that would benefit a large number of families (ideally the entire village), and villages that are more vulnerable to population loss or other detrimental changes should their karez not be rejuvenated. Villages with karez that meet these criteria are listed in Table 2.

	<u>Village Name</u>	<u>Governorate</u>	<u>District</u>	<u>Number of Karez</u>
1	Gawilan	Dohuk	Akre	1
2	Daratu	Dohuk	Akre	1
3	Qarqur	Dohuk	Semel	1
4	Kasnazan	Erbil	Erbil	1
5	Pirash	Erbil	Erbil	1
6	Arabkand-Kasim Aga	Erbil	Erbil	1
7	Sardar-Haji Elias	Erbil	Erbil	1
8	Murtka	Erbil	Erbil	1
9	Grid Mala	Erbil	Erbil	1
10	Grid Araq	Erbil	Erbil	1
11	Harmota	Erbil	Koysinjaq	1
12	Kawlan-Chawlaw	Erbil	Koysinjaq	1
13	Qasr Kharaba	Erbil	Koysinjaq	2
14	Kharaba	Erbil	Koysinjaq	3
15	Zeborak	Erbil	Shaqlaw	1
16	Kunaflusa	Erbil	Shaqlaw	1
17	Shekh Mamudian	Erbil	Shaqlaw	1
18	Kichan	Sulaymaniyah	Chamchamal	1
19	Khurdalukisaru	Sulaymaniyah	Dukan	5
20	Qarachatan	Sulaymaniyah	Dukan	9
21	Qazan	Sulaymaniyah	Dukan	1
22	Pris	Sulaymaniyah	Halabja	1
23	Bakhakon	Sulaymaniyah	Halabja	1

24	Hanasura	Sulaymaniyah	Halabja	2
25	Saraw	Sulaymaniyah	Halabja	2
26	Chrustana	Sulaymaniyah	Halabja	1
27	Jelila	Sulaymaniyah	Halabja	1
28	Darakaisar	Sulaymaniyah	Halabja	3
29	Girdashekhal	Sulaymaniyah	Pishdar	4
30	Hero	Sulaymaniyah	Pishdar	3
31	Dere	Sulaymaniyah	Pishdar	3
32	Sitak-Pirmalak	Sulaymaniyah	Sharbazher	1
33	Barsmaq	Sulaymaniyah	Sharbazher	1
34	Gankawa	Sulaymaniyah	Sharbazher	3
35	Chinara Basak	Sulaymaniyah	Sharbazher	1
36	Chingyan-Awail	Sulaymaniyah	Sharbazher	1
37	Goradem	Sulaymaniyah	Sharbazher	22
38	Garade	Sulaymaniyah	Sharbazher	1
39	Kani Bardina	Sulaymaniyah	Sulaymaniyah	1
40	Faqira	Sulaymaniyah	Sulaymaniyah	2
41	Kulajo	Sulaymaniyah	Sulaymaniyah	1
42	Qamisham	Sulaymaniyah	Sulaymaniyah	1
43	Tafan	Sulaymaniyah	Sulaymaniyah	1
44	Timar	Sulaymaniyah	Sulaymaniyah	3
45	Sewsenan	Sulaymaniyah	Sulaymaniyah	35
46	Hargena	Sulaymaniyah	Sulaymaniyah	3
47	Kanipira	Sulaymaniyah	Sulaymaniyah	2
48	Piskandi	Sulaymaniyah	Sulaymaniyah	2
49	Jafaran	Sulaymaniyah	Sulaymaniyah	52
50	Taramar Nawarast	Sulaymaniyah	Sulaymaniyah	1

Special interest and assistance is urgently recommended for villages wholly dependent on karez that have recently experienced the demise or dwindling of their sole water source. These worst cases, where out-migration is imminent or now underway, are highlighted in Table 1 in Chapter 9.

Refurbishment methods

Before beginning the planned karez refurbishment phase of this program, UNESCO must decide how they wish to pursue karez repairs, and to what ends. A key issue that must be addressed early is whether (1) karez are an important water resource that must be revived using any method possible, even if the excavation work destroys the original tunnel, or (2) karez are important historical features, in addition to key water sources, and their historical configuration must be preserved. It is possible (and preferable) to refurbish karez without employing the method of digging up karez and replacing the tunnel with a concrete channel. Karez can be refurbished using traditional methods employed for centuries by moghannis and wastas (although updated using newer casing materials); methods that preserve the historic integrity of the karez while also leaving the tunnel as a “living” and adaptable structure that can be subsequently modified to respond to future changes in the water table or other needs. A tunnel replaced by a cut-and-cover, form-poured, reinforced concrete channel may prevent tunnel collapse now, but is rigid and cannot be modified in the future without digging up the whole structure and starting over with another channel. This might be recommended, in a few cases, where recent government efforts to refurbish a karez, using a trenched, reinforced concrete tunnel, so altered the original channel flow that the karez died as a result of the refurbishment attempt.

Almost 20 karez visited during fieldwork have been refurbished this way—excavating the tunnel and replacing it with a concrete channel—by the KRG or Government of Iraq (Figures 12 and 13).

Some of these projects have been successful and have revived the karez, most notably in Sulaymaniyah and several villages east of Halabja. An equal number of refurbishment attempts have irreparably damaged and killed karez in northern Iraq (e.g. Chalaw karez at Kawlan, Kanipira karez at Kanipira, Chalakon karez at Kani Bardina, Kani Mala karez at Kani Goran, Karezi Seri at Timar, and Kani Tu karez at Qazan). The lack of success noted at these places is not only the result of altered tunnel gradients, but because most of the unsuccessful projects replaced only a section of carrier tunnel and did not touch the *tayan* section of the karez (the first or infiltration section, near the mother well) or attempt to extend a channel into the aquifer to enhance water flow.



Figure 12. Doundar karez under refurbishment by the KRG Ministry of Agriculture in July 2009. (Photo by Dale Lightfoot)

(A)



(B)



Figure 13(A): Lower section of Barzawan Saru karez at Sewsenan, excavated by Irrigation and Surface Water Directorate of Sulaymaniyah. The upper section of this karez was refurbished the traditional way using wastas who cleaned and reinforced the wells and tunnel (completed July 2009).

Figure 13(B): Traditional well casing and tunnel are visible in this excavated cross section of the Barzawan Saru karez at Sewsenan. (Photos by Dale Lightfoot)

Respecting the social contract

Karez are a part of the culture, history, and life of the villages that rely on them. People in the village must be consulted for opinions and ideas regarding refurbishment, to be certain of local support and assistance with projects. The ministries and international organizations that work on these projects should be mindful that karez refurbishment is for the village and villagers. Karez refurbishments engineered by the KRG and GOI have sometimes been dictated to villagers without village input and, in some cases, without village support. In a few cases (not pictured in photos), informants report that arguments took place between government engineers and village residents regarding how best to refurbish the karez. For example, residents pointed out that the karez slope was not right, or the channel was too high, or the channel was being altered in ways that would not allow the water to flow as it once did. In some cases, refurbishments have improved karez flow. In some cases the village residents were right to oppose the engineer's decisions. In the few cases where government karez refurbishment damaged a karez, and led to abandonment of the karez, hard feelings remain among village residents. Though they are not technically-trained engineers, local residents know their karez. It is best to consult with a village committee, and arrive at a mutually-agreeable work plan that involves village residents, when designing a karez refurbishment project (Wessels 2008).

12. Caveats of the survey

One potential barrier to the reception of this study lies in the definition of “karez.” The survey has accounted for only the infiltration karez in northern Iraq, while local residents and various ministries will assume “karez” to mean all spring, seep, channeled and otherwise non-pumped traditional sources of water. Another limitation was the lack of material evidence or archaeological reports for karez in the region, which made difficult the task of building a case for historical connections and the diffusion of karez. The dearth of academic literature in any language on the subject was also a challenge; one that could be accommodated only by generalizing the history of karez in northern Iraq.

Another shortcoming is an artifact of the number of karez encountered in the Sulaymaniyah governorate during a fieldwork season that was long, but not unlimited. We were able to visit all of the karez in the Dohuk and Erbil governorates (except for those recorded on historic cadastral maps whose visible trace on the ground and remembered trace in living history are both now gone). However, with so many karez in the Sulaymaniyah governorate, and insufficient time (and budget) to visit each of them, only the most basic details could be obtained for many karez in this region (e.g. confirmation of infiltration karez, whether it was flowing or dried, and the year that karez use ended (if dried)). These and many other details were often obtained from the same expert informants who accompanied us to the karez we visited. In villages with 10, 16, 22, 27, 35, or 52 karez (to use a few real examples) we would typically visit three or four karez around the village while collecting GPS data, detailed information and stories, and then sit with a local landowner family, a village mukhtar, or an expert wasta from the area and gather additional details on nearby karez through interviews, phone interviews, village records, or district office records. It is possible that a few karez were missed; that with more fieldworkers, more time, and a greater budget a few more karez might still be found. Even if more could be found, however, the general trends and important findings of this report would not be changed. The sampling process employed during this survey was very thorough and (we believe) accounted for every infiltration karez in northern Iraq, even if the details collected on each karez varied from extensive to basic. No shortcuts were taken that would degrade the accuracy of reported information, and any shortcomings are acts of omission and not commission.

Acknowledgements

UNESCO-Iraq Natural Sciences Officer Casey Walther, and Dina Al-Dabbagh, Science and Culture Program Assistant, were very helpful in providing descriptions and photos of known karez sites in northern Iraq. They also ensured that we had a letter of introduction, a sound fieldwork plan, and ensured timely disbursements to keep the work flowing. Casey was the driving force behind this karez survey, offered all of the support needed to get the work done, and expertly crafted survey results into the next phase of karez rehabilitation and community development.

In-country hosting, letters of introduction, and other fieldwork assistance were cordially arranged by Dr. Govand Sherwani, General Director of the KRG Ministry of Higher Education, and Dr. Beriwan Khailany, Deputy Minister of Higher Education for the KRG Ministry of Higher Education. This project was hosted and directly supported by Dr. Idris Hadi, the KRG Minister of Higher Education. Dr. Idris personally arranged for our fieldwork vehicle, provided a driver and security guard, regularly monitored our progress and security, and arranged for local hosts in distant regions to assist our efforts. The success of this project can be directly attributed to this magnanimous Minister.

Existing karez data were made available from Mohammed Amin Faris, UNESCO partner and General Director of the KRG Surface Water and Irrigation Directorate (Ministry of Water) in Erbil, and from his staff at the Irrigation and Surface Water Directorate in Sulaymaniyah. These helpful collaborators provided karez lists and offered guidance for fieldwork. Kanan Mufti, General Director of the KRG Ministry of Culture, provided helpful information on the history of karez in Iraq and arranged for staff at the Ministry of Antiquities and Museum of Erbil to provide access to cadastral maps and personnel support during this important phase of our work. The staff at the Ministry of Agriculture office in Sulaymaniyah, likewise, provided help with historic cadastral maps and other fieldwork assistance in that region.

The General Manager for the Directorate of Agriculture in Qaradagh (Sulaymaniyah district) provided details for the many karez in his district and assistance contacting many other knowledgeable individuals in surrounding villages. Ms. Niaz, Municipality of Sulaymaniyah, provided expert guidance during our survey of the karez in Sulaymaniyah city. Dr. Polla Khanaqa, Kurdistan Technology and Research Centres, hosted our visit to the Sulaymaniyah region and graciously assisted with fieldwork in the Barzinja-Chwarta area.

Reber Hussein Ahmed (from the Ministry of Higher Education) officially served a security role for the project but often made first contact with village participants and greatly aided daily fieldwork and logistics. Bestun Hussein Aula (also with the Ministry of Higher Education) was the skilled driver of our fieldwork vehicle and a valued member of the research team.

I especially wish to thank Abdulkareem Hawta Al-Khayyat (Salahaddin University and Oklahoma State University) for his tireless work and companionship during the long hours and many weeks of fieldwork and GIS database assembly. Hawta played a key role in arranging all meetings with ministry personnel and served as the Fieldwork Coordinator. The success of this project is largely due to his keen organizational talents, interviewing skills, and his knack for navigating through unusual situations.

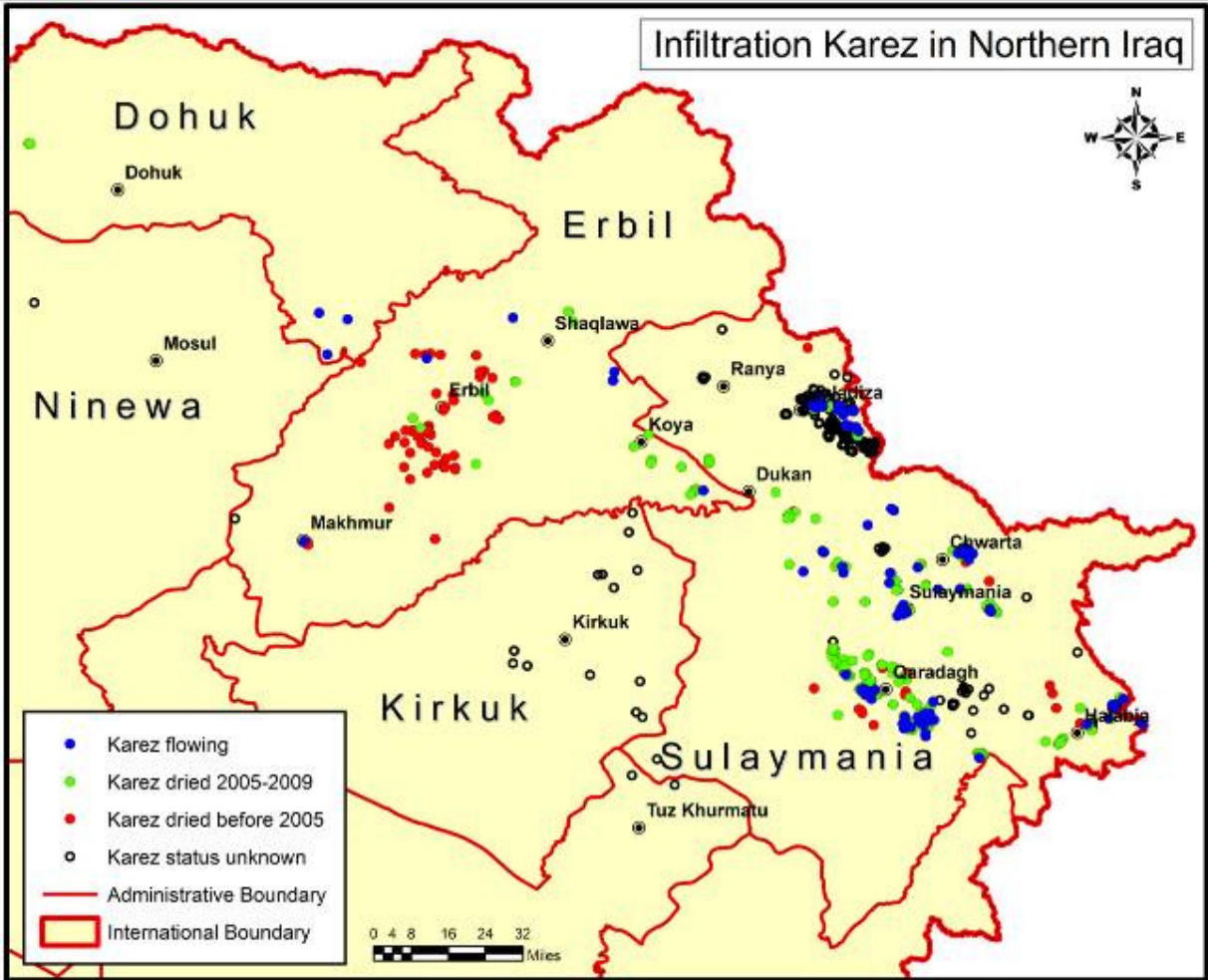
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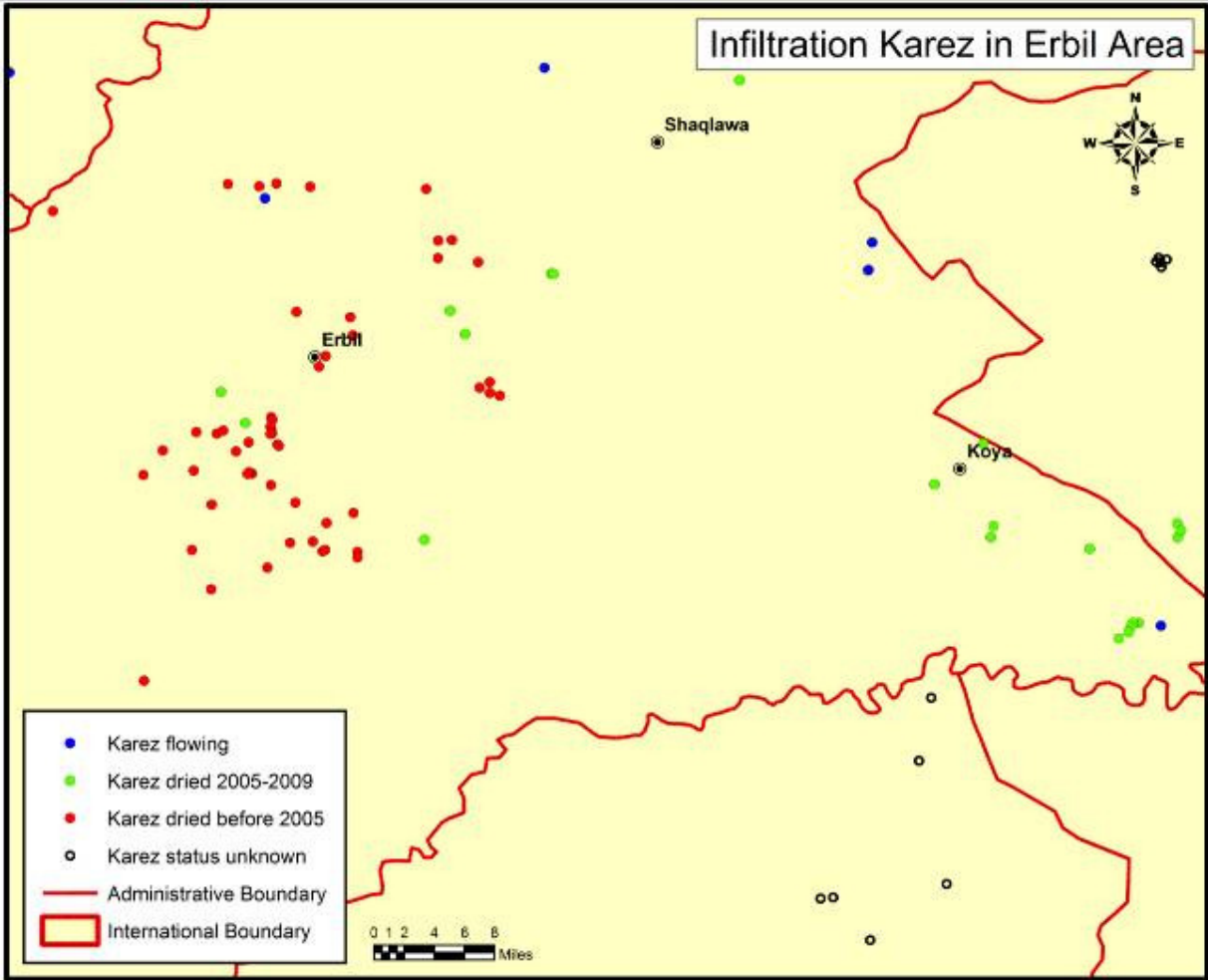
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Appendix A: Status of karez (flowing vs non-flowing)

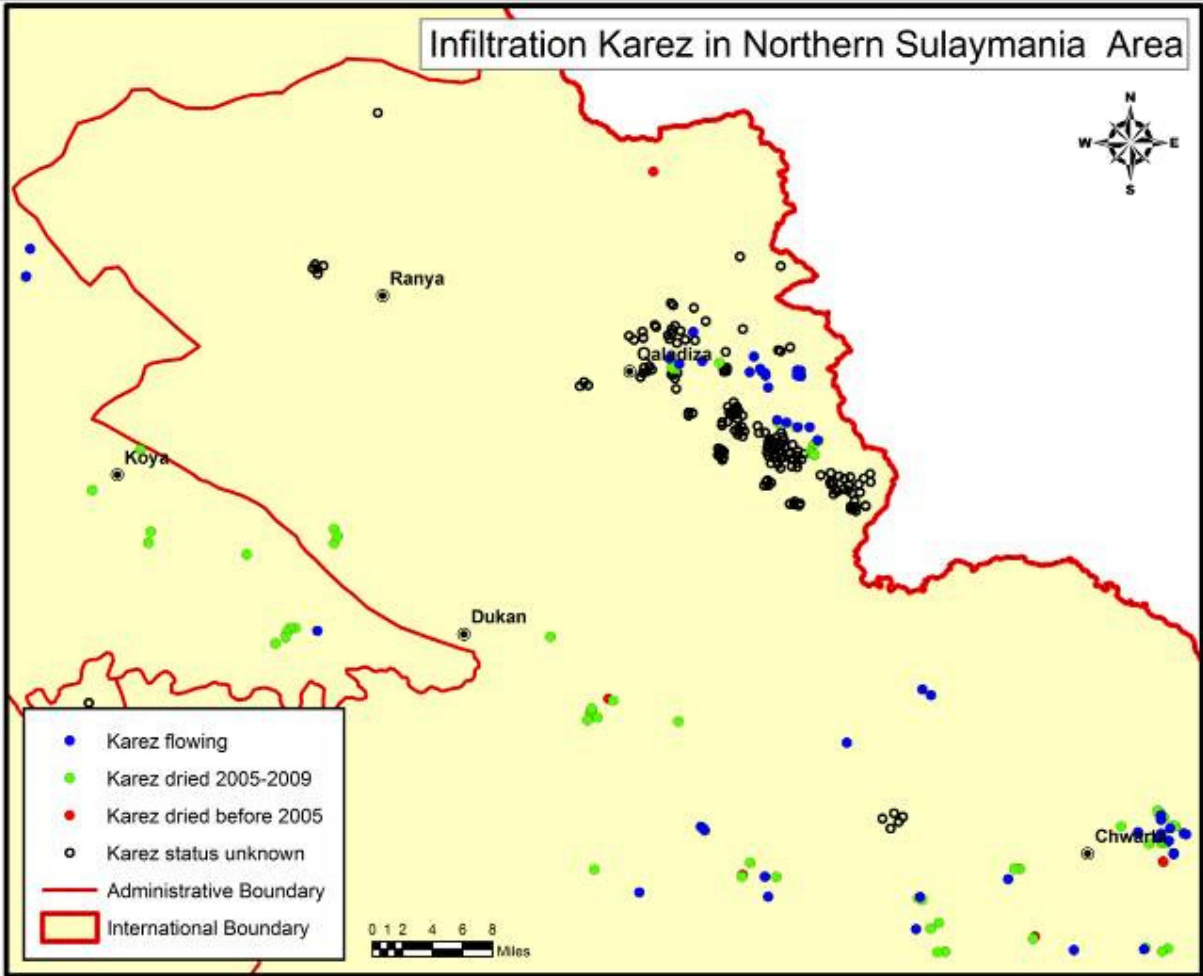
Map A.1. Status of infiltration karez in northern Iraq



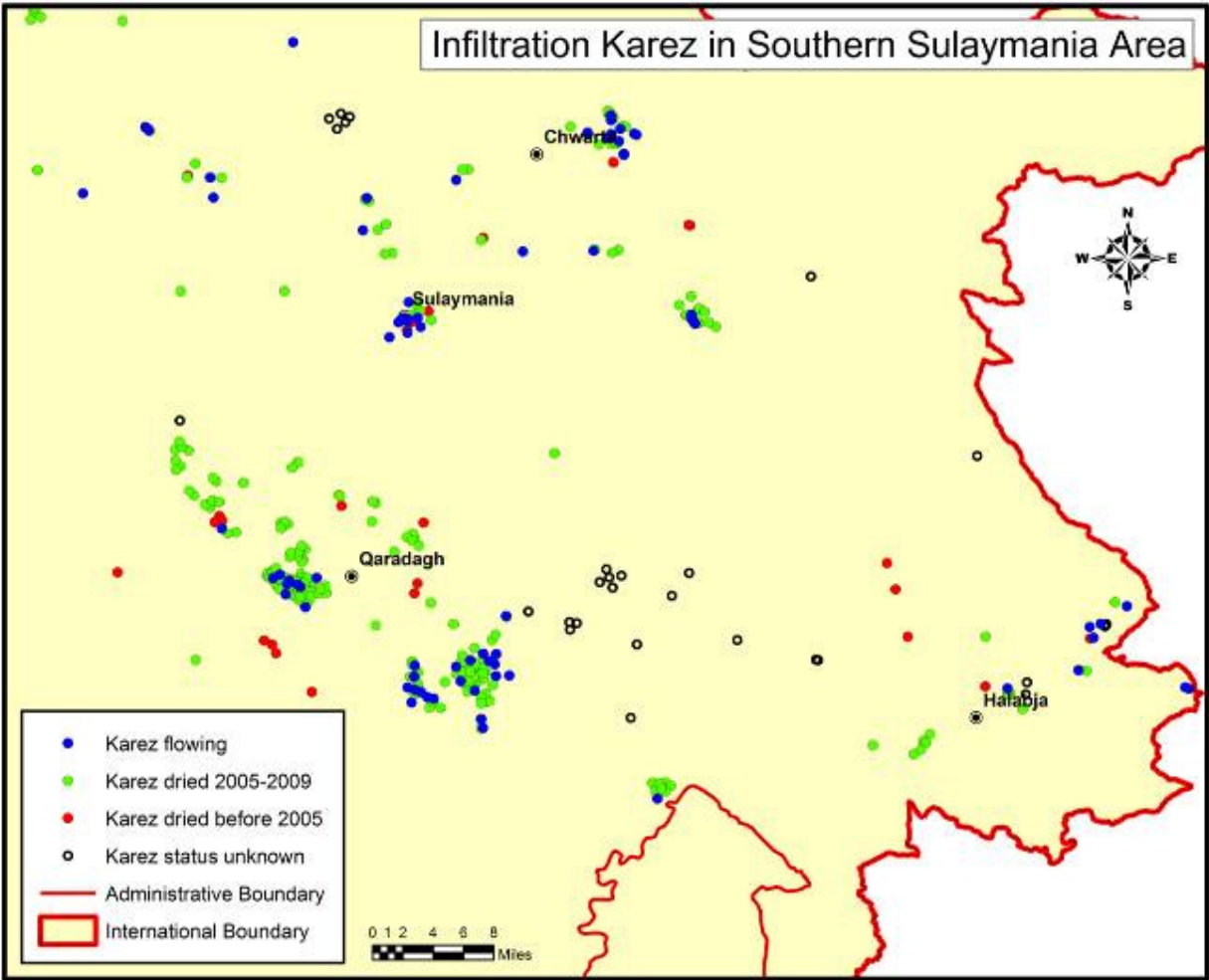
Map A.2. Status of infiltration karez near Erbil



Map A.3. Status of infiltration karez in northern Sulaymania Governorate



Map A.4. Status of infiltration karez in southern Sulaymania Governorate



Appendix B: List of infiltration karez in northern Iraq (status and location)

	Governorate	District	Village	Karez Name	Status ¹	Dried ²	Latitude ³	Longitude ³
1	Dohok	Akre	Daratu	Daratu	Flowing		36.463667	43.715115
2	Dohok	Akre	Gawilan	Gawilan	Flowing		36.354131	43.651597
3	Dohok	Akre	Zimzimuk	Kuna Zimzim	Flowing		36.483863	43.626084
4	Dohok	Semel	Balqusi Sare	Balqus	Dried	2005	37.008742	42.728762
5	Dohok	Semel	Qarqur	Qarqur	Dried	2008	37.009703	42.721612
6	Erbil	Ankawa	Ankawa	Ankawa	Dried		36.233547	43.991343
7	Erbil	Banslaw	Banslaw	Banslaw	Dried	1999	36.09573	44.10373
8	Erbil	Banslaw	Banslaw	Mala Fandi	Dried	1996	36.09198	44.10303
9	Erbil	Banslaw	Punginah	Punginah	Dried		36.09106	44.11126
10	Erbil	Erbil	Agholan	Mandaris	Dried			
11	Erbil	Erbil	Arabkand	Kasim Aga	Dried	2007	36.09234	43.5506
12	Erbil	Erbil	Arabkand	Shekhzada	Dried	1990	36.07002	43.57597
13	Erbil	Erbil	Bagluminara	Assad Afandi	Dried		36.132517	43.966787
14	Erbil	Erbil	Baglunimara	Baglunimara	Dried		36.130052	43.967929
15	Erbil	Erbil	Banslaw	Khauni Baba	Dried		36.160332	44.167458
16	Erbil	Erbil	Baqirta	Baqirta	Dried	1986	35.966613	43.909145
17	Erbil	Erbil	Bastora	Qullan	Dried	1900	36.35168	44.115753
18	Erbil	Erbil	Berkot	Dawood Aga	Dried		36.228414	44.0431
19	Erbil	Erbil	Beryat	Sofi Aga	Dried		36.099097	43.933141
20	Erbil	Erbil	Braim Lak	Braim Lak	Dried	1990	36.030472	44.020223
21	Erbil	Erbil	Chiman	Said Hasan	Dried			
22	Erbil	Erbil	Daldagan	Shahab	Dried	1990	36.06172	43.582689
23	Erbil	Erbil	Daldagan	Ibrahim Afandi	Dried	1990	36.07095	43.55142
24	Erbil	Erbil	Duztappa	Duztappa	Dried		36.100177	43.862728
25	Erbil	Erbil	Erbil	Juja Mohmed	Dried	1960		
26	Erbil	Erbil	Erbil	Miri	Dried	1960	36.180797	44.013053
27	Erbil	Erbil	Erbil	Koja Mohamed	Dried			
28	Erbil	Erbil	Gird Achal	Girdachal	Dried		36.356513	43.925203
29	Erbil	Erbil	Gird Araq	Gird Araq	Flowing		36.34274	43.960867
30	Erbil	Erbil	Gird Mala	Gird Mala	Dried	2005	36.0142	44.114189
31	Erbil	Erbil	Gird Mala	Mahmood Kakakhan	Dried		36.002456	44.049918
32	Erbil	Erbil	Gird Mala	Qushtapai Sulayman	Dried		35.997218	44.049797
33	Erbil	Erbil	Golak Gichka	Zamzamin	Dried	1986	36.281353	44.165919
34	Erbil	Erbil	Gozka	Merkhuzar	Dried		36.011026	43.984831
35	Erbil	Erbil	Hanara	Kani Rash	Dried	2008	36.270201	44.23666
36	Erbil	Erbil	Hanara	Hawar Senchar	Dried	2008	36.270056	44.238368
37	Erbil	Erbil	Haza	Kadim	Dried		36.117781	43.894801
38	Erbil	Erbil	Jazhnikan	Ababakir	Dried	1993	36.353831	44.00454
39	Erbil	Erbil	Jazhnikan	Maulud Aga	Dried		36.357026	43.97202
40	Erbil	Erbil	Jazhnikan Afandi	Hasan Aga	Dried	1930	36.354115	43.955379
41	Erbil	Erbil	Kasnazan	Kasnazan	Dried	2007	36.12442	44.0913
42	Erbil	Erbil	Kasnazan	Punginah	Dried			
43	Erbil	Erbil	Kunaqir	Kunaqir	Dried	1700	36.048108	43.909777
44	Erbil	Erbil	Mala Omar	Mala Omar	Dried	1979		
45	Erbil	Erbil	Mala Omar	Haji Kadir	Dried	1979		
46	Erbil	Erbil	Mala Omar	Mandaris	Dried			
47	Erbil	Erbil	Murtka	Murtka	Dried	2000	36.040107	44.046203
48	Erbil	Erbil	Mza Ahmed	Mam Rash	Dried	1940	36.062878	43.56426
49	Erbil	Erbil	Pirash	Pirash	Dried	2007	36.1405	44.08253
50	Erbil	Erbil	Plinga	Plinga	Dried	1986	36.008749	43.975091
51	Erbil	Erbil	Qatawi	Qatawi	Dried		36.117301	43.967283
52	Erbil	Erbil	Qatawi	Bastan	Dried		36.116265	43.966247
53	Erbil	Erbil	Qoritan	Surezh	Dried	1989	36.062213	43.582198
54	Erbil	Erbil	Qoritan	Mohamed Amin	Dried		36.079308	43.945431
55	Erbil	Erbil	Qoritan	Haji Hidayat	Dried		36.077863	43.944215
56	Erbil	Erbil	Qucha Bilbas	Glah	Dried		36.050285	43.990278
57	Erbil	Erbil	Qushtapai Gawra	Gawra	Dried	2000	36.003073	44.016462
58	Erbil	Erbil	Qushtapai Gawra	Gichka	Dried	1970	36.004432	44.018855

59	Erbil	Erbil	Qushtapai Gichka	Qushtapai Gichka	Dried	1940	36.012462	44.007079
60	Erbil	Erbil	Sardar	Maitar	Dried	1996	36.06591	43.54523
61	Erbil	Erbil	Sardar	Haji Elias	Dried	2006	36.073549	43.56307
62	Erbil	Erbil	Sardar	Hler	Dried	1996	36.04401	43.565389
63	Erbil	Erbil	Sardar	Sardar	Dried	2003	36.07219	43.57132
64	Erbil	Erbil	Sherawa	Qoritan	Dried		36.066862	43.966638
65	Erbil	Erbil	Surezha	Surezha	Dried		36.004442	43.890457
66	Erbil	Erbil	Tandura	Mustafa Amin	Dried			
67	Erbil	Erbil	Timar Gawra	Beryat	Dried		36.123099	43.965576
68	Erbil	Erbil	Turaq	Alwand	Dried	1970	36.071441	43.58011
69	Erbil	Erbil	Turaq	Haji	Dried	1983	36.06599	43.58029
70	Erbil	Koysinjaq	Dundar	Dundar	Dried	2009	36.005427	44.75411
71	Erbil	Koysinjaq	Haibat Sultan	Zaytun	Dried	2007	36.106794	44.651756
72	Erbil	Koysinjaq	Harmota	Harmota	Dried	2007	36.067692	44.604954
73	Erbil	Koysinjaq	Kawlan	Shewe Sawaran	Flowing		35.931527	44.822644
74	Erbil	Koysinjaq	Kharaba	Salhashen	Dried	2007	35.930171	44.793087
75	Erbil	Koysinjaq	Kharaba	Twarash	Dried	2006	35.925374	44.791679
76	Erbil	Koysinjaq	Kharaba	Karezi Gawra	Dried	2006	35.919477	44.782056
77	Erbil	Koysinjaq	Qasr Kharaba	Saleh Aga	Dried	2007	35.934262	44.801344
78	Erbil	Koysinjaq	Qasr Kharaba	Kani Mallan	Dried	2007	35.934315	44.795928
79	Erbil	Koysinjaq	Shawjer	Shawaga	Dried	2005	36.027286	44.661662
80	Erbil	Koysinjaq	Shawjer	Naw Mallan	Dried	2007	36.01659	44.659293
81	Erbil	Makhmur	Makhmur	Haji Saleh	Dried			
82	Erbil	Makhmur	Makhmur	Khasraw Aga	Dried			
83	Erbil	Makhmur	Makhmur	Garabish	Dried			
84	Erbil	Makhmur	Makhmur	Darmanawa	Flowing			
85	Erbil	Makhmur	Saidawa	Saidawa	Undetermined			
86	Erbil	Makhmur	Sarbashakh	Sarbashakh	Dried			
87	Erbil	Shaqqlawa	Kamusak	Sulak	Dried	2008	36.273148	44.54073
88	Erbil	Shaqqlawa	Kamusak	Kamusak	Flowing		36.273977	44.541221
89	Erbil	Shaqqlawa	Kuna Flusa	Kuna Flusa	Flowing		36.300224	44.544992
90	Erbil	Shaqqlawa	Shekh Mamudian	Shekh Mamudian	Dried	2009	36.456276	44.417366
91	Erbil	Shaqqlawa	Zebarok	Zebarok	Flowing		36.468105	44.22966
92	Sulaymania	Chamchamal	Garachya	Garachya	Dried			
93	Sulaymania	Chamchamal	Khairi (Khidr)	Shekh Ismaili	Dried	1970		
94	Sulaymania	Chamchamal	Kichan	Kichan	Dried	2007		
95	Sulaymania	Chamchamal	Qalqanlu	Qalqanlu	Undetermined			
96	Sulaymania	Chamchamal	Zhala	Kani Shanass	Dried	1996		
97	Sulaymania	Chamchamal	Zhala	Zhala Saru	Dried	1997		
98	Sulaymania	Chamchamal	Zhala	Khuarui De	Dried	1997		
99	Sulaymania	Darbandikan	Awakala	Ahmed Qazi	Undetermined			
100	Sulaymania	Darbandikan	Bisalmen	Pri Mahmud	Undetermined			
101	Sulaymania	Darbandikan	Bisalmen	Karezi Kon	Undetermined			
102	Sulaymania	Darbandikan	Chukh	Kni Gird Quchka	Undetermined			
103	Sulaymania	Darbandikan	Daq	Kani Wais	Undetermined			
104	Sulaymania	Darbandikan	Darbandikhan	Sartak	Dried	2007		
105	Sulaymania	Darbandikan	Darbandikhan	Kuerak	Dried	2007		
106	Sulaymania	Darbandikan	Darbandikhan	Garmik	Dried	2007		
107	Sulaymania	Darbandikan	Darbandikhan	Saraw	Dried	2007		
108	Sulaymania	Darbandikan	Darbandikhan	Banibe	Dried	2007		
109	Sulaymania	Darbandikan	Darbandikhan	Bani Khelan	Dried	2007		
110	Sulaymania	Darbandikan	Darbandikhan	Nawtaq	Dried	2007		
111	Sulaymania	Darbandikan	Darbandikhan	Chamarga	Flowing			
112	Sulaymania	Darbandikan	Diskara	Khalifa	Undetermined			
113	Sulaymania	Darbandikan	Diskara	Girdamalan	Undetermined			
114	Sulaymania	Darbandikan	Diskara	Shekh	Undetermined			
115	Sulaymania	Darbandikan	Diskara	Chamejulana	Undetermined			
116	Sulaymania	Darbandikan	Diskara	Balol	Undetermined			
117	Sulaymania	Darbandikan	Nawtaq	Karezi Boqa	Undetermined			
118	Sulaymania	Darbandikan	Setalan	Abdulrahim	Undetermined			
119	Sulaymania	Darbandikan	Setalan	Qabristan	Undetermined			
120	Sulaymania	Darbandikan	Setalan	Salih Omer	Undetermined			

121	Sulaymania	Darbandikan	Yakhshi	Mohammed Abdulkadin	Undetermined			
122	Sulaymania	Darbandikan	Zala Rash	Kani Bawa	Undetermined			
123	Sulaymania	Dukan	Khalakan	Bar Mizgawta	Dried	2005	36.01628	44.838658
124	Sulaymania	Dukan	Khalakan	Kola Khalakan	Dried	2008	36.02998	44.838664
125	Sulaymania	Dukan	Khalakan	Kani Twan	Dried	2007	36.022812	44.842046
126	Sulaymania	Dukan	Khurdaluk Saru	Kani Girdal	Dried	2008	35.853064	45.08642
127	Sulaymania	Dukan	Khurdaluk Saru	Halima Kuer	Dried	2009	35.853833	45.087502
128	Sulaymania	Dukan	Khurdaluk Saru	Sare	Dried	2007	35.856349	45.087507
129	Sulaymania	Dukan	Khurdaluk Saru	Hawzi Piawan	Dried	2007	35.848139	45.093174
130	Sulaymania	Dukan	Khurdaluk Saru	Berdiwaxhan	Dried	2007	35.845264	45.083557
131	Sulaymania	Dukan	Qalam Pasha	Nawde	Dried	2006	35.925472	45.048018
132	Sulaymania	Dukan	Qarachatan	Nawde	Flowing		35.742666	45.193011
133	Sulaymania	Dukan	Qarachatan	Kani Piawan	Flowing		35.742641	45.193018
134	Sulaymania	Dukan	Qarachatan	Kani Jinan	Flowing			
135	Sulaymania	Dukan	Qarachatan	Haji Wasman	Dried	2009		
136	Sulaymania	Dukan	Qarachatan	Haji Karim	Flowing			
137	Sulaymania	Dukan	Qarachatan	Hama Qarchawsh	Flowing			
138	Sulaymania	Dukan	Qarachatan	Hama Qadir	Dried	2009		
139	Sulaymania	Dukan	Qarachatan	Kani Drezh	Dried	2007		
140	Sulaymania	Dukan	Qarachatan	Kani Plusk	Flowing			
141	Sulaymania	Dukan	Qazan	Kani Tu	Dried	2007	35.701482	45.090187
142	Sulaymania	Dukan	Sargalo	Sargalo	Dried	2006	35.844252	45.171437
143	Sulaymania	Dukan	Surdash	Surdash-1	Dried	2006	35.864133	45.108157
144	Sulaymania	Dukan	Surdash	Surdash-2	Dried	1991	35.866038	45.103898
145	Sulaymania	Halabja	Anab	Pirajine	Flowing		35.205697	46.016105
146	Sulaymania	Halabja	Anab	Kani Bag	Dried	2005		
147	Sulaymania	Halabja	Anab	Mawre	Dried	2008		
148	Sulaymania	Halabja	Bakhakon	Bakhakon	Flowing		35.26743	46.104954
149	Sulaymania	Halabja	Bakhakon	Bakhakon-2	Undetermined			
150	Sulaymania	Halabja	Bakhakon	Bakhakon-3	Undetermined			
151	Sulaymania	Halabja	Bani Bnok	Bani Bnok	Undetermined		35.428158	45.987221
152	Sulaymania	Halabja	Chrustana	Chrustana	Dried	2006		
153	Sulaymania	Halabja	Dara Qaisar	Chawana	Dried	2006	35.2231	46.083882
154	Sulaymania	Halabja	Dara Qaisar	Asnaward	Flowing		35.223091	46.0839
155	Sulaymania	Halabja	Dara Qaisar	Hanatudman	Dried	2009	35.222376	46.091498
156	Sulaymania	Halabja	Darashish Khuaru	Darashish	Undetermined		35.200349	46.033126
157	Sulaymania	Halabja	Darashish Saru	Darashish	Undetermined		35.211642	46.034636
158	Sulaymania	Halabja	Dolash	Dolash	Dried		35.300349	45.909409
159	Sulaymania	Halabja	Dwanza Imam	Qularash Haji Salah	Dried	1996		
160	Sulaymania	Halabja	Gulop	Gulop	Flowing		35.264406	46.094843
161	Sulaymania	Halabja	Gulop	Faqe Rostam	Flowing			
162	Sulaymania	Halabja	Gulop	Hanawaka	Dried	1988		
163	Sulaymania	Halabja	Hanasura	Hawt Kani	Dried	2005		
164	Sulaymania	Halabja	Hanasura	Kani Haml	Dried	2006		
165	Sulaymania	Halabja	Jallila	Dekon	Dried	2007	35.185989	46.030626
166	Sulaymania	Halabja	Jallila	Jallila	Dried	2009	35.200684	46.018851
167	Sulaymania	Halabja	Nawgirdan	Hajisalah	Dried		35.325716	45.901086
168	Sulaymania	Halabja	Piris	Piris	Dried	2006	35.161876	45.942054
169	Sulaymania	Halabja	Saraw	Saruchawga	Dried	2005		
170	Sulaymania	Halabja	Saraw	Qulqula	Dried	2006		
171	Sulaymania	Halabja	Sargat	Tayar	Dried	2008		
172	Sulaymania	Halabja	Sargat	Hana Totmani Zhurwe	Flowing			
173	Sulaymania	Halabja	Tapakura	Tapakura	Dried	2007	35.255179	45.995213
174	Sulaymania	Halabja	Tawela	Awesar	Flowing			
175	Sulaymania	Halabja	Tawela	Hanadiwa	Flowing			
176	Sulaymania	Halabja	Zamaq	Zamaq	Dried	1987	35.207847	45.995128
177	Sulaymania	Pishdar	Ahmadan	Kanyasara	Undetermined			
178	Sulaymania	Pishdar	Ahmadan	Kokhasee	Undetermined			
179	Sulaymania	Pishdar	Ahmadan	Kunre	Undetermined			
180	Sulaymania	Pishdar	Ahmadan	Tuisari	Undetermined			
181	Sulaymania	Pishdar	Ahmadan	Jgaspi	Undetermined			
182	Sulaymania	Pishdar	Ahmadan	Ahmanda	Undetermined			

183	Sulaymania	Pishdar	Ahmadan	Kokhelka	Undetermined
184	Sulaymania	Pishdar	Ahmadan	Mergan	Undetermined
185	Sulaymania	Pishdar	Ahmadan	Molan	Undetermined
186	Sulaymania	Pishdar	Ahmadan	Khre	Undetermined
187	Sulaymania	Pishdar	Alan	Qabrawme	Undetermined
188	Sulaymania	Pishdar	Alan	Khlake	Undetermined
189	Sulaymania	Pishdar	Alan	Haji Mina	Undetermined
190	Sulaymania	Pishdar	Alan	Khre	Undetermined
191	Sulaymania	Pishdar	Alan	Said Ahmadan	Undetermined
192	Sulaymania	Pishdar	Alan	Newamande	Undetermined
193	Sulaymania	Pishdar	Alan	Alke	Undetermined
194	Sulaymania	Pishdar	Alan	Mama Skekha	Undetermined
195	Sulaymania	Pishdar	Ashkane	Mere	Undetermined
196	Sulaymania	Pishdar	Ashkane	Fqeyan	Undetermined
197	Sulaymania	Pishdar	Ashkane	Korakhani	Undetermined
198	Sulaymania	Pishdar	Ashkane	Kalazhe	Undetermined
199	Sulaymania	Pishdar	Ashkane	Hanjiroke	Undetermined
200	Sulaymania	Pishdar	Ashkane	Babakre	Undetermined
201	Sulaymania	Pishdar	Ashkane	Mam Khadre	Undetermined
202	Sulaymania	Pishdar	Ashkane	Badar	Undetermined
203	Sulaymania	Pishdar	Ashkane	Dol Mishkan	Undetermined
204	Sulaymania	Pishdar	Ashkane	Zalan	Undetermined
205	Sulaymania	Pishdar	Ashkane	Twa Rashe	Undetermined
206	Sulaymania	Pishdar	Ashkane	Kani Dro	Undetermined
207	Sulaymania	Pishdar	Ashkane	Gorke	Undetermined
208	Sulaymania	Pishdar	Awaka	New Chalan	Undetermined
209	Sulaymania	Pishdar	Awaka	Pisht Malan	Undetermined
210	Sulaymania	Pishdar	Awaka	Twagaya	Undetermined
211	Sulaymania	Pishdar	Awaka	Gawra	Undetermined
212	Sulaymania	Pishdar	Awaka	Aga Li	Undetermined
213	Sulaymania	Pishdar	Awaka	Mihraban	Undetermined
214	Sulaymania	Pishdar	Awaka	Sargrde	Undetermined
215	Sulaymania	Pishdar	Awaka	Bere	Undetermined
216	Sulaymania	Pishdar	Awaka	Faqe Shekhe	Undetermined
217	Sulaymania	Pishdar	Awaka	Berkalki	Undetermined
218	Sulaymania	Pishdar	Awaka	Palesine	Undetermined
219	Sulaymania	Pishdar	Awaka	Khregojar	Undetermined
220	Sulaymania	Pishdar	Awaka	Qaplana	Undetermined
221	Sulaymania	Pishdar	Awaka	Qamishoke	Undetermined
222	Sulaymania	Pishdar	Awaka	Zarawe	Undetermined
223	Sulaymania	Pishdar	Awaka	Palkana	Undetermined
224	Sulaymania	Pishdar	Awaka	Ala Surkan	Undetermined
225	Sulaymania	Pishdar	Awaka	Falaqe	Undetermined
226	Sulaymania	Pishdar	Awaka	Salena	Undetermined
227	Sulaymania	Pishdar	Awaka	Newraze	Undetermined
228	Sulaymania	Pishdar	Awaka	Bawa Watman	Undetermined
229	Sulaymania	Pishdar	Awaka	Bezwe	Undetermined
230	Sulaymania	Pishdar	Awaka	Abbassi	Undetermined
231	Sulaymania	Pishdar	Awaka	Pashqabran	Undetermined
232	Sulaymania	Pishdar	Awaka	Mergasere	Undetermined
233	Sulaymania	Pishdar	Awaka	Tusapan	Undetermined
234	Sulaymania	Pishdar	Awaka	Khredure	Undetermined
235	Sulaymania	Pishdar	Badaliyan	Salim Aga	Undetermined
236	Sulaymania	Pishdar	Badawan	Khre	Undetermined
237	Sulaymania	Pishdar	Badawan	Razaweshkan	Undetermined
238	Sulaymania	Pishdar	Badin	Pisht Malan	Undetermined
239	Sulaymania	Pishdar	Badin	Mamand Aga	Undetermined
240	Sulaymania	Pishdar	Badin	Zaragul	Undetermined
241	Sulaymania	Pishdar	Bard Bard	Karezi Gawra	Undetermined
242	Sulaymania	Pishdar	Bard Bard	Mahomood Aga	Undetermined
243	Sulaymania	Pishdar	Bard Bard	Bare Merge	Undetermined
244	Sulaymania	Pishdar	Bawze	Darushe	Undetermined

245	Sulaymania	Pishdar	Bawze	Mergi Badine	Undetermined			
246	Sulaymania	Pishdar	Beklo Seru	Haji Khedir	Flowing			
247	Sulaymania	Pishdar	Beklo Seru	Gazoi	Flowing			
248	Sulaymania	Pishdar	Beklo Seru	Pash Kulawi	Flowing			
249	Sulaymania	Pishdar	Beklo Seru	Haji Marif	Flowing			
250	Sulaymania	Pishdar	Beklo Seru	Rasha Harne	Flowing			
251	Sulaymania	Pishdar	Beklo Seru	Aulla Shekhan	Flowing			
252	Sulaymania	Pishdar	Bemush	Awlai Ahmed Aga	Undetermined			
253	Sulaymania	Pishdar	Bemush	Faqe Ahmed	Undetermined			
254	Sulaymania	Pishdar	Bemush	Ismail Jhangir Aga	Undetermined			
255	Sulaymania	Pishdar	Besher	Merga Talar	Undetermined			
256	Sulaymania	Pishdar	Besher	Guman	Undetermined			
257	Sulaymania	Pishdar	Besher	Turish	Undetermined			
258	Sulaymania	Pishdar	Besher	Ismail Aga	Undetermined			
259	Sulaymania	Pishdar	Besher	Qalatka	Undetermined			
260	Sulaymania	Pishdar	Besher	Haji Aga	Undetermined			
261	Sulaymania	Pishdar	Besher	Baryana	Undetermined			
262	Sulaymania	Pishdar	Besher	Agaii	Undetermined			
263	Sulaymania	Pishdar	Besher	Garshotan	Undetermined			
264	Sulaymania	Pishdar	Besher	Chnare	Undetermined			
265	Sulaymania	Pishdar	Chakwan	Khalane	Undetermined			
266	Sulaymania	Pishdar	Chakwan	Mreshki Newde	Undetermined			
267	Sulaymania	Pishdar	Darshmana	Kulmarif	Flowing	36.18155	45.240272	
268	Sulaymania	Pishdar	Darshmana	Muchaka Drwena	Flowing	36.166748	45.258007	
269	Sulaymania	Pishdar	Darshmana	Dali Mallan	Flowing	36.178271	45.255487	
270	Sulaymania	Pishdar	Darshmana	Kani Kawa	Flowing	36.182352	45.251826	
271	Sulaymania	Pishdar	Darshmana	Shekh Junaied	Flowing	36.184813	45.250265	
272	Sulaymania	Pishdar	Darshmana	Berbil	Flowing	36.196336	45.244203	
273	Sulaymania	Pishdar	Darshmana	Bari Breme	Flowing	36.180311	45.255187	
274	Sulaymania	Pishdar	Darwena	Goran	Undetermined			
275	Sulaymania	Pishdar	Darwena	Wasta Hamad	Undetermined			
276	Sulaymania	Pishdar	Darwena	Shakran	Undetermined			
277	Sulaymania	Pishdar	Darwena	Golkazia	Undetermined			
278	Sulaymania	Pishdar	Darwena	Bardi Karezan	Undetermined			
279	Sulaymania	Pishdar	Darwena	Rash Hanjera	Undetermined			
280	Sulaymania	Pishdar	Darwena	Qulashare	Undetermined			
281	Sulaymania	Pishdar	Dashtiw Saru	Braim Aga	Undetermined			
282	Sulaymania	Pishdar	Dashtiw Saru	Misumer Aga	Undetermined			
283	Sulaymania	Pishdar	Dashtiw Saru	Khadre Gulawe	Undetermined			
284	Sulaymania	Pishdar	Dashtiw Saru	Khandaki	Undetermined			
285	Sulaymania	Pishdar	Dashtiw Saru	Bre Qurawe	Undetermined			
286	Sulaymania	Pishdar	Dashtiw Saru	Pala Mkane	Undetermined			
287	Sulaymania	Pishdar	Dashtiw Saru	Bakhchoke	Undetermined			
288	Sulaymania	Pishdar	Dashtiw Saru	Hama Aga	Undetermined			
289	Sulaymania	Pishdar	Dashtiw Saru	Duriene	Undetermined			
290	Sulaymania	Pishdar	Dashtiw Saru	Gloze	Undetermined			
291	Sulaymania	Pishdar	Dashtiw Saru	Zhazhoke	Undetermined			
292	Sulaymania	Pishdar	Dawzhan	Dawzhan	Undetermined			
293	Sulaymania	Pishdar	Dawzhan	Sar Qadagha	Undetermined			
294	Sulaymania	Pishdar	Dere	Omer Aga	Dried	2005	36.194301	45.162898
295	Sulaymania	Pishdar	Dere	Omer Aga	Flowing		36.194909	45.162748
296	Sulaymania	Pishdar	Dere	Ibrahim Aga	Flowing		36.220492	45.185818
297	Sulaymania	Pishdar	Doladza	Babakir Aga	Dried	2006	36.190533	45.211117
298	Sulaymania	Pishdar	Dolle	Karez Hama Amin	Undetermined			
299	Sulaymania	Pishdar	Girda Shekhal	Khre Chnarau	Dried	2005	36.115267	45.30657
300	Sulaymania	Pishdar	Girda Shekhal	Sarsula	Dried	2008	36.11121	45.301989
301	Sulaymania	Pishdar	Girda Shekhal	Kani Baroz	Flowing		36.115781	45.305581
302	Sulaymania	Pishdar	Girda Shekhal	Dashta Zeneya	Dried	2005	36.105191	45.298799
303	Sulaymania	Pishdar	Girda Shekhal	Girdi Benas	Dried	2005	36.10281	45.300357
304	Sulaymania	Pishdar	Girda Shekhal	Kaina Sar	Dried	2005	36.101345	45.302371
305	Sulaymania	Pishdar	Girdaspyan	Babakir Aga	Undetermined			
306	Sulaymania	Pishdar	Goshgosh	Mama Babakir Ibrahim	Flowing		36.189456	45.172351

307	Sulaymania	Pishdar	Grid Maitar	Ahmed Aga	Dried	2006	36.184534	45.168081
308	Sulaymania	Pishdar	Grid Maitar	Husain Aga	Dried	2005	36.185587	45.164851
309	Sulaymania	Pishdar	Gulan	Palibilare	Undetermined			
310	Sulaymania	Pishdar	Gwaran	Bardas	Undetermined			
311	Sulaymania	Pishdar	Gwaran	Hama Aga	Undetermined			
312	Sulaymania	Pishdar	Gwaran	Khdir Sware	Undetermined			
313	Sulaymania	Pishdar	Gwaran	Mewa rash	Undetermined			
314	Sulaymania	Pishdar	Gwaran	Titka	Undetermined			
315	Sulaymania	Pishdar	Gwezela	Gund	Undetermined			
316	Sulaymania	Pishdar	Gwezela	Pasha	Undetermined			
317	Sulaymania	Pishdar	Gwezela	Mamand Aga	Undetermined			
318	Sulaymania	Pishdar	Hasar	Mam Audel	Undetermined			
319	Sulaymania	Pishdar	Hasar	Saruchawa	Undetermined			
320	Sulaymania	Pishdar	Hasar	Haji Watman	Undetermined			
321	Sulaymania	Pishdar	Hasar	Razuke	Undetermined			
322	Sulaymania	Pishdar	Hasar	Bayze	Undetermined			
323	Sulaymania	Pishdar	Hasar	Khulena	Undetermined			
324	Sulaymania	Pishdar	Hero	Mala Hamed	Dried	2005	36.128107	45.285325
325	Sulaymania	Pishdar	Hero	Bez hale	Flowing		36.128487	45.286816
326	Sulaymania	Pishdar	Hero	Beghlid	Flowing		36.128582	45.298022
327	Sulaymania	Pishdar	Hero	Doli Zherwan	Flowing		36.132723	45.275928
328	Sulaymania	Pishdar	Hurewa	Qatqa	Undetermined			
329	Sulaymania	Pishdar	Hurewa	Lase	Undetermined			
330	Sulaymania	Pishdar	Hurewa	Betool	Undetermined			
331	Sulaymania	Pishdar	Hurewa	Watmana Rash	Undetermined			
332	Sulaymania	Pishdar	Isawe	Aziz Aga	Undetermined			
333	Sulaymania	Pishdar	Isawe	Surawke	Undetermined			
334	Sulaymania	Pishdar	Isawe	Kani Jinda	Undetermined			
335	Sulaymania	Pishdar	Kastana	Nawde	Flowing		36.192257	45.194612
336	Sulaymania	Pishdar	Kastana	Watman Aga	Flowing		36.192113	45.194375
337	Sulaymania	Pishdar	Kolara	Chkola	Undetermined			
338	Sulaymania	Pishdar	Kolara	Jnan	Undetermined			
339	Sulaymania	Pishdar	Kolara	Faqeyan	Undetermined			
340	Sulaymania	Pishdar	Kolara	Hanjere	Undetermined			
341	Sulaymania	Pishdar	Kolara	Mam Khale	Undetermined			
342	Sulaymania	Pishdar	Kushqala	Twa Rash	Undetermined			
343	Sulaymania	Pishdar	Kushqala	Pawani	Undetermined			
344	Sulaymania	Pishdar	Kushqala	Binawati	Undetermined			
345	Sulaymania	Pishdar	Kushqala	Khalmirani	Undetermined			
346	Sulaymania	Pishdar	Lawzha	Haji Ghafor	Undetermined			
347	Sulaymania	Pishdar	Mirra	Tese	Undetermined			
348	Sulaymania	Pishdar	Mirra	Plinga Shekha	Undetermined			
349	Sulaymania	Pishdar	Mirra	Khrebnawetesal	Undetermined			
350	Sulaymania	Pishdar	Nise	Sulawkan	Undetermined			
351	Sulaymania	Pishdar	Nise	Sindole Barozh	Undetermined			
352	Sulaymania	Pishdar	Nise	Bnawile	Undetermined			
353	Sulaymania	Pishdar	Norista	Haji Shakhsha	Undetermined			
354	Sulaymania	Pishdar	Norista	Kuekha Sulayman	Undetermined			
355	Sulaymania	Pishdar	Razan	Dolabi	Undetermined			
356	Sulaymania	Pishdar	Razan	Qalatan	Undetermined			
357	Sulaymania	Pishdar	Razan	Jawan	Undetermined			
358	Sulaymania	Pishdar	Razan	Mergan	Undetermined			
359	Sulaymania	Pishdar	Razan	Guezan	Undetermined			
360	Sulaymania	Pishdar	Razan	Gundi	Undetermined			
361	Sulaymania	Pishdar	Razga	Razga	Dried	1980	36.374799	45.147074
362	Sulaymania	Pishdar	Said Ahmadan	Watman Aga	Undetermined			
363	Sulaymania	Pishdar	Said Ahmadan	Bard Qalat	Undetermined			
364	Sulaymania	Pishdar	Sarshe	Kania Khorani	Undetermined			
365	Sulaymania	Pishdar	Sarshe	Kani Badar	Undetermined			
366	Sulaymania	Pishdar	Sarshe	Gwezamiram	Undetermined			
367	Sulaymania	Pishdar	Sawrta	Sawrta	Undetermined			
368	Sulaymania	Pishdar	Shene	Spidare	Undetermined			

369	Sulaymania	Pishdar	Shlamra	Bardarkan	Undetermined			
370	Sulaymania	Pishdar	Shoran	Sarkestan	Undetermined			
371	Sulaymania	Pishdar	Sune	Basan	Undetermined			
372	Sulaymania	Pishdar	Tangzha	Mushawe	Undetermined			
373	Sulaymania	Pishdar	Umar Kako	Zawyanbare	Undetermined			
374	Sulaymania	Pishdar	Waswena	Lasoka	Dried	2009	36.132789	45.266955
375	Sulaymania	Pishdar	Waswena	Sewatala	Flowing		36.135185	45.266686
376	Sulaymania	Ranya	Sarkapkan	Khaja Kar	Undetermined			
377	Sulaymania	Ranya	Sarkapkan	Qaqian Piawan	Undetermined			
378	Sulaymania	Ranya	Sarkapkan	Mewa	Undetermined			
379	Sulaymania	Ranya	Sarkapkan	Khara Kurda	Undetermined			
380	Sulaymania	Ranya	Sarkapkan	Rasu Haji Saqawan	Undetermined			
381	Sulaymania	Sharbazher	Bar Smaq	Bar Smaq	Flowing		35.869567	45.415376
382	Sulaymania	Sharbazher	Bar Smaq	Rash Hermi	Flowing		35.874887	45.407388
383	Sulaymania	Sharbazher	Basak	Lamalan	Flowing		35.55915	45.714485
384	Sulaymania	Sharbazher	Basak	Shekh Garib	Flowing		35.562893	45.71431
385	Sulaymania	Sharbazher	Basak	Nawde	Flowing		35.554526	45.717873
386	Sulaymania	Sharbazher	Basak	Knai Mam Essa	Dried	2007	35.563468	45.714472
387	Sulaymania	Sharbazher	Basak	Najmaddin	Dried	2007	35.566233	45.719188
388	Sulaymania	Sharbazher	Basak	Kani Said Ali	Dried	2007	35.569523	45.721751
389	Sulaymania	Sharbazher	Basak	Kani Bogana	Dried	2007	35.580725	45.713973
390	Sulaymania	Sharbazher	Basak	Kani Bnaw	Dried	2007	35.562852	45.708794
391	Sulaymania	Sharbazher	Basak	Knai Pungala	Dried	2007	35.563348	45.709909
392	Sulaymania	Sharbazher	Basak	Shekh Kader	Dried	2007	35.572518	45.702845
393	Sulaymania	Sharbazher	Basak	Awaie	Dried	2007	35.555603	45.716848
394	Sulaymania	Sharbazher	Basak	Kani Arif	Dried	2007	35.56025	45.716601
395	Sulaymania	Sharbazher	Basak	Rushala	Dried	2007	35.555479	45.722177
396	Sulaymania	Sharbazher	Basak	Kani Hanar	Dried	2007	35.555045	45.720008
397	Sulaymania	Sharbazher	Basak	Ladar	Dried	2007	35.555913	45.730914
398	Sulaymania	Sharbazher	Basak	Chaletwan	Dried	2007	35.565888	45.727196
399	Sulaymania	Sharbazher	Byane	Kani Piawan	Dried	2008		
400	Sulaymania	Sharbazher	Byane	Kani Jinan	Dried	2008		
401	Sulaymania	Sharbazher	Byane	Kani Dega	Dried	2008		
402	Sulaymania	Sharbazher	Chingyan	Awaii	Flowing		35.624351	45.621102
403	Sulaymania	Sharbazher	Chingyan	Mala Sadik	Dried	2008	35.625755	45.62226
404	Sulaymania	Sharbazher	Chingyan	Mala Husain	Dried	2008	35.62557	45.622667
405	Sulaymania	Sharbazher	Chingyan	Bayan	Dried	2007	35.625115	45.644327
406	Sulaymania	Sharbazher	Chingyan	Saranj	Dried	2008	35.623027	45.638643
407	Sulaymania	Sharbazher	Chnara Basak	Chnara Basak	Dried	2009	35.551544	45.737917
408	Sulaymania	Sharbazher	Dolpamu	Kani Rostam	Dried			
409	Sulaymania	Sharbazher	Dolpamu	Kani Bi	Dried			
410	Sulaymania	Sharbazher	Gankawa	Kani Piawan	Dried	2009	35.701975	45.501164
411	Sulaymania	Sharbazher	Gankawa	Kani Qulamanga	Flowing		35.692308	45.489789
412	Sulaymania	Sharbazher	Gankawa	Kani Gwez	Dried	2006	35.701632	45.495705
413	Sulaymania	Sharbazher	Garade	Garade	Flowing		35.823681	45.333959
414	Sulaymania	Sharbazher	Goradem	Hawzi Mizgawt	Flowing		35.735497	45.637361
415	Sulaymania	Sharbazher	Goradem	Zale-1	Flowing		35.749621	45.637154
416	Sulaymania	Sharbazher	Goradem	Zale-2	Dried	2009	35.750705	45.640168
417	Sulaymania	Sharbazher	Goradem	Zale-3	Dried	2009	35.753242	45.639114
418	Sulaymania	Sharbazher	Goradem	Zale-4	Flowing		35.754171	45.637453
419	Sulaymania	Sharbazher	Goradem	Zale-5	Dried	2008	35.754848	45.63534
420	Sulaymania	Sharbazher	Goradem	Zale-6	Dried	2009	35.756762	45.63627
421	Sulaymania	Sharbazher	Goradem	Zale-7	Dried	2009	35.758688	45.634211
422	Sulaymania	Sharbazher	Goradem	Darbarro	Flowing		35.732716	45.635527
423	Sulaymania	Sharbazher	Goradem	Swerwan-1	Flowing		35.735809	45.615732
424	Sulaymania	Sharbazher	Goradem	Goija Parwawe	Flowing		35.737632	45.6154
425	Sulaymania	Sharbazher	Goradem	Bakhcha	Flowing		35.735592	45.637498
426	Sulaymania	Sharbazher	Goradem	Bermalan	Flowing		35.728685	45.645273
427	Sulaymania	Sharbazher	Goradem	Swerwan-2	Dried	2009	35.736083	45.614384
428	Sulaymania	Sharbazher	Goradem	Qula Bandan	Dried	2008	35.726281	45.625959
429	Sulaymania	Sharbazher	Goradem	Wasman Bag	Dried	2008	35.726962	45.637677
430	Sulaymania	Sharbazher	Goradem	Nelle	Flowing		35.741149	45.646272

431	Sulaymania	Sharbazher	Goradem	Sarmergan-1	Dried	2008	35.743235	45.64811
432	Sulaymania	Sharbazher	Goradem	Sarmergan-2	Dried	2008	35.74285	45.651447
433	Sulaymania	Sharbazher	Goradem	Palke Kuaru	Flowing		35.736221	45.65951
434	Sulaymania	Sharbazher	Goradem	Palke Saru	Flowing		35.735557	45.66187
435	Sulaymania	Sharbazher	Goradem	Kani Jinan	Flowing		35.735779	45.637499
436	Sulaymania	Sharbazher	Kani Shekhan	Shekh Babatahir	Flowing		35.623572	45.553336
437	Sulaymania	Sharbazher	Mubra	Hawzi Piawan	Flowing			
438	Sulaymania	Sharbazher	Mubra	Hawzi Jinan	Flowing			
439	Sulaymania	Sharbazher	Mubra	Haji Abdul	Flowing			
440	Sulaymania	Sharbazher	Plinga	Kani Lolo	Dried			
441	Sulaymania	Sharbazher	Plinga	Debaran	Dried			
442	Sulaymania	Sharbazher	Sarkan	Sarkan	Undetermined			
443	Sulaymania	Sharbazher	Sarsir	Sarsir	Dried	2007	35.743073	45.598985
444	Sulaymania	Sharbazher	Sitak	Pirmalak	Dried	2009	35.634706	45.513678
445	Sulaymania	Sharbazher	Sitak	Kani Awber	Dried		35.636699	45.51567
446	Sulaymania	Sulaymania	Arbat	Arbat	Dried	2008	35.430666	45.583679
447	Sulaymania	Sulaymania	Bakhan	Bakhan	Dried	2005	35.36542	45.409449
448	Sulaymania	Sulaymania	Balakjar	Balakjar	Dried	2009		
449	Sulaymania	Sulaymania	Balakjar	Hanadomar	Flowing			
450	Sulaymania	Sulaymania	Balakjar	Mizra	Flowing			
451	Sulaymania	Sulaymania	Balakjar	Kunagurg	Dried	2007		
452	Sulaymania	Sulaymania	Balakjar	Hara Syawe	Dried	2007		
453	Sulaymania	Sulaymania	Balkha	Kula Gurzaie	Dried	2009	35.167679	45.513517
454	Sulaymania	Sulaymania	Balkha	Zriskan	Flowing		35.168002	45.515421
455	Sulaymania	Sulaymania	Balkha	Bakhi Husain	Dried	2008	35.176566	45.513045
456	Sulaymania	Sulaymania	Balkha	Bakhi Habib	Flowing		35.176244	45.514201
457	Sulaymania	Sulaymania	Bawamrda	Bawamrda	Dried	2007	35.585735	45.325786
458	Sulaymania	Sulaymania	Chawlik	Mala Aziz	Dried	2008		
459	Sulaymania	Sulaymania	Daraban	Saru	Dried	2008	35.622254	45.42903
460	Sulaymania	Sulaymania	Daraban	Nawarast	Dried	2008	35.621483	45.421673
461	Sulaymania	Sulaymania	Daratu Mawlana	Daratu Mawlana	Flowing		35.675142	45.257953
462	Sulaymania	Sulaymania	Darawyan	Laghmaka	Dried	2009		
463	Sulaymania	Sulaymania	Darawyan	Hanjira	Dried	2009		
464	Sulaymania	Sulaymania	Darawyan	Shatuaka	Dried	2009		
465	Sulaymania	Sulaymania	Darawyan	Bardaqule	Dried	2009		
466	Sulaymania	Sulaymania	Darawyan	Dewana	Dried	2009		
467	Sulaymania	Sulaymania	Darawyan	Merkhuzar	Dried	2009		
468	Sulaymania	Sulaymania	Darawyan	Kaka Maud	Dried	2009		
469	Sulaymania	Sulaymania	Darawyan	Kani Sard	Dried	2009		
470	Sulaymania	Sulaymania	Dariziyayin	Shekh Omer	Dried	2002	35.306019	45.452826
471	Sulaymania	Sulaymania	Dariziyayin	Mira	Dried	2002		
472	Sulaymania	Sulaymania	Dariziyayin	Kunaqir	Dried	2008		
473	Sulaymania	Sulaymania	Dariziyayin	Faraj	Dried	2008		
474	Sulaymania	Sulaymania	Dariziyayin	Ahmed Mustafa	Dried	2005		
475	Sulaymania	Sulaymania	Dolan Saru	Qaya	Dried	2008		
476	Sulaymania	Sulaymania	Dolan Saru	Bnawa Rash	Dried	2009		
477	Sulaymania	Sulaymania	Dolan Saru	Dolana Qul	Dried	2008		
478	Sulaymania	Sulaymania	Dolan Saru	Mekaiel Pash	Dried	2008		
479	Sulaymania	Sulaymania	Faqira	Kani Kuerka	Flowing			
480	Sulaymania	Sulaymania	Faqira	Karezi Gawra	Dried	2007		
481	Sulaymania	Sulaymania	Gomata	Karezi Saru	Dried	2009		
482	Sulaymania	Sulaymania	Gomata	Khuaru	Dried	2009		
483	Sulaymania	Sulaymania	Gomata	Jinan	Dried	2009		
484	Sulaymania	Sulaymania	Gomata	Mizgawt	Dried	2009		
485	Sulaymania	Sulaymania	Gomata	Merquli	Dried	2009		
486	Sulaymania	Sulaymania	Gomata	Bakha Bichkola	Dried	2009		
487	Sulaymania	Sulaymania	Gurbaz	Mergapan	Dried	2006		
488	Sulaymania	Sulaymania	Gurbaz	Jalakan	Dried	2006		
489	Sulaymania	Sulaymania	Gurbaz	Mala Hama Amin	Dried	2006		
490	Sulaymania	Sulaymania	Gurbaz	Musa	Dried	2008		
491	Sulaymania	Sulaymania	Haldara	Kani Khubi	Dried	2008		
492	Sulaymania	Sulaymania	Haldara	Rostam Bag	Dried	2008		

493	Sulaymania	Sulaymania	Hargena	Kani Jinan	Dried	2006	35.422072	45.338728
494	Sulaymania	Sulaymania	Hargena	Kani Piawan	Dried	2007	35.422106	45.339356
495	Sulaymania	Sulaymania	Hargena	Gund	Dried	2007	35.417063	45.333286
496	Sulaymania	Sulaymania	Jafaran	Sarpati-1	Dried	2007	35.303618	45.350816
497	Sulaymania	Sulaymania	Jafaran	Kani Bi-1	Dried	2008	35.315231	45.341656
498	Sulaymania	Sulaymania	Jafaran	Hama Saleh Hama Ali	Dried	2009		
499	Sulaymania	Sulaymania	Jafaran	Bakhi Khuaya	Dried	2009		
500	Sulaymania	Sulaymania	Jafaran	Hamza	Dried	2009		
501	Sulaymania	Sulaymania	Jafaran	Kani Bi-2	Dried	2009		
502	Sulaymania	Sulaymania	Jafaran	Sarpati-2	Dried	2009		
503	Sulaymania	Sulaymania	Jafaran	Gwejawlu-1	Flowing			
504	Sulaymania	Sulaymania	Jafaran	Guryan	Dried	2009		
505	Sulaymania	Sulaymania	Jafaran	Ashaka	Dried	2009		
506	Sulaymania	Sulaymania	Jafaran	Gwejawlu-2	Flowing			
507	Sulaymania	Sulaymania	Jafaran	Drozna	Flowing			
508	Sulaymania	Sulaymania	Jafaran	Mama Toufiq	Dried	2009		
509	Sulaymania	Sulaymania	Jafaran	Shala	Dried	2009		
510	Sulaymania	Sulaymania	Jafaran	Hama Karim	Dried	2009		
511	Sulaymania	Sulaymania	Jafaran	Haji Jafa	Dried	2009		
512	Sulaymania	Sulaymania	Jafaran	Hamadmin Gawan-1	Dried	2009		
513	Sulaymania	Sulaymania	Jafaran	Hamadmin Gawan-2	Dried	2009		
514	Sulaymania	Sulaymania	Jafaran	Kani Zard	Dried	2009		
515	Sulaymania	Sulaymania	Jafaran	Haji Namiq	Dried	2009		
516	Sulaymania	Sulaymania	Jafaran	Abbas	Dried	2009		
517	Sulaymania	Sulaymania	Jafaran	Hama Amin Malarahim	Dried	2009		
518	Sulaymania	Sulaymania	Jafaran	Basti-1	Dried	2009		
519	Sulaymania	Sulaymania	Jafaran	Basti-2	Dried	2009		
520	Sulaymania	Sulaymania	Jafaran	Hama Hasan	Dried	2009		
521	Sulaymania	Sulaymania	Jafaran	Kawla Kon	Dried	2009		
522	Sulaymania	Sulaymania	Jafaran	Dada Khaje	Dried	2009		
523	Sulaymania	Sulaymania	Jafaran	Kani Jinan Nawde	Dried	2009		
524	Sulaymania	Sulaymania	Jafaran	Mizgawt	Dried	2009		
525	Sulaymania	Sulaymania	Jafaran	Mama Abro	Dried	2009		
526	Sulaymania	Sulaymania	Jafaran	Kawrahman	Dried	2009		
527	Sulaymania	Sulaymania	Jafaran	Qura Rasha	Flowing			
528	Sulaymania	Sulaymania	Jafaran	Bakhi Qala-1	Flowing			
529	Sulaymania	Sulaymania	Jafaran	Bakhi Qala-2	Flowing			
530	Sulaymania	Sulaymania	Jafaran	Chaqali Saru	Dried	2009		
531	Sulaymania	Sulaymania	Jafaran	Chaqali Khuaru	Dried	2009		
532	Sulaymania	Sulaymania	Jafaran	Qamishan-1	Dried	2009		
533	Sulaymania	Sulaymania	Jafaran	Qamishan-2	Dried	2009		
534	Sulaymania	Sulaymania	Jafaran	Kani Kara	Dried	2009		
535	Sulaymania	Sulaymania	Jafaran	Hama Amin Afandi	Dried	2009		
536	Sulaymania	Sulaymania	Jafaran	Hama Amin	Dried	2009		
537	Sulaymania	Sulaymania	Jafaran	Balakari Haji Yasin	Dried	2009		
538	Sulaymania	Sulaymania	Jafaran	Ali Toufiq	Dried	2009		
539	Sulaymania	Sulaymania	Jafaran	Zawe Asi	Dried	2009		
540	Sulaymania	Sulaymania	Jafaran	Omar Latif	Dried	2009		
541	Sulaymania	Sulaymania	Jafaran	Sherdara	Dried	2009		
542	Sulaymania	Sulaymania	Jafaran	Kak Ahmed	Dried	2009		
543	Sulaymania	Sulaymania	Jafaran	Homar	Dried	2009		
544	Sulaymania	Sulaymania	Jafaran	Gozhaka Ahmed Raza	Dried	2009		
545	Sulaymania	Sulaymania	Jafaran	Qishl Bashabra	Flowing			
546	Sulaymania	Sulaymania	Jafaran	Kawalan	Flowing			
547	Sulaymania	Sulaymania	Jafaran	Kani Chnar	Dried	2009		
548	Sulaymania	Sulaymania	Kani Bardina	Chalakon	Flowing		35.64389	45.40092
549	Sulaymania	Sulaymania	Kani Goran	Kani Mala	Dried	2008	35.671828	45.406735
550	Sulaymania	Sulaymania	Kani Goran	Kani Marif Bag	Flowing		35.674799	45.404676
551	Sulaymania	Sulaymania	Kani Goran	Bakhi Khuaru	Dried	2006	35.673519	45.402812
552	Sulaymania	Sulaymania	Kani Jena	Kani Jena	Dried	2007	35.585588	45.226803
553	Sulaymania	Sulaymania	Kani Pira	Kani Pira	Dried	2007	35.649867	45.422967
554	Sulaymania	Sulaymania	Kani Pira	Saruna	Dried	2007	35.644407	45.414967

555	Sulaymania	Sulaymania	Kasnazan	Mizgawt	Dried	1997		
556	Sulaymania	Sulaymania	Kasnazan	Kani Sard	Dried	1998		
557	Sulaymania	Sulaymania	Kasnazan	Shakra	Dried	2000		
558	Sulaymania	Sulaymania	Kasnazan	Kasnazani Saru	Dried	2009		
559	Sulaymania	Sulaymania	Kasnazan	Chikchka	Dried	2006		
560	Sulaymania	Sulaymania	Kasnazan	Garmaka	Flowing			
561	Sulaymania	Sulaymania	Khawe	Kani Chnar	Dried	2008		
562	Sulaymania	Sulaymania	Khawe	Kuekha	Dried	2008		
563	Sulaymania	Sulaymania	Khawe	Hasana Sur	Dried	2008		
564	Sulaymania	Sulaymania	Khawe	Kani Shinka	Dried	2008		
565	Sulaymania	Sulaymania	Koshki Khuaru	Haji Mohammed Gule	Flowing			
566	Sulaymania	Sulaymania	Koshki Khuaru	Kanyarash	Dried	2007		
567	Sulaymania	Sulaymania	Koshki Khuaru	Abdullah Hama Amin Hame	Dried	2009		
568	Sulaymania	Sulaymania	Koshki Khuaru	Ahmed Hamarash	Dried	2008		
569	Sulaymania	Sulaymania	Koshki Saru	Sarchawa	Flowing			
570	Sulaymania	Sulaymania	Koshki Saru	Ali Karam	Dried	2005		
571	Sulaymania	Sulaymania	Koshki Saru	Kani Jinan	Dried	2007		
572	Sulaymania	Sulaymania	Kula Jo	Kula Jo	Dried	2009		
573	Sulaymania	Sulaymania	Mewli	Jinan	Dried	2008		
574	Sulaymania	Sulaymania	Mewli	Kani Jina	Dried	2005		
575	Sulaymania	Sulaymania	Mewli	Kani Khuaru	Dried	2008		
576	Sulaymania	Sulaymania	Piskandi	Nawde	Flowing		35.694484	45.255068
577	Sulaymania	Sulaymania	Piskandi	Kani Jinan	Dried	2009	35.694379	45.254855
578	Sulaymania	Sulaymania	Piskandi	Taqabi	Dried	2008		
579	Sulaymania	Sulaymania	Piskandi	Hasan Ali	Dried	2005		
580	Sulaymania	Sulaymania	Piskandi	Haji Abdulkarem	Dried	2006		
581	Sulaymania	Sulaymania	Piskandi	Kak Salam	Dried	2009		
582	Sulaymania	Sulaymania	Piskandi	Ashikon	Dried			
583	Sulaymania	Sulaymania	Qamishan	Kochala	Dried	2009		
584	Sulaymania	Sulaymania	Qaraman	Banu	Dried	2006		
585	Sulaymania	Sulaymania	Qaraman	Darwesh Qadir	Dried	2006		
586	Sulaymania	Sulaymania	Qazanqaya	Mala Hasan	Dried	2008		
587	Sulaymania	Sulaymania	Qazanqaya	Shekh Marif	Dried	2008		
588	Sulaymania	Sulaymania	Sarko	Kani Jinan	Dried	2009		
589	Sulaymania	Sulaymania	Sarko	Hawzi Piawan	Dried	2009		
590	Sulaymania	Sulaymania	Sarko	Kani Henjer	Dried	2009		
591	Sulaymania	Sulaymania	Sarko	Bakhi Zorab	Dried	2009		
592	Sulaymania	Sulaymania	Sewsenan	Suraban Saru	Dried	2009	35.211024	45.498574
593	Sulaymania	Sulaymania	Sewsenan	Suraban Kuaru	Dried	2006	35.209269	45.498035
594	Sulaymania	Sulaymania	Sewsenan	Barzawan Saru	Flowing		35.212596	45.49395
595	Sulaymania	Sulaymania	Sewsenan	Halat	Dried	2008		
596	Sulaymania	Sulaymania	Sewsenan	Holawka	Flowing			
597	Sulaymania	Sulaymania	Sewsenan	Barzawani Fariq	Dried	2009		
598	Sulaymania	Sulaymania	Sewsenan	Hamaukuri	Dried	2009		
599	Sulaymania	Sulaymania	Sewsenan	Shekh Rasul	Dried	2009		
600	Sulaymania	Sulaymania	Sewsenan	Hana Sawza	Dried	2009		
601	Sulaymania	Sulaymania	Sewsenan	Hama Saleh	Dried	2009		
602	Sulaymania	Sulaymania	Sewsenan	Awaii Sewsenan	Flowing			
603	Sulaymania	Sulaymania	Sewsenan	Solawe	Dried	2009		
604	Sulaymania	Sulaymania	Sewsenan	Imam Hama	Dried	2009		
605	Sulaymania	Sulaymania	Sewsenan	Maji Husain	Dried	2009		
606	Sulaymania	Sulaymania	Sewsenan	Chamibakh	Dried	2009		
607	Sulaymania	Sulaymania	Sewsenan	Galga	Flowing			
608	Sulaymania	Sulaymania	Sewsenan	Dardare	Dried	2009		
609	Sulaymania	Sulaymania	Sewsenan	Barzawani Khuaru	Flowing			
610	Sulaymania	Sulaymania	Sewsenan	Kani Qalat	Flowing			
611	Sulaymania	Sulaymania	Sewsenan	Kamaran	Flowing			
612	Sulaymania	Sulaymania	Sewsenan	Kani Fatim	Dried	2009		
613	Sulaymania	Sulaymania	Sewsenan	Qulchawt	Flowing			
614	Sulaymania	Sulaymania	Sewsenan	Barash	Flowing			
615	Sulaymania	Sulaymania	Sewsenan	Hanachela	Flowing			
616	Sulaymania	Sulaymania	Sewsenan	Boua	Dried	2009		

617	Sulaymania	Sulaymania	Sewsenan	Kani Yakamolina	Dried	2009		
618	Sulaymania	Sulaymania	Sewsenan	Shewe Kayi Khuaru	Dried	2009		
619	Sulaymania	Sulaymania	Sewsenan	Qurashay Ubed	Dried	2009		
620	Sulaymania	Sulaymania	Sewsenan	Hana Chnar	Dried	2009		
621	Sulaymania	Sulaymania	Sewsenan	Shewe Kayi Saru	Dried	2009		
622	Sulaymania	Sulaymania	Sewsenan	Duarai Saru	Dried	2009		
623	Sulaymania	Sulaymania	Sewsenan	Duarai Khuaru	Dried	2009		
624	Sulaymania	Sulaymania	Sewsenan	Kotra Rashi Ali Smen	Dried	2009		
625	Sulaymania	Sulaymania	Sewsenan	Kotra Rashi Imam	Dried	2009		
626	Sulaymania	Sulaymania	Sewsenan	Kotra Rashi Faraj	Dried	2009		
627	Sulaymania	Sulaymania	Sola	Kabinakan	Undetermined		35.46199	45.226045
628	Sulaymania	Sulaymania	Sulaymania	Aziz Aga	Dried	2008	35.563361	45.448744
629	Sulaymania	Sulaymania	Sulaymania	Haji Bag	Dried	2007	35.567058	45.455421
630	Sulaymania	Sulaymania	Sulaymania	Shekh Mahmood	Dried	2009	35.573535	45.451543
631	Sulaymania	Sulaymania	Sulaymania	Ahmad Zangana	Flowing		35.559282	45.443092
632	Sulaymania	Sulaymania	Sulaymania	Wasta Sharif	Flowing		35.559797	45.438166
633	Sulaymania	Sulaymania	Sulaymania	Qanisha	Flowing		35.551659	45.45586
634	Sulaymania	Sulaymania	Sulaymania	Ali Jola	Dried	2007	35.55801	45.465981
635	Sulaymania	Sulaymania	Sulaymania	Darogha	Flowing		35.560169	45.452753
636	Sulaymania	Sulaymania	Sulaymania	Hamasur	Dried		35.566484	45.463358
637	Sulaymania	Sulaymania	Sulaymania	Kani Said Hasan	Flowing		35.557109	45.443326
638	Sulaymania	Sulaymania	Sulaymania	Khana Sutawa	Dried		35.556385	45.447658
639	Sulaymania	Sulaymania	Sulaymania	Mawlana	Flowing		35.541757	45.425901
640	Sulaymania	Sulaymania	Sulaymania	Khabat	Flowing			
641	Sulaymania	Sulaymania	Sulaymania	Homar Mandan	Dried			
642	Sulaymania	Sulaymania	Sulaymania	Kaneskan	Flowing			
643	Sulaymania	Sulaymania	Sulaymania	Qoria Shkaw	Dried			
644	Sulaymania	Sulaymania	Sulaymania	Majid Bag	Flowing			
645	Sulaymania	Sulaymania	Swerawa	Nawde	Dried	1991		
646	Sulaymania	Sulaymania	Tafan	Tafan	Flowing		35.311322	45.356684
647	Sulaymania	Sulaymania	Takya	Sharafain	Flowing			
648	Sulaymania	Sulaymania	Takya	Kani Chaqal	Flowing			
649	Sulaymania	Sulaymania	Takya	Taimanjala	Flowing			
650	Sulaymania	Sulaymania	Takya	Kani Ba	Flowing			
651	Sulaymania	Sulaymania	Takya	Karezi Nawde	Dried	2009	35.199814	45.450177
652	Sulaymania	Sulaymania	Taramar Nawarast	Nawde	Flowing		35.679252	45.133502
653	Sulaymania	Sulaymania	Tilazait	Kuna Such	Dried	2007		
654	Sulaymania	Sulaymania	Tilazait	Haji Saleh	Dried	2008		
655	Sulaymania	Sulaymania	Tilazait	Hama Amin Damdar	Dried	2008		
656	Sulaymania	Sulaymania	Tilazait	Shekh	Dried	2008		
657	Sulaymania	Sulaymania	Tilazait	Bana Gawra	Dried	2008		
658	Sulaymania	Sulaymania	Timar	Qura Rash	Dried	2009	35.390477	45.377931
659	Sulaymania	Sulaymania	Timar	Sarchawa	Dried	2008	35.389661	45.379028
660	Sulaymania	Sulaymania	Timar	Seri	Dried	1996	35.380322	45.380056
661	Sulaymania	Sulaymania	Walyan	Hama Amin	Dried	2005		
662	Kirkuk	Daquq	Topzawa	Topzawa	Undetermined			
663	Kirkuk	Laylan	Baydawah	Baydawah	Undetermined			
664	Kirkuk	Laylan	Palkana	Palkana	Undetermined			
665	Kirkuk	Laylan	Salih	Salih	Undetermined			
666	Kirkuk	Laylan	Tarjil	Tarjil	Undetermined			
667	Kirkuk	Qara Hanj	Qafar	Qafar	Undetermined			
668	Kirkuk	Shwan	Gorzin	Gorzin	Undetermined			
669	Kirkuk	Shwan	Hisar Ahmad	Hisar Ahmad Bag	Undetermined			
670	Kirkuk	Shwan	Hisar Ahmad	Ahmad Bage New	Undetermined			
671	Kirkuk	Shwan	Mama Rash	Mama Rash	Undetermined			
672	Kirkuk	Shwan	Papilan	Papilan	Undetermined			
673	Kirkuk	Shwan	Qaranaw	Qaranaw Salam Fatihulla	Undetermined			
674	Kirkuk	Shwan	Qaranaw	Qadirzma	Undetermined			
675	Kirkuk	Shwan	Umar Mandan	Umar Mandan	Undetermined			
676	Kirkuk	Shwan	Umar Mandan	Sewran	Undetermined			
677	Kirkuk	Shwan	Yaychi	Ezat Pasha	Undetermined			
678	Kirkuk	Shwan	Yaychi	Osman Wale	Undetermined			

679	Kirkuk	Shwan	Yaychi	Said Omer	Undetermined
680	Kirkuk	Tuzhurmatu	Aghaja	Aghaja	Undetermined
681	Kirkuk	Tuzhurmatu	Goma Yi	Goma Yi	Undetermined
682	Ninewa	Mosul	Eski Mosul	Eski Mosul	Undetermined
683	Ninewa	Sinjar	Sinjar	Sinjar	Undetermined

¹ Indicates whether a karez was dried or flowing in 2009 (undertermined if not known)

² The year that a karez dried or so dwindled that use of the karez ended (blank if not known)

³ Geocoordinates in digital degrees from GPS or georeferenced base map (both WGS 84 projection)
(blank if geocoordinates not collected)

Appendix C: Sample field notes from visits to the following villages in Iraqi Kurdistan

From the notes of Dale Lightfoot, Survey of Infiltration Karez in Northern Iraq

Qasr Kharaba: karez Salhaga – Died 2007; last cleaned 1986 (before Anfal evacuation). Karez had been diminishing since 2005.

Karez died because of drought but they also suspect a section of tunnel collapse. Many wells in karez collapsed after Anfal. When Saddam Hussein's Anfal campaign to depopulate the restive Kurdish countryside destroyed many villages in this area—including Qasr Kharaba—people left the village and could not clean/maintain the karez and sections collapsed and flow decreased. The recent drought just finished them off.

900m long with 30 wells in alluvium. Mother well is 10 meters deep. Tunnel is about 1.5m high and 1m wide (no casing; in alluvium). There are burn marks in tunnel from previous cleaning operations. Owner (in living memory) was Aziz Aga; now owned by Ghafuri family (Luqman, Abed Aga, and Arasu, all Aziz Aga's children), but reportedly this karez was recently donated to the village by the Ghafuri family. The man who used to maintain this karez was from Iran (Iranian wasta). Karez still has water and the upper tunnel still flows a little but collapsed in the middle (should flow if cleaned).

Irrigated tobacco, rice, and vegetables (about 100 donums) and also provided drinking water and water for animals. Land formerly irrigated is now dry farmed in wheat and barley.

They say they are suffering now because the karez is dry, they don't have enough water, and several families have left the village in the past two years because of the lack of water. They now rely on water delivered to the village by trucks.

They have water quality tests (with documents available on request) to show that the karez was the cleanest source in the village (better than hand pumped wells in the area).
Geo-coordinates (unprojected): N 35 56' 03.3" E 44 48' 04.8"

Piskandi: karez Nowdeh – Still flows a little (trickles) and still used. It flows a little better in winter, but still insufficient. Village now depends on water trucked in at irregular intervals. Last cleaned thoroughly in 1988. Tried cleaning it briefly in late July 2009 but with no effect.

25 meters long with 3 wells in limestone; the lower channel is encased in cinder block/cement. Mother well is 3 meters deep.

Tunnel exits at small cement basin enclosed in concrete structure adjacent to village mosque. Used for ablution at the "men's mosque", drinking water, and animals. It remains the only local source of drinking water for the village (unless water is delivered by truck). Its use for ablution ended early 2009. It also used to irrigate three donums of summer vegetables.

Originally 40 families in the village; displaced by Anfal; 15 moved back in 1992 and rebuilt. Since karez began dwindling in 2006-2007 seven families have moved away. Eight remain tied to the village, but two of these live here only part time (they also stay with relatives in Sulaymania city); only six live full time in the village because of water scarcity.

Owned and operated by the village committee. They would like to repair this karez, or put in a pumped well, or something. They don't want their village to die. The family whose house is adjacent to the karez exit just sold their sheep and goats and moved away shortly before we arrived. Remaining families face the same decision and are daily evaluating their chances for staying in the village. Geo-coordinates (unprojected): N 35 41' 40.1" E 45 15' 18.3"

There is a second karez in this village (karez Kani Jinan) which barely seeps but is insufficient to be used for anything. It used to provide water to the “women’s mosque” (women’s washing and social gathering area) but they stopped using it in spring 2009.

Kunaflusa: karez Kunaflusa – still flows a little. Last cleaned before 2004 (they think maybe 2000). Flow has diminished since 2000.

30 meters long with 3 wells in limestone. Mother well 12 meters deep. One well now covered up; two still provide access to the tunnel. Tunnel is 80cm high and 50cm wide in limestone (no casing). Still depend on this karez for drinking and animals and mosque ablution. It is the only local source of water available in the village. Karez is located inside the village and ends in an enclosed public basin adjacent to the village mosque. It is used for ablution, and is an important focal point for life in the village since it is the only source where women and girls gather water, men meet for the mosque, everyone gathers for social visits, and animals are brought each evening for watering in the basins adjacent to the karez.

They plug the exit pipe for timed periods to allow water pressure to build in the karez and families come to get their water at their appointed time (according to the clock hanging on a wall visible from the collection basin); 10 families have an appointed time for collection (three of these collect for another family, too, so that 13 families receive water). After the last family collects at 6:00 p.m. the karez is left to flow into the basin and this overflow then sent to watering troughs below the basin where animals are brought in to be watered each evening.

Owned by the village committee; 13 families are supported.

Vague plans for putting in a pumped well or fixing the karez or something, but they don’t have the tools or knowledge to do either; they are just desperate to get more water to remain in their village. They now rely mostly on water trucked in every two to three days and deposited in a separate village basin/cistern. The karez is the preferred source of water but has become supplementary water.

Geo-coordinates (unprojected): N 36 18’ 00.8” E 44 32’ 42.0”