

Paktika Province, Afghanistan Water Resource Study:  
Watershed Characterization and Management  
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## 9.1 Introduction

Objectives of the Watershed Condition and Management part of this study:

Identify on a project planning level (scale of approximately 1:250,000), candidate watersheds for long term erosion/sediment production reduction, based on the following criteria:

- Contributing sediment/flooding/gullying to either planned or existing irrigation works or fields in the Barmal (Bermel) and Urgon (Orgun) valleys.
- Erosion problems related to human-caused deforestation/or overgrazing as identified by imagery modeling for deforestation/devegetation and erosion modeling for erosion/sediment potential
- Have characteristics of “sensitive” watersheds: Steep slopes, landforms, unstable rock types, bare soils, climatic factors, hydrologic sensitivity

Identify two demonstration project areas (at approximately 1:24,000) that have:

- Security is either present or practical to achieve
- Access is practical using local labor and technical expertise (ACC, Dept. of Forestry, etc.)
- Cultural capacity is present (local villages, ACC, access)
- Consistent with recommended engineering projects
- Values are present (adequate soils, slopes for agriculture) and are at risk from identified watershed conditions

For these project watersheds, review in more detail the probable erosion and sediment conditions that affect irrigation water supply and reservoir sediment-filling, and finally, make management recommendations on ameliorating these conditions. These recommendations are to be based on security, cultural capacity, watershed condition, and proposed uses.

### The Study Area

The Paktika Province is about 2,800,000 ha. This is too large for effective review within the scope of this project, so a study area was delineated with boundaries determined from initial discussions emphasizing the Barmal and Urgun valleys (Figure 16). The Study Area is 366,443 ha. Though some potential watersheds were added outside this area after this determination, only watersheds within the study area were evaluated per the study objectives. Map projection for all work was UTM Zone 42 WGS84. Because of its larger footprint, LANDSAT imagery was obtained for a wider region. QUICKBIRD imagery was processed for most of the study area, including the study watersheds.

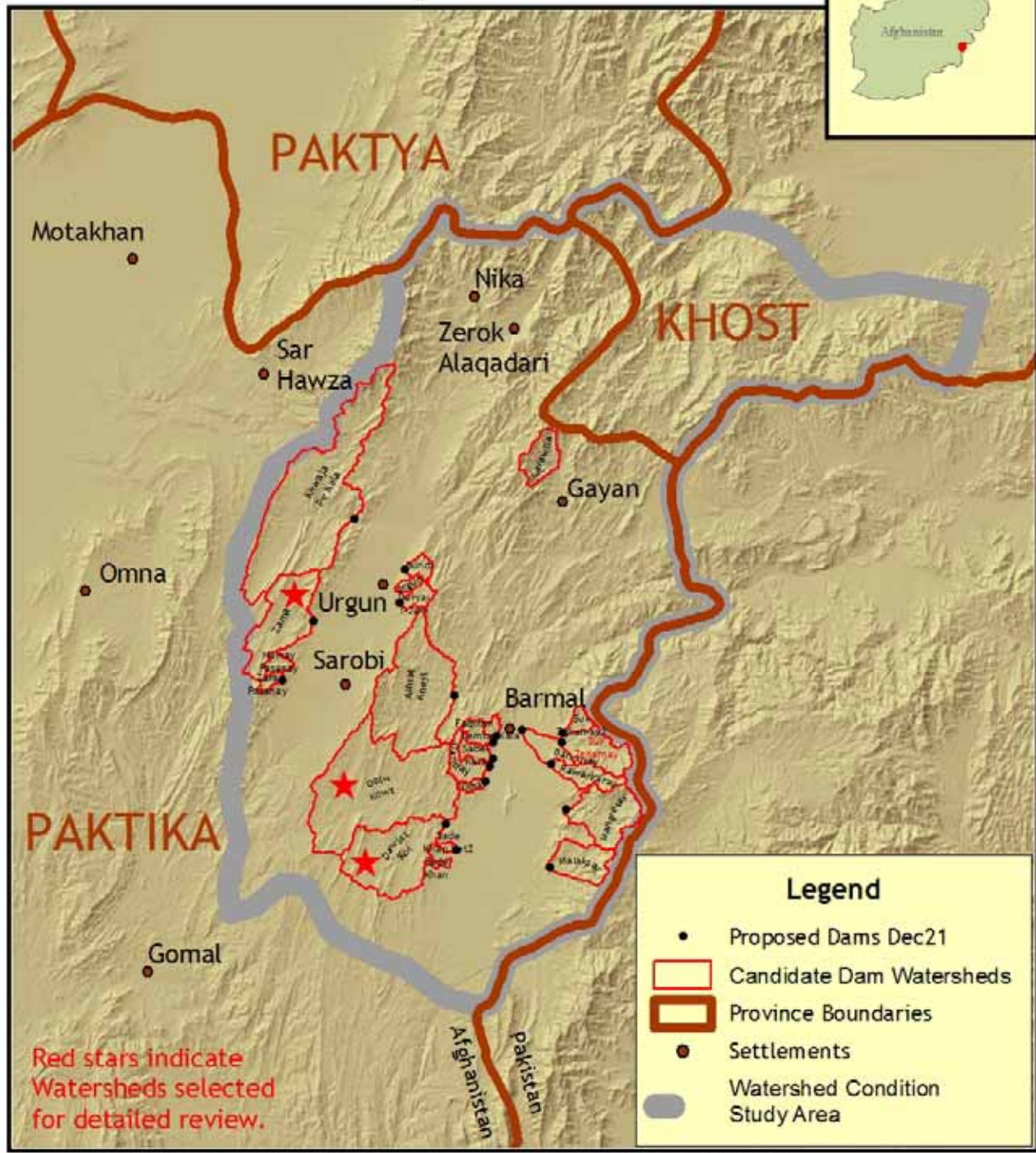
To further focus the study, watershed boundary spatial data were obtained in February, 2008 (version of Dec 21). The 24 watersheds ranged from 161 to 16,542 ha with a mean at 3,238 ha (Table 1). These watersheds had been determined to have significant potential for water resource management, and were being considered by the Army Corps of Engineers for irrigation dam potential. All landscape evaluation and detailed watershed examinations were confined to these watersheds.

The Zama, Gol Kowt, and Dawlat Kot watersheds were selected for detailed watershed examination as having high potential for further work in irrigation improvement (Figure 16).

Table 1. Watershed Area and Proportion

Watershed Name	Total Area (ha)	% of Total Watershed Area
Ashral Kheyl	9,657	12%
Banduray	5,367	7%
Bundi	614	1%
Carawna	1,765	2%
Danday	1,289	2%
Darya-i-Jani	692	1%
Dawlat Kot	6,858	9%
Faqiran	690	1%
Golw Kowt	15,151	19%
Khwaja Pir Kala	16,542	21%
Lembe Kala	314	0%
Malaksay	2,380	3%
Mangretay	3,870	5%
Naway Pasanay	537	1%
Nkhal	312	0%
orgun	348	0%
Rawarkaray	1,538	2%
Sabel Kala	705	1%
Sade Khan	155	0%
Sade Khan Kot2	161	0%
Sur Zghamay	2,625	3%
Sur Zghamay2	577	1%
Zama	5,219	7%
Zara Pasanay	352	0%
Total Watershed Area	77,719	100%

Afghanistan - Water Resources Study -  
 Watershed Management Section  
 Barmal and Urgun Area - Paktika Province



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 Prepared By: Henry F. Shovic  
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1:600,000

This map was made from information provided by the Army Corps of Engineers - Afghanistan, AIMS (Afghan Information Mapping Services) and the United Nations  
 This is part of a cooperative project between the Army Corps of Engineers and the U. S. Forest Service



Figure 16. Paktika province, the Study Area, and Candidate Watersheds

## **9.2 Methods**

### ***Digital Satellite Imagery***

QUICKBIRD ©, IKONOS ©, and LANDSAT satellite images were procured for this project, covering various aspects of the project area. LANDSAT imagery was used to interpret for vegetation change, primarily in forested watersheds, using two dates chosen to estimate a reasonable accuracy of deforestation rate, as well as considering availability and image quality. IKONOS imagery was used to help georeference the LANDSAT imagery, and QUICKBIRD data was used to do most of the aerial interpretation.

The QUICKBIRD imagery proved to be very useful in aerial interpretation at scales down to 1:2000, to determine watershed condition and potentials for rehabilitation. The LANDSAT data was very helpful in determining deforestation. All images were displayed using a simulated Color Infrared (CIR) color band combination. This interpretation is useful for determining areas of actively transpiring vegetation. These show red or pink, whereas dormant vegetation is generally gray. Bare rock or soil shows as blue, and surface water can show as black.

All images are during the fall season of the year. This time frame was chosen to emphasize perennial wetlands, irrigated agriculture, and forested vegetation. However, low sun angles sometimes shadowed features.

### ***Digital Landscape Data***

Slope and elevation classes were mapped using a digital elevation model (DEM) provided by space shuttle missions (SRTM) at 30 m resolution and mosaic'd over the study area. Classes were determined by those breaks most useful in erosion modeling. Roads, settlements, major rivers, and provincial boundaries were provided by AIMS (Afghanistan Information Mapping Services). The Afghanistan/Pakistan boundary data proved to be too coarse to use for this project (Appendix G).

Generalized geologic data was from Russian geology digital data obtained in earlier TDY's by the author. Generalized land cover was from United Nations data from the year 2002. Soils data were also from generalized digital data obtained by the author, with some older (1970's vintage) images of hard copy soil maps. Climate data were from the Army Corps of Engineers (ACE).

The country boundary spatial data used for the above modeling was somewhat different than used for watershed delineation in this study (See Appendix G for examples). Therefore, geologic, soils, and land cover data were incomplete for some watersheds in the far eastern part of the study area (Mangretay, Malaksay, Rawarkaray, Sur Zghamay2, and Banduray watersheds). These data were extrapolated using imagery.

### ***Aerial Interpretation***

Using ARCMAP ©, The detailed QUICKBIRD imagery was used to interpret landscape features at scales of 1:2,000 (for vegetation, erosional features such as gullies, evidence of logging operations), at 1:5,000 (for stream channel characteristics), and at 1:24,000 for geologic and geomorphologic features. Because no true stereo imagery was available, ARCGLOBE © and ARCSCEEN © were used to provide 3D landscape views to simulate stereo projections. Standard techniques were used for identification of features.

### ***Other Data***

The author made two trips to Afghanistan in 2005 to aid in agricultural reconstruction with the objectives of reducing soil erosion and improving watershed conditions. (ref....). This was sponsored by USAID (U. S. Agency for International Development) and the FAS (Foreign Agricultural Service) of the U. S. Department of Agriculture. Because of the difficulty of ground access, much of his work was done using remote sensing and use of remote observers, including Afghan scientists and U. S. personnel. This method was continued in the present project, using more detailed imagery as well as U. S. Army ground observers.

### ***Watershed Evaluation***

For purposes of this report, watersheds are divided into three components or “zones”. These are the “collection” zone (steeper slopes and headwaters), the “transport” zone, where larger streams transport water relatively rapidly in narrow valleys, and the “depositional” zone, where streams deposit most sediment and meander across broad plains (Fripp, 2005). Most large-scale agriculture occurs in the “depositional” zone, but the quality and quantity of the irrigation water supply is most heavily influenced by condition and potential of the higher zones.

All candidate watersheds were evaluated for general landscape characteristics that influence water resources. Elevation and slope range, land cover, basic landforms and their geologic origins, lithology (geology), surficial materials were described. Geologic and geomorphic terminology follow Thornbury (1969).

Since deforestation is a concern for the entire eastern side of Afghanistan, deforestation rates were estimated using the two LANDSAT images and a digital model used in the U. S. Forest Service for wildfire-caused deforestation. Ground-truth was provided by high-resolution QUICKBIRD imagery. See Appendix G for more information and data.

Three watersheds were selected for detailed review. The high-resolution QUICKBIRD imagery was used to determine watershed features from vertical review at scales ranging from 1:2,000 to 1:10,000. Where slope was a factor, but not apparent from vertical maps, data were draped on the digital elevation model (DEM) to provide a three-dimensional view. This method also provided an easily-interpreted context of the watersheds.

### ***Stream Network Characteristics***

The kinds and density of stream drainage networks help indicate the character of a watershed as well as potential for uses of the transported surface waters. All defined stream channels

visible at a scale of 1:5,000 were digitized. Each was rated by reach per the following classification, developed by a reconnaissance of the entire watershed at 1:24,000. The classes rate characteristics important for water production, stream bank restoration, and geomorphic stability: channel character (braiding, incisement, bank stability), size (average width of channel > 20 m or < 20 m), and seasonal surface flow (perennial or intermittent as evidenced by a visually apparent surface flow). Braiding is indicated by a wide, un-vegetated, multi-channel flood plain. An “incised” channel is defined one in which stream banks are steep and high (> 10 m) with little associated flood plain.

Both braiding and incisement (Classes 1-8) indicate a geomorphically unstable system. (Table 2). Class 9 is reserved for those stream channels which appear to have a “normal” or “stable” channel. Banks slope to the stream, with apparent live vegetation, and little braiding is visible. These characteristics indicate a more stable geomorphic environment.

Table 2. Stream Channel Characteristics

Class	Size *	Water flow	Channel Character
1	Large	Perennial	Braided
2	Large	Perennial	Incised
3	Large	Intermittent	Braided
4	Large	Intermittent	Incised
5	Small	Perennial	Braided
6	Small	Perennial	Incised
7	Small	Intermittent	Braided
8	Small	Intermittent	Incised
9	Any size	Any	Vegetated banks, not incised, not braided

\* Large is > 20 m average channel width.

### ***Estimation of Soil Erosion***

Soil erosion is the process of removal and transport of soil material. The rate of soil loss from a slope is related to the following factors.

- precipitation
- soil erodibility
- slope length and steepness
- vegetative cover
- management practices.

These factors were estimated for all watersheds using available small-scale data, including a broad-scale soil survey and geologic data, climatic data from the Army Corps of Engineers, quantitative analysis of slope and elevation, a broad land-cover map, and indirect data on agricultural practices common in the region.

The three representative watersheds (Zama, Dawlat Kot, and Gol Kowt) were evaluated for active soil erosion using QUICKBIRD imagery. A canvass of the entire watershed was completed at a scale of 1:12,000 to inventory Class 4 erosion or “badlands”. These are vegetation-free areas having extremely fine-textured drainage patterns, indicating rapid, usually geologically-related erosion. The nature of these areas is probably not strongly related to human management of the landscape.

Based on an aerial imagery reconnaissance at 1:2,500, probable eroding slopes were found to be too common to inventory completely within the scope of this study. Therefore a stratified sample was taken to estimate kind and extent. This consisted of six regularly spaced squares of nine ha each (Class 2 areas). Within these a complete inventory was completed. The axis of this sample set was determined at a scale of 1:50,000 by crossing the widest part of the watershed, and the spacing set to cross the entire watershed. The land area in each rectangle was canvassed for evidence of accelerated soil erosion visible at 1:2,000 (Class 3 erosion). Indicators included gullies, light-colored bare soils, and drainage patterns radically more fine textured than surrounding lands. These features are commonly management-related. Data were proportioned between the six sample areas for one watershed, to illustrate distribution.

### 9.3 Results

#### *Watershed Zones*

All candidate watersheds are in the collection and transport zones, whereas most of the present irrigated agriculture is in the depositional zone. (Figure 17). Many irrigation water supply problems in the depositional zone can be traced to higher zones, and this is the case here. Improving irrigation water supply in the depositional zone through pumps and wells, ponds, diversions and dams, spring development, and other methods must be accompanied by management of those upper zones, since the irrigation water supply is so heavily influenced by them. These upper zones have significant problems in terms of soil erosion, stream sedimentation, and management practices, as discussed below.

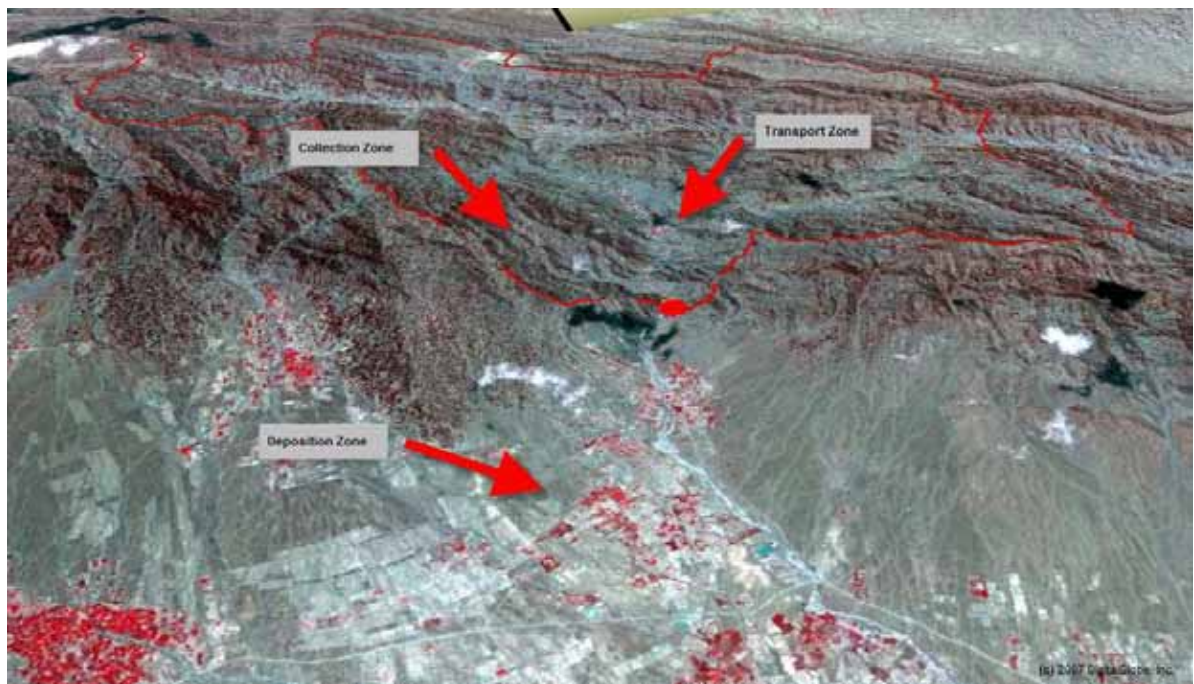


Figure 17. Zama Perspective Overview and Example of Watershed Zones

### ***Soil Properties***

Geologic materials are categorized by area in Table 3, and by proportion in Table 4. The geologic maps are rather general, but it is obvious that a large component is interbedded sedimentary rocks of variable composition, dominated by tilted and interbedded clay, shale, siltstone, and sandstone. Landforms correlate well with this conclusion (bedrock-structure controlling slopes, rectangular drainage patterns, with fine-dendritic patterns in shale units). Harder, more resistant rocks may dominate Banduray, Malaksay, Mangretay, Rawarkaray, Sur Zghamay, and Sur Zghamay2. This is consistent with their location and topography (in the mountainous east).

Table 3. Geologic Materials of the Watersheds by Area

Watershed Name	Not mapped	Clay, shale, siltstone, sandstone, limestone, marl, gypsum, conglomerate	Dunite, Peridotite, Serpentinite	Limestone, shale, sandstone	Sandstone, siltstone, clay, conglomerate, limestone, marl, acid and mafic volcanic rocks	Shingly and detrital sediments, gravel, sand, clay, clay sand, loess, travertine	Total (ha)
Ashral Kheyl		9,657					9,657
Banduray	1,132			3,477		758	5,367
Bundi		592				22	614
Carawna		1,745				20	1,765
Danday		1,275				14	1,289
Darya-i-Jani		692					692
Dawlat Kot		6,857				1	6,858
Faqiran		688				2	690
Golw Kowt		15,019				132	15,151
Khwaja Pir Kala		2,277			14,266		16,542
Lembe Kala		308				6	314
Malaksay	21		538	1,820			2,380
Mangretay	1,673		47	2,151			3,870
Naway Pasanay		537					537
Nkhal		307				4	312
orgun		339				10	348
Rawarkaray	313			1,226			1,538
Sabel Kala		683				21	705
Sade Khan		155					155
Sade Khan Kot2		161					161
Sur Zghamay	819			1,806			2,625
Sur Zghamay2				577			577
Zama		4,008			1,211		5,219
Zara Pasanay		352					352
Totals	3,957	45,652	585	11,057	15,477	991	77,719

Table 4. Geologic Materials of the Watersheds by Proportion

Watershed Name	Not mapped	Clay, shale, siltstone, sandstone, limestone, marl, gypsum, conglomerate	Dunite, Peridotite, Serpentinite	Limestone, shale, sandstone	Sandstone, siltstone, clay, conglomerate, limestone, marl, acid and mafic volcanic rocks	Shingly and detrital sediments, gravel, sand, clay, clay sand, loess, travertine	Total
Ashral Kheyil		100					100
Banduray	21			65		14	100
Bundi		96				4	100
Carawna		99				1	100
Danday		99				1	100
Darya-i-Jani		100					100
Dawlat Kot		100				0	100
Faqiran		100				0	100
Golw Kowt		99				1	100
Khwaja Pir Kala		14			86		100
Lembe Kala		98				2	100
Malaksay	1		23	76			100
Mangretay	43		1	56			100
Naway Pasanay		100					100
Nkhal		99				1	100
orgun		97				3	100
Rawarkaray	20			80			100
Sabel Kala		97				3	100
Sade Khan		100					100
Sade Khan Kot2		100					100
Sur Zghamay	31			69			100
Sur Zghamay2				100			100
Zama		77			23		100
Zara Pasanay		100					100

The mountainous parts of Afghanistan are tectonically active. Earthquakes are common. Some streams show evidence of rapid uplift, with incised meanders. Valley floors also show evidence of arid climatic processes, with wide areas of almost featureless valley fill between mountain ranges and braiding of stream bottoms, with small currently active channels.

Based on the geology, landforms, and information from observers, soils are likely to have a significant clay content (with exception of the probable sandstone/intrusive areas that may occur in all watersheds). Overlaying the soil map over the candidate watersheds (Tables 5 and 6) shows soil suborders having little soil structure development, warm temperature regimes, low organic matter content (Haplocambids with Torriorthents), and shallow depths (rocky land with Lithic Haplocambids). The Zama, Carawna, and Khwaja Pir Kala watersheds probably have deeper soils, but are likely to be no more fertile. Generally, soils like these have low agricultural potential unless extensively irrigated, tilled, and fertilized. However, ponds and reservoirs are likely to have good bottom sealing characteristics. These soil characteristics are also associated with high erodibility and transport potential by water or wind.

Table 5. Soil Characteristics of the Watersheds by Area

Watershed Name	Not mapped	Haplocambids with Torriorthents	Rocky Land with Lithic Haplocambids	Total (ha)
Ashral Khey1			9,657	9,657
Banduray			5,367	5,367
Bundi			614	614
Carawna		1,601	163	1,765
Danday			1,289	1,289
Darya-i-Jani			692	692
Dawlat Kot			6,858	6,858
Faqiran			690	690
Golw Kowt			15,151	15,151
Khwaja Pir Kala		10,797	5,745	16,542
Lembe Kala			314	314
Malaksay	215		2,165	2,380
Mangretay	96		3,774	3,870
Naway Pasanay			537	537
Nkhal			312	312
orgun			348	348
Rawarkaray			1,538	1,538
Sabel Kala			705	705
Sade Khan			155	155
Sade Khan Kot2			161	161
Sur Zghamay			2,625	2,625
Sur Zghamay2			577	577
Zama		1,958	3,262	5,219
Zara Pasanay			352	352
Totals	311	14,357	63,051	77,719

Table 6. Soil Characteristics of the Watersheds by Proportion

Watershed Name	Not mapped	Haplocambids with Torriorthents	Rocky Land with Lithic Haplocambids	Totals
Ashral Kheyl			100	100
Banduray			100	100
Bundi			100	100
Carawna		91	9	100
Danday			100	100
Darya-i-Jani			100	100
Dawlat Kot			100	100
Faqiran			100	100
Golw Kowt			100	100
Khwaja Pir Kala		65	35	100
Lembe Kala			100	100
Malaksay	9		91	100
Mangretay	2		98	100
Naway Pasanay			100	100
Nkhal			100	100
orgun			100	100
Rawarkaray			100	100
Sabel Kala			100	100
Sade Khan			100	100
Sade Khan Kot2			100	100
Sur Zghamay			100	100
Sur Zghamay2			100	100
Zama		38	62	100
Zara Pasanay			100	100

This broad scale soil survey has had little review, so there could be significant areas of better (or worse) soil included in these map units. Also, all these watersheds are in the collection and transport zones for irrigation water supply, and do not include the valley bottoms where most agriculture is located (Figure 17).

### *Climate*

This part of Afghanistan has a semi-arid climate, characterized by very dry summers and wet springs. Snowmelt and occasional flash-flooding from single storms dominate stream flow characteristics. Average elevation is used to approximate relative differences in climate between watersheds (Table 7). Those with most potential rainfall group above 2500 m, but there is a significant range in average elevation (from 2128 to 2808 m, or 680 m), so rainfall probably varies significantly, with the eastern mountainous watersheds receiving more snow than the western watersheds.

Table 7. Elevation Distribution by Watershed

Watershed Name	MIN	MAX	RANGE	MEAN	STD	MEDIAN
Ashral Khey1	1994	2672	678	2255.03	140.561	2238
Banduray	2007	2538	531	2183.18	101.458	2166
Bundi	2273	2516	243	2423.7	59.958	2430
Carawna	2325	3062	737	2682.5	183.675	2674
Danday	2042	2359	317	2174.17	83.0238	2166
Darya-i-Jani	2321	2588	267	2462.78	60.228	2468
Dawlat Kot	2120	2521	401	2277.97	67.2108	2275
Faqiran	2029	2366	337	2144.49	75.5583	2121
Golw Kowt	2102	2629	527	2323.42	105.901	2316
Khwaja Pir Kala	2316	3423	1107	2622.29	166.818	2590
Lembe Kala	2026	2146	120	2087.05	27.4909	2091
Malaksay	2384	3072	688	2633.36	164.609	2591
Mangretay	2324	3108	784	2637.3	150.634	2612
Naway Pasanay	2549	2885	336	2694.84	69.3782	2692
Nkhal	2072	2235	163	2128.29	45.4497	2124
orgun	2293	2514	221	2431.24	58.9438	2442
Rawarkaray	2231	2958	727	2595.04	171.94	2607
Sabel Kala	2033	2350	317	2126.81	74.2202	2104
Sade Khan	2120	2328	208	2161.33	43.5892	2143
Sade Khan Kot2	2113	2265	152	2143.68	28.7579	2136
Sur Zghamay	2192	2973	781	2553.64	159.143	2573
Sur Zghamay2	2223	2769	546	2507.87	116.157	2517
Zama	2426	2931	505	2629.65	79.3673	2625
Zara Pasanay	2640	2958	318	2808.26	71.2441	2818

### *Slope*

Slope statistics for each watershed are in Table 8. The Carawna, Mangretay, Malaksay, Rawarkaray, Sur Zghamay2, and Banduray watersheds are quite steep, averaging over 28% in slope. Most are in the mountainous east (Figure 18). These watersheds also have the longest slope lengths, particularly near peaks. The remainder, in the western part, have a higher proportion of low hills (Figure 19), with average slopes between 10 and 23% (Table 8). An exception is Naway Pasana which is quite steep.

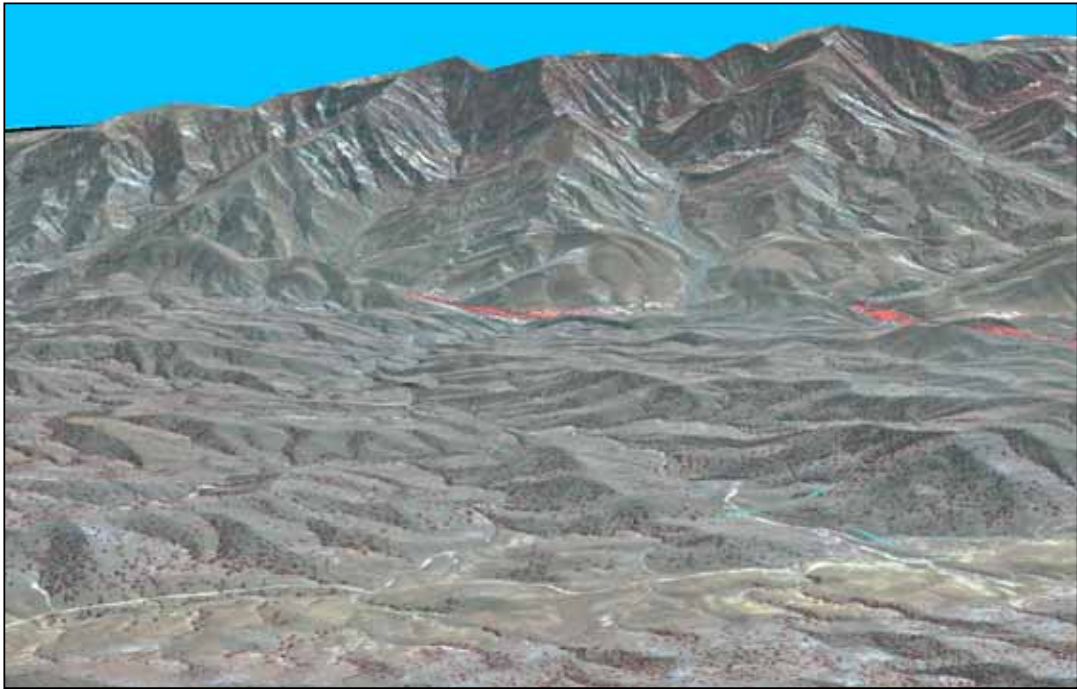


Figure 18. Mountainous Landforms in the East



Figure 19. Hilly landforms in the west

Table 8. Slope Distribution by Watershed

Watershed Name	MIN	MAX	RANGE	MEAN	STD	MEDIAN
Ashral Kheyl	5	55	50	22.208	8.59131	21
Banduray	4	41	37	13.7739	9.49717	9
Bundi	6	50	44	21.0211	9.00757	20
Carawna	10	82	72	47.3216	14.4266	49
Danday	6	53	47	19.7161	8.48334	18
Darya-i-Jani	8	35	27	17.3538	4.51751	18
Dawlat Kot	3	49	46	17.3493	9.85174	15
Faqiran	6	63	57	22.5714	10.4734	20
Golw Kowt	2	52	50	16.3604	8.17967	15
Khwaja Pir Kala	3	81	78	23.0531	12.4549	21
Lembe Kala	6	37	31	16.604	6.41329	15
Malaksay	7	61	54	27.8903	10.1705	28
Mangretay	11	55	44	30.1535	8.37823	30
Naway Pasanay	9	56	47	28.7904	10.3159	29
Nkhal	5	36	31	17.9222	7.497	16
orgun	7	37	30	21.8316	7.05416	22
Rawarkaray	10	54	44	30.4085	8.96798	31
Sabel Kala	5	53	48	18.9256	9.65132	17
Sade Khan	4	46	42	10.0476	9.3247	7
Sade Khan Kot2	4	42	38	10.5745	7.4169	10
Sur Zghamay	10	59	49	30.8666	8.56242	30
Sur Zghamay2	17	59	42	35.0452	6.67385	35
Zama	5	55	50	22.3524	8.23883	21
Zara Pasanay	22	57	35	36.4952	8.17444	37

### *Land Cover or Current Vegetation*

Land cover was estimated by intersecting the general land cover map with all watersheds (Tables 9 and 10). As expected, irrigated agriculture is only a small part of all watersheds. This is consistent with the dominant watershed zones, and there is probably a low potential for significant irrigated agriculture in them because of slope and soil types. The eastern and northern mountainous watersheds (Banduray, Malaksay, Mangretay, Rawarkaray, Sur Zghamay, Carawna, and Sur Zghamay2.) are almost entirely forested, with the remainder largely rangeland (grasslands/forbs/low shrubs).

Table 9. Land Cover of the Watersheds by Area

Watershed Name	Irrigated: Intensively Cultivated (1 Crop/Year)	Irrigated: Intermittently Cultivated	Natural Forest (closed cover)	Natural Forest (open cover)	Rangeland (grassland/forbs/low shrubs)	Rock Outcrop / Bare Soil	Total (ha)
Ashral Khey1		26			9,631		9,657
Banduray	49		4,545			773	5,367
Bundi					614		614
Carawna			1,360	390	14		1,765
Danday					1,289		1,289
Darya-i-Jani					692		692
Dawlat Kot	39				6,431	388	6,858
Faqiran					690		690
Golw Kowt	150				13,784	1,217	15,151
Khwaja Pir Kala	63	113		904	15,131	331	16,542
Lembe Kala					314		314
Malaksay			2,380				2,380
Mangretay			3,870				3,870
Naway Pasanay					537		537
Nkhal					312		312
orgun					348		348
Rawarkaray			1,538				1,538
Sabel Kala					705		705
Sade Khan					155	0	155
Sade Khan Kot2					161		161
Sur Zghamay			2,625				2,625
Sur Zghamay2			577				577

Table 10. Land Cover of the Watersheds by Proportion

Name	Irrigated: Intensively Cultivated (1 Crop/Year)	Irrigated: Intermittently Cultivated	Natural Forest (closed cover)	Natural Forest (open cover)	Rangeland (grassland/forbs/low shrubs)	Rock Outcrop / Bare Soil	Total
Ashral Kheyl		0			100		100
Banduray	1		85			14	100
Bundi					100		100
Carawna			77	22	1		100
Danday					100		100
Darya-i-Jani					100		100
Dawlat Kot	1				94	6	100
Faqiran					100		100
Golw Kowt	1				91	8	100
Khwaja Pir Kala	0	1		5	91	2	100
Lembe Kala					100		100
Malaksay			100				100
Mangretay			100				100
Naway Pasanay					100		100
Nkhal					100		100
orgun					100		100
Rawarkaray			100				100
Sabel Kala					100		100
Sade Khan					100	0	100
Sade Khan Kot2					100		100
Sur Zghamay			100				100
Sur Zghamay2			100				100
Zama					100		100
Zara Pasanay					100		100

### ***Management Practices***

Estimation of management practices is probably the most difficult task from a remote-sensing perspective. However, there is indirect and direct evidence of grazing, logging, and large-scale water management efforts in the candidate watersheds, based on literature, the author's experience, aerial interpretation, and ground-observers.

It is very likely all suitable lands are heavily grazed season-long, with high utilization and relatively un-managed distribution (though most lands are high in terms of potential grass production). The effects of these practices have been reviewed, and generally concluded to cause excessive soil erosion and lowering of productivity, on a broad scale in Afghanistan (Fripp, et. al, 2006; Fripp, 2006; UNEP; 2003, Domian and DeCamp, 2007; Domian, undated). Figure 20 has sample photographs from these publications showing grazing practices and effects on soils. These are probably related to the critical social and environmental problems in-country, with most agrarian families struggling to survive with limited resources, and limited choices. Landcover for most watersheds is generally suitable for grazing (Table 10), so is concluded to occur in all watersheds.

Certain management practices can benefit soils and biomass production. Control of herd and flock distribution, using utilization standards, supplemental feeding, gully-control, riparian protection, and other practices can radically improve range condition (Fripp, et. al). See the last image in Figure 20 for recovery after just one year of rest in In pistachio woodlands (which are intensively grazed), recommendations were made on a national level to control grazing to reduce seedling mortality and improve productivity (Grauke and Shovic, 2005). This proposal was not successful, until a second project was completed that directly involved local villagers (Shovic, 2005). This local effort was highly successful in increasing productivity by controlling grazing and other harvest practices (USAID, 2006). The current efforts in the Paktika province also emphasize the need for locally controlled and implemented projects (Guthrie, 2008).

Figure 20. Images of grazing and soil effects.



Efforts have been made to improve waters management in some areas. In the Zama and Gol Kowt watersheds, upstream dams and reservoirs were identified, but the majority were filled with sediment or breached (Figures 21 and 22). This is a problem in other areas (Figure 23) This is likely due to poor management of the reservoir and watershed. (Johannes Oosterkamp, email communication).

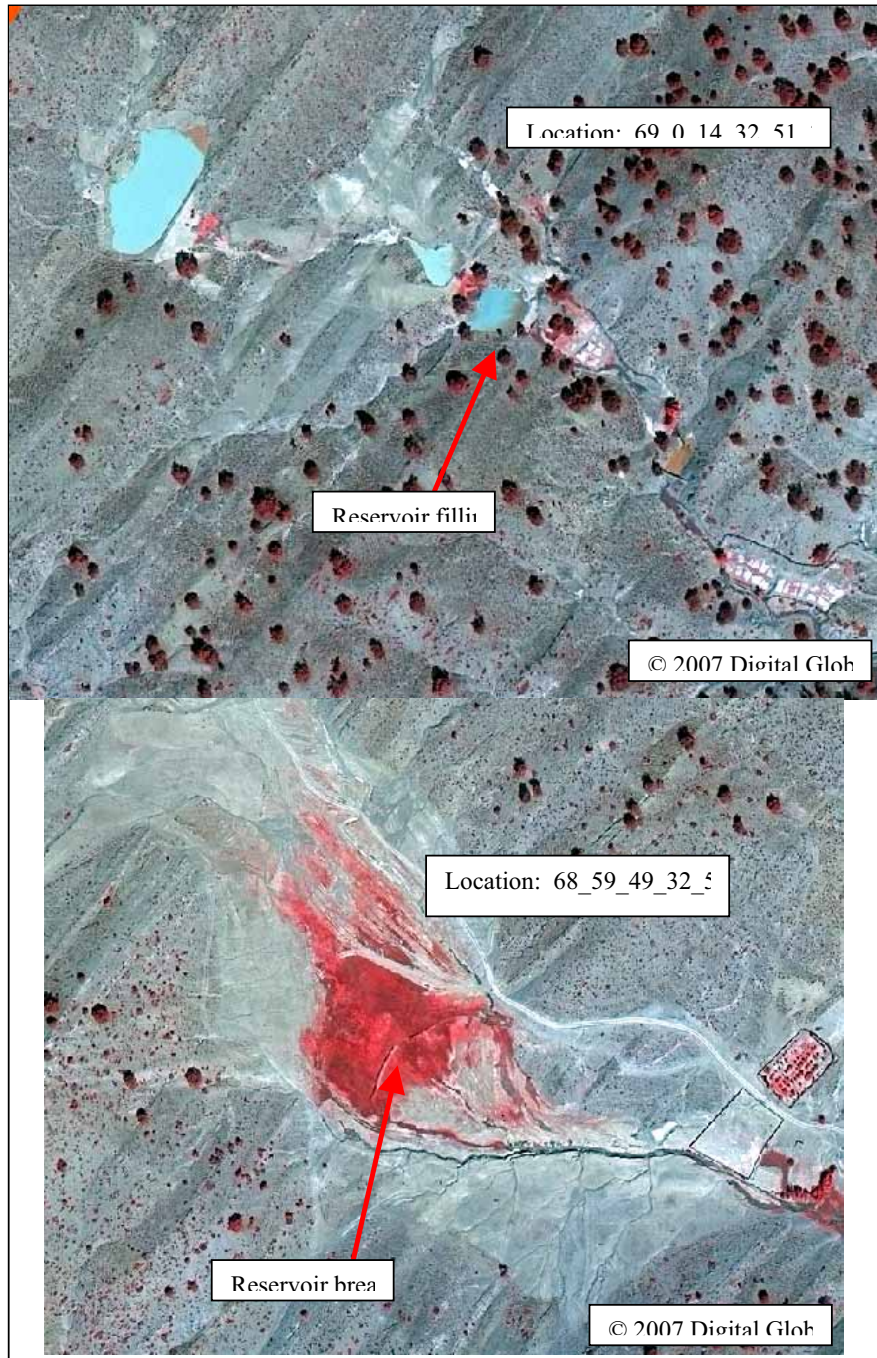


Figure 21. Images of Zama dams and reservoirs

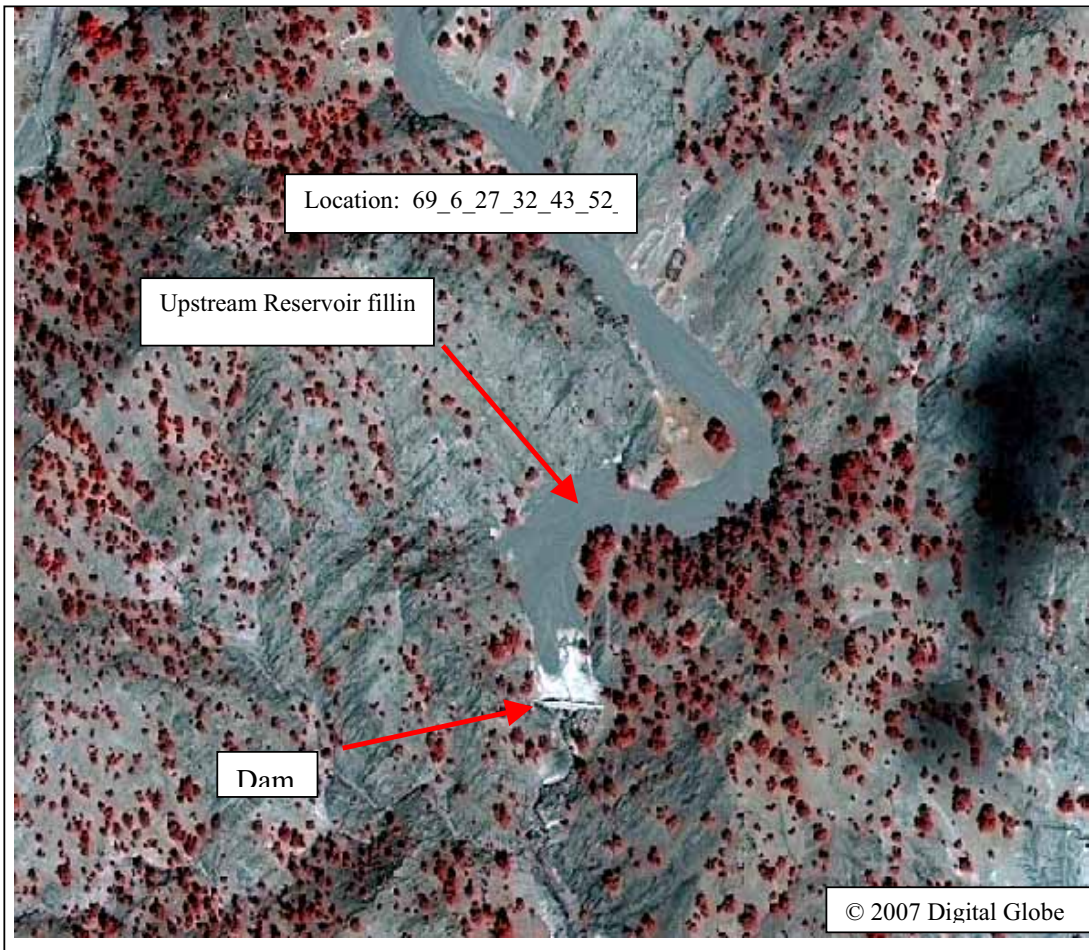


Figure 22. Image of Gol Kowt dam and reservoir



Figure 23. Sediment filling in reservoirs near Logar (Oosterkamp)

The most potentially-serious management practice is deforestation. This was estimated using the deforestation model (See Appendix G for details) using LANDSAT imagery, and ground-truthed with QUICKBIRD imagery. Based on the last eight years data, Malaksay watershed

has been significantly affected by deforestation (Table 11). Out of 166 ha of probable vegetation change, 51 ha has been recently logged. Either fire or previous logging has affected another 103 ha. These are small proportions of the watershed (2% and 4% respectively), but have potentially serious erosional consequences. Logging is concentrated in the highest, steepest part of the collection zone, and therefore significantly influences the irrigation water supply (Figure 24). This logging is also apparently not in the control of Afghanistan, as evidenced by the probable movement of timber out-of-country (Figure 25). Logging increases could significantly affect all the eastern watersheds.

Table 11. Deforestation of the Malaksay Watershed

Label	Description	Total (ha)	% of Sum Total
1	logged, probably more recent than 1998	47	29%
2	logging, probably older than 1998	12	7%
3	logging, probably older than 1998	1	0%
4	Logged, but probably older than 1998, possible small areas more recent	56	34%
5	old fire scar-possible old salvage logging before 1998	14	8%
7	Normally barren area or fire scar before 1998	12	7%
10	probably fire scar before 1998	16	9%
11	Logging more recent than 1998	4	3%
12	possible fire scar before 1998	4	3%
	Sum Total	166	100%

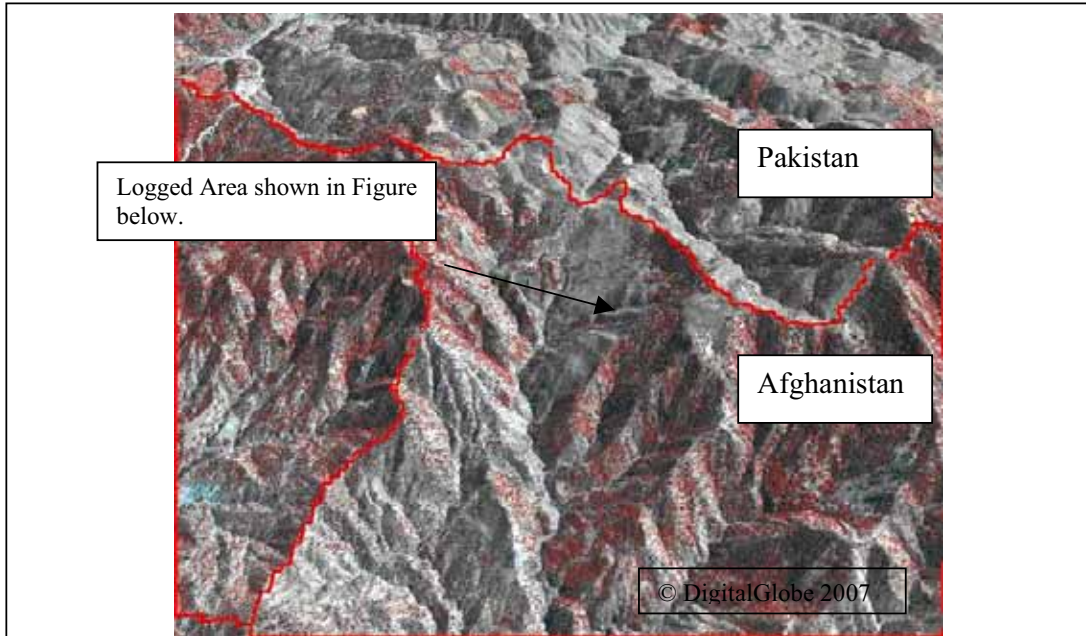


Figure 24. Image of Deforestation in Malaksay Watershed

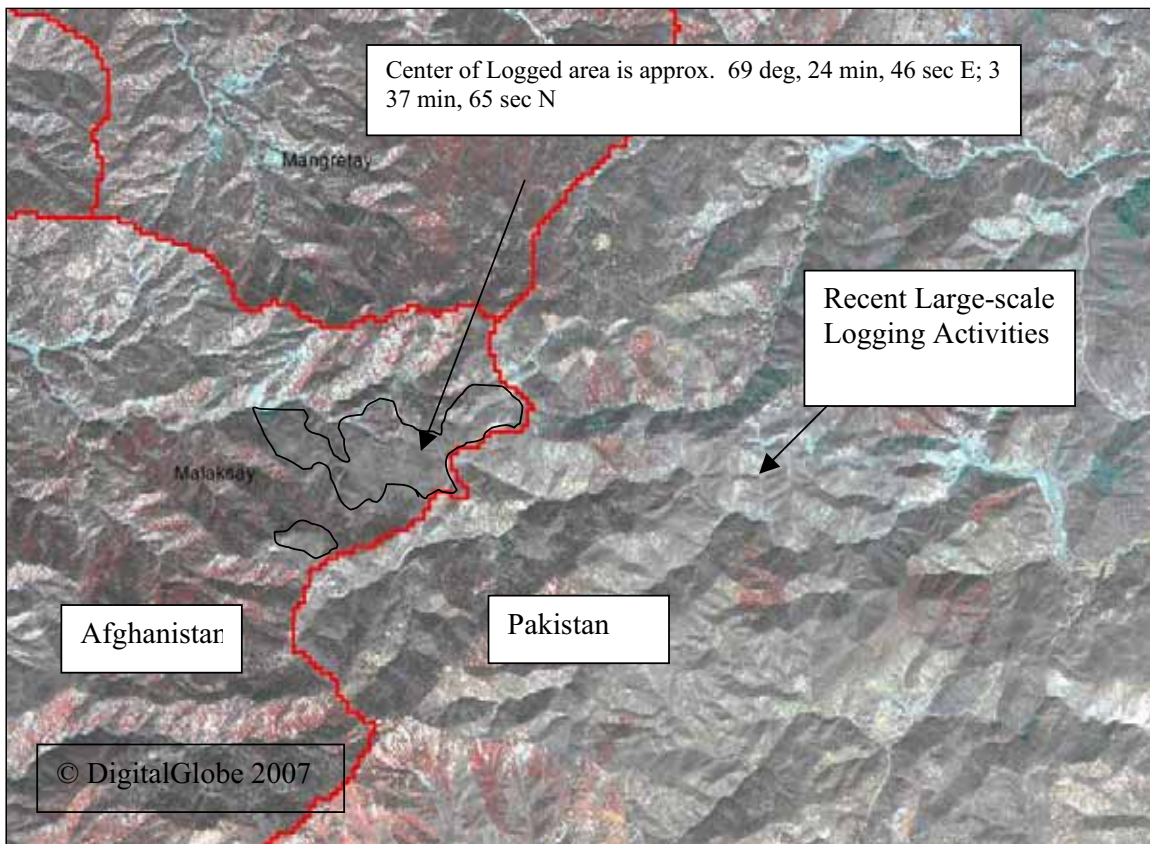


Figure 25. Map of Deforestation in Malaksay Watershed

Three watersheds were chosen for more detailed evaluation (Zama (part of the Urgan Valley), Gol Kowt, and Dawlat Kot, both part of the Barmal Valley, as shown on Figure 16). These have high potential for watershed management and for improvement in irrigation water supply, and were suggested by the Army Corps of Engineers. The evaluation consisted of more detailed geomorphic description, estimation of erosion extent, stream channel characterization, and more detailed recommendations for watershed management.

### ***Zama Watershed***

This watershed is 5,219 ha (Table 1). An aerial canvass using the QUICKBIRD imagery verified landforms and stream systems are controlled by underlying bedrock structure, and surficial materials are weathered from siltstone and shale, with some sandstone on ridges. See Figure 26 for a perspective view. Soils are generally fine-textured and erosive, yet productive when irrigated. The potential dam location is at the base of the watershed, just above the depositional zone (Figure 27).

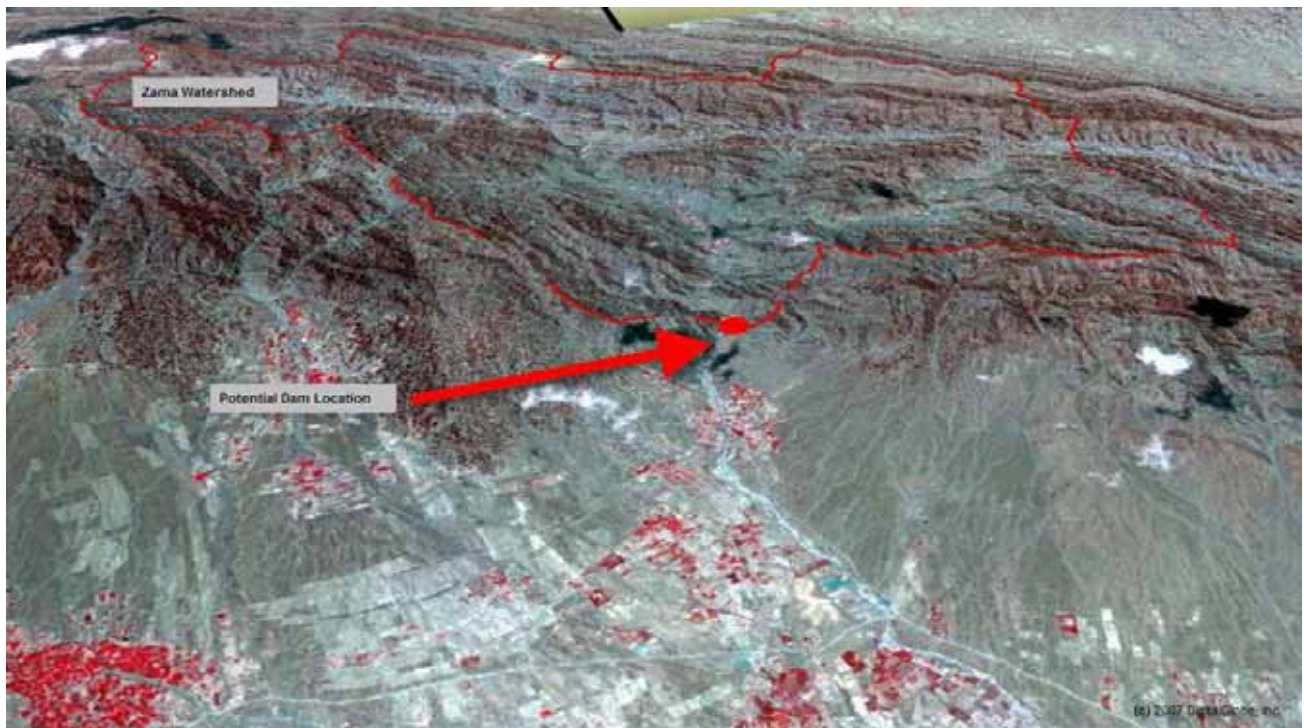


Figure 26. Perspective Overview of the Zama Watershed

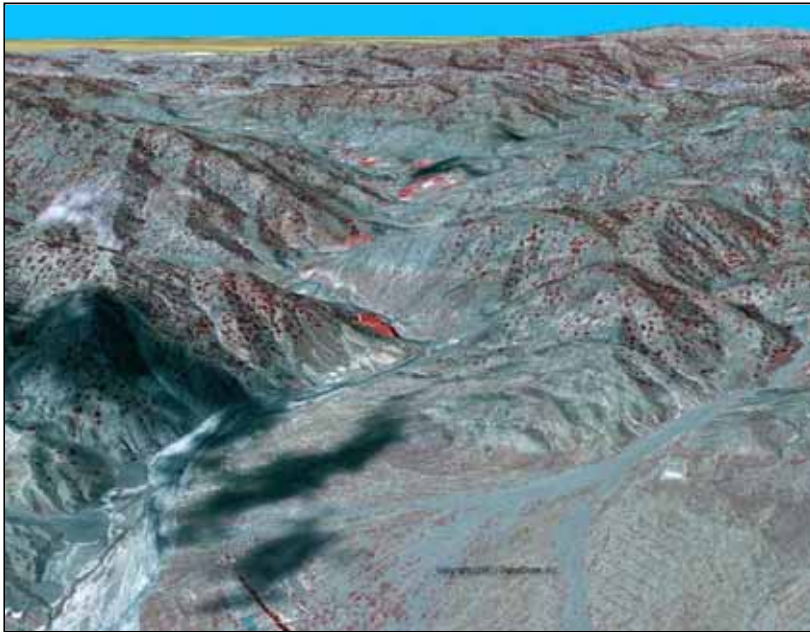


Figure 27. Zama Potential Dam Location

Soil erosion is active in this watershed, based on sampling for eroded areas, and a canvass of badland areas. Badlands (which are primarily geologic in origin) make up 4% of the watershed (Table 12 and Figure 28). Gullied, eroding lands outside of this class make up 11% (Table 12). The gullied lands are probably related to grazing. This is a significant area (782 ha), suggesting the watershed has significant soil erosion, largely related to management. It is well distributed over the watershed, as is shown in the “% of type 3 of Total” column.

Table 12. Eroding Areas – Zama Watershed

Type	Area (ha)	Description	% of Watershed	% of Type 3 of Total
2	54	Sample Area	-	
3*	6	Eroding Areas	11	
3 - sample 1	1.9	Eroding Areas		31
3 - sample 2	1.5	Eroding Areas		25
3 - sample 3	0.9	Eroding Areas		15
3 - sample 4	1.4	Eroding Areas		23
3 - sample 5	0.3	Eroding Areas		6
3 - sample 6	0	Eroding Areas		0
4	181	Badlands	4	

\* The Area (ha) for Type 3 is the sum of all six samples listed directly below. This is also used to calculate % of Type 3 Total.

The second aspect of erosion is transport. The density (m/ha) of stream channels influences the ability of streams to transport sediment. Stream channel characterization (Tables 1 and 13) shows a drainage density of 22m/ha. Streams are generally highly braided, having large active flood plains and relatively small active channels. Geomorphically this is indicative of high variations in surface flow with large sediment loadings. See Figure 27 for an example in

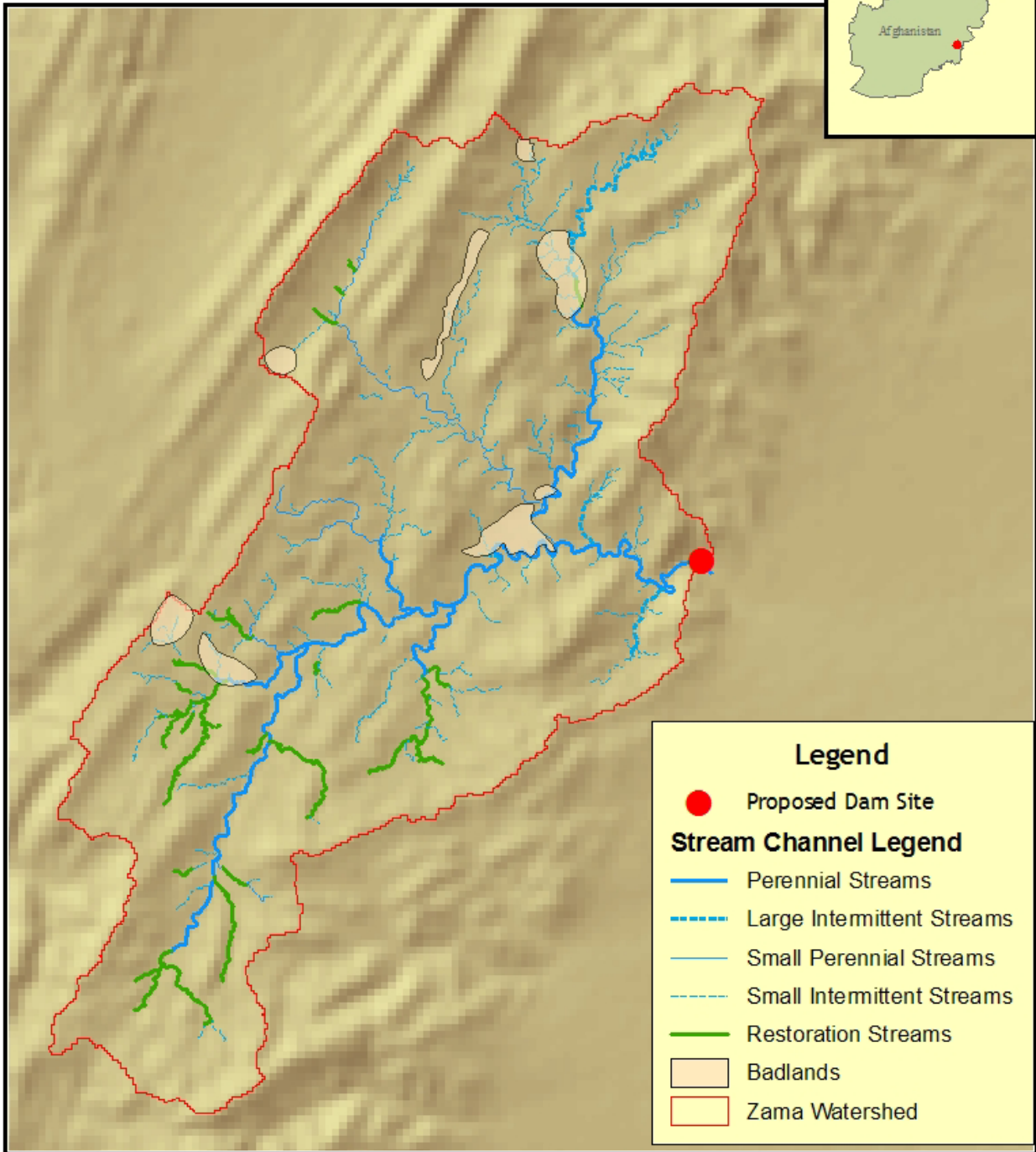
the lower right.

Table 13. Surface Stream Channel Characterization for Zama Watershed

Type	Length (m)	% of Total	Size	Water flow	Channel Character
1	21,865	18%	Large	Perennial	Braided
2	159	1%	Large	Perennial	Incised
3	5,266	4%	Large	Intermittent	Braided
4	0	0	Large	Intermittent	Incised
5	7,962	7%	Small	Perennial	Braided
6	3,066	3%	Small	Perennial	Incised
7	51,392	43%	Small	Intermittent	Braided
8	10,233	9%	Small	Intermittent	Incised
9	18,286	15%	Any size	Any	Vegetated banks, not incised, not braided
Total	118,228	100%			

Most streams are intermittent (56%) (Table 13), with flow probably continuing throughout the year under the surface (Figure 28). However, the large trunk streams above the potential dam location are perennial. Streams having restoration potential were delineated for the Zama Watershed. They are generally perennial, but are not braided (so have better potential for bank-moisture), and not incised, but appear to have poor vegetation cover. About 15% of the total stream network has this potential (18, 286 m) (Table 13 and Figure 28).

# Afghanistan - Water Resources Study - Zama Watershed Characteristics



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 USDA Forest Service, Gallatin National Forest  
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This map was made from information provided by the Army Corps of Engineers - Afghanistan, AIMS (Afghan Information Mapping Services) and the United Nations

This is part of a cooperative project between the Army Corps of Engineers and the U. S. Forest Service



Figure 28. Zama Stream Channel Network

### ***Gol Kowt Watershed***

This watershed is 15,151 ha, about three times larger than the Zama watershed. An aerial canvass using the QUICKBIRD imagery verified landforms and stream systems are controlled by underlying bedrock structure, and surficial materials are weathered from siltstone and shale, but harder rocks appear to be more extensive than in the Zama watershed, with sandstone or intrusive rocks on ridges influencing about 1/3 of the topography. See Figure 29 for a perspective view. Soils are generally fine to medium-textured, and less productive, harboring more sparse forest than in Zama's case. The potential dam location is at the base of the watershed, just above the depositional zone (Figure 30).

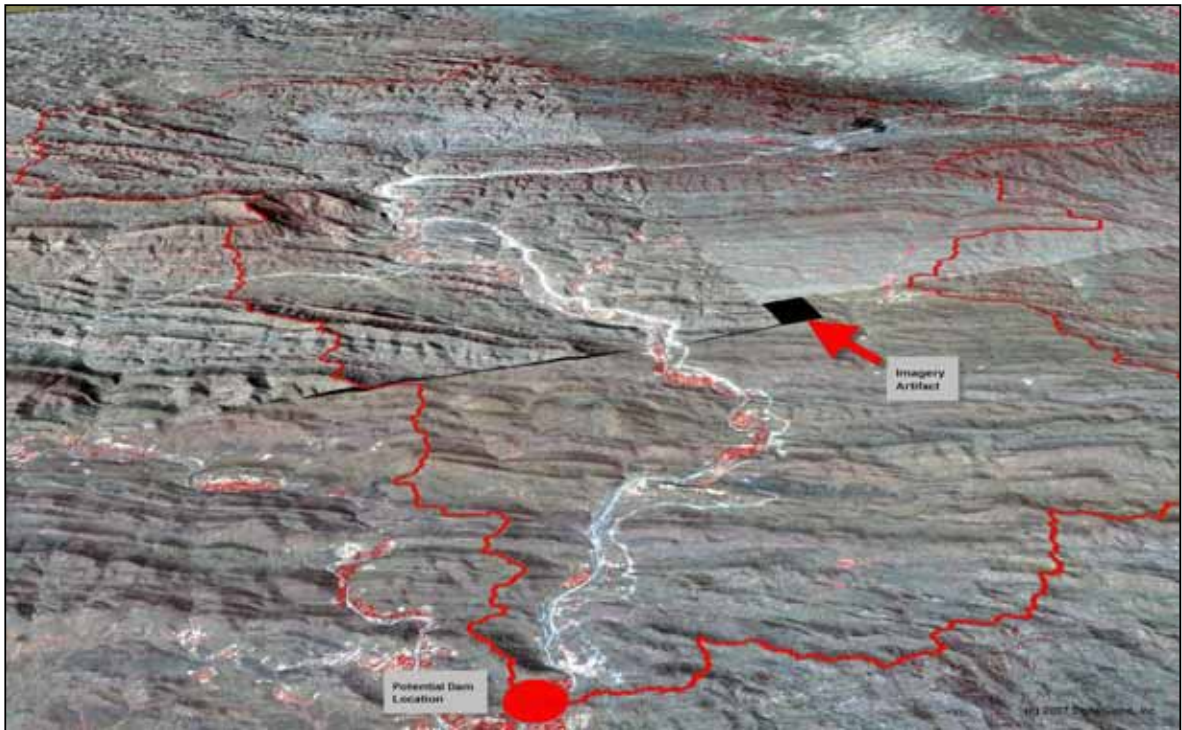


Figure 29. Perspective Overview of the Gol Kowt Watershed



Figure 30. Gol Kowt Potential Dam Location

Soil erosion is active in this watershed, based on sampling for eroded areas, and a canvass of badland areas. However, it is less evident than in the Zama watershed. Badlands (which are primarily geologic in origin) do not occur in the watershed (Table 14). Gullied, eroding lands outside of this class make up 2% (Table 14). The gullied lands are probably related to grazing. This area (303 ha) suggests the watershed has ongoing soil erosion, largely related to management.

Table 14. Eroding Areas – Gol Kowt Watershed

Type	Area (ha)	Description	% of Watershed
2	54	Sample Area	-
3	1	Eroding Areas	2
4	0	Badlands	0

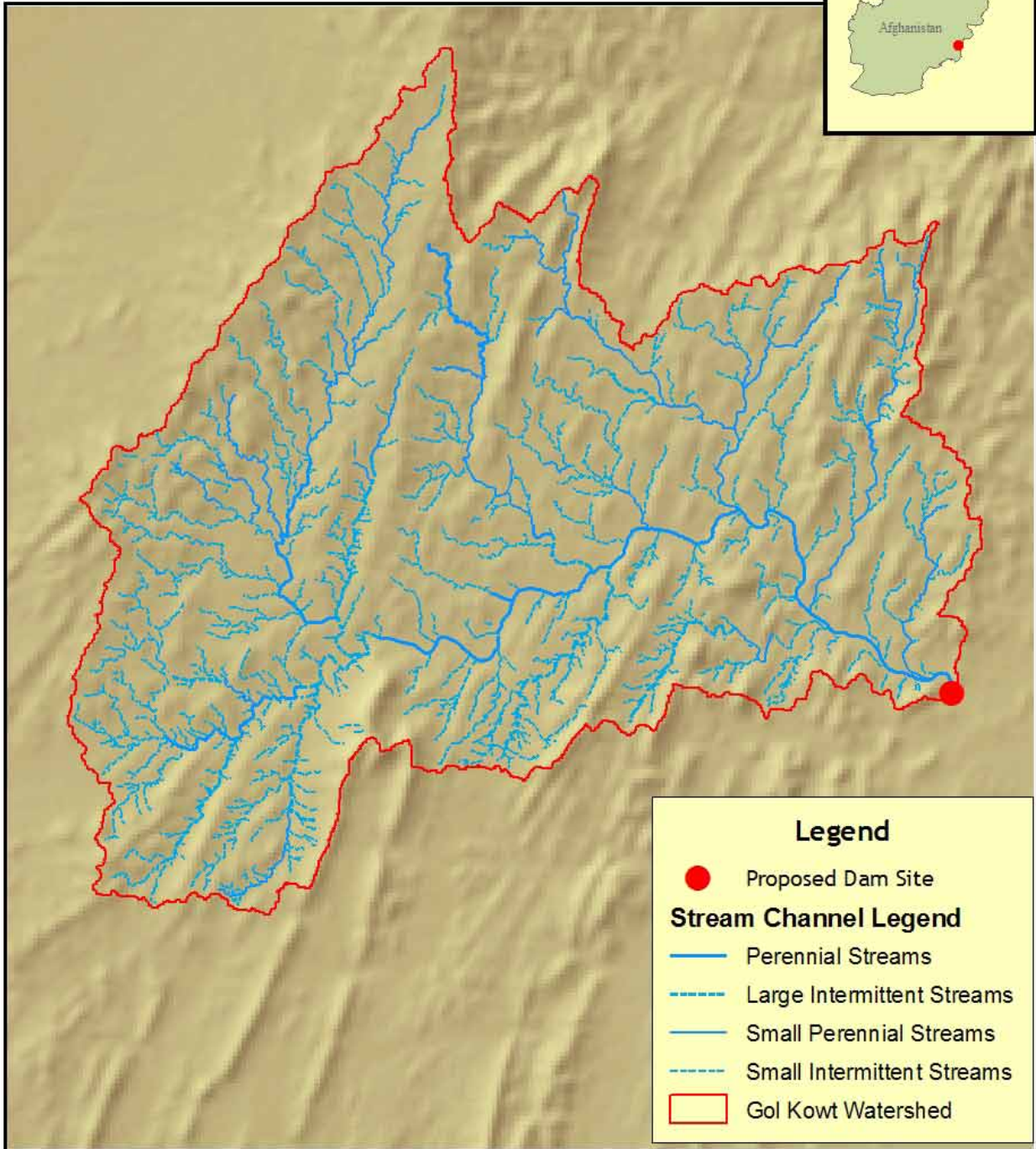
The second aspect of erosion is transport. Stream channel characterization (Tables 1 and 15) shows a drainage density of 29 m/ha. Streams are generally highly braided, with large flood plains and small active channels. Geomorphically this is indicative of high variations in surface flow with large sediment loadings. See Figure 30 for an example in the lower center.

Table 15. Surface Stream Channel Characterization for Gol Kowt Watershed

Type	Length (m)	% of Total	Size	Water flow	Channel Character
1	30,889	7%	Large	Perennial	Braided
2	0	0	Large	Perennial	Incised
3	26,417	6%	Large	Intermittent	Braided
4	0	0	Large	Intermittent	Incised
5	63,124	14%	Small	Perennial	Braided
6	2,251	1%	Small	Perennial	Incised
7	312,625	71%	Small	Intermittent	Braided
8	5,485	1%	Small	Intermittent	Incised
9	-	-	Any size	Any	Vegetated banks, not incised, not braided
Total	440,790	100%			

Most streams are intermittent (78%) (Table 15) with flow probably continuing throughout the year under the surface. However, the large trunk streams above the potential dam location are perennial (Figure 31). Streams having restoration potential were not delineated for the Gol Kowt Watershed, though there are some with those characteristics.

# Afghanistan - Water Resources Study - Gol Kowt Watershed Characteristics



**Legend**

- Proposed Dam Site

**Stream Channel Legend**

- Perennial Streams
- - - Large Intermittent Streams
- . . . Small Perennial Streams
- . . . . . Small Intermittent Streams
- Gol Kowt Watershed



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This map was made from information provided by the Army Corps of Engineers - Afghanistan, AIMS (Afghan Information Mapping Services) and the United Nations

This is part of a cooperative project between the Army Corps of Engineers and the U. S. Forest Service



Figure 31. Gol Kowt Stream Channel Network

*Dawlat Kot Watershed*

This watershed is 6,858 ha, similar to the Gol Kowt watershed. An aerial canvass using the QUICKBIRD imagery verified landforms and stream systems are controlled by underlying bedrock structure, and surficial materials are weathered from siltstone and shale, but harder rocks appear to be extensive in the watershed, with sandstone or intrusive rocks on ridges influencing about 1/2 of the topography (Figure 32). Soils are likely generally fine to medium-textured, and less productive, harboring more sparse forest than in Zama watershed. The potential dam location is at the base of the watershed, just above the depositional zone (Figure 33).



Figure 32. Perspective Overview of the Dawlat Kot Watershed



Figure 33. Dawlat Kot Potential Dam Location

Soil erosion is active in this watershed, based on sampling for eroded areas, and a canvass of badland areas. However, it is less evident than in the Zama watershed. Badlands (which are primarily geologic in origin) do not occur in the watershed (Table 16). Gullied, eroding lands outside of this class make up 2% (Table 16). The gullied lands are probably related to grazing. This area (137 ha) suggests the watershed has ongoing soil erosion, largely related to management.

Table 16. Eroding Areas – Dawlat Kot Watershed

Type	Area (ha)	Description	% of Watershed
2	54	Sample Area	-
3	1	Eroding Areas	2
4	0	Badlands	0

The second aspect of erosion is transport. Stream channel characterization (Tables 1 and 17) shows a drainage density of 27 m/ha. Streams are generally highly braided, with large flood plains and small active channels. Geomorphically this is indicative of high variations in surface flow with large sediment loadings. See Figure 33 for an example in the upper left.

Table 17. Surface Stream Characteristics for Dawlat Kot Watershed

Type	Length (m)	% of Total	Size	Water flow	Channel Character
1	12,661	7%	Large	Perennial	Braided
2	0	0	Large	Perennial	Incised
3	12,120	7%	Large	Intermittent	Braided
4	0	0	Large	Intermittent	Incised
5	3,021	2%	Small	Perennial	Braided
6	0	0	Small	Perennial	Incised
7	122,819	67%	Small	Intermittent	Braided
8	32,879	18%	Small	Intermittent	Incised
9	-	-	Any size	Any	Vegetated banks, not incised, not braided
Total	183,501	100%			

Most streams are intermittent (92%) (Table 17) with flow probably continuing throughout the year under the surface. However, the large trunk streams above the potential dam location are perennial, but do not reach to the dam site (Figure 34). This should be investigated on the ground to verify enough flow is present for storage. Streams having restoration potential were not delineated for the Dawlat Kot Watershed, though there are some with those characteristics.



## 9.4 Conclusions and Recommendations for Watershed Management

This study's first objective was to provide a systematic overview of the watershed situation in the Paktika Province. The data gathered on soils, landforms, climate, slope, land cover, and management practices paint a picture of instability, active soil erosion, and sedimentation; based partly on geomorphic and geologic factors. These include active tectonic (mountain building) processes, arid land stream characteristics, and highly-erodible soils on steep slopes. The watersheds have a high rate of water delivery, partially due to their location in the Collection and Delivery watershed zones, with little in the Depositional zone. The high rate of reservoir sediment-filling is likely related to these larger geomorphic and climatic controls. Because of these factors, these watersheds are likely to be a challenge for any sort of irrigation water supply management.

However, cultural factors are also important. Wide-spread, intensive grazing has probably increased the instability of soils and streams, as well as reduced productivity. Based on its location, recent deforestation in the eastern mountains is likely to increase flood potential and sediment, and is a growing problem, especially across borders. Existing reservoirs appear poorly maintained or have been destroyed.

The above results help focus on the large-scale potential of the area. However, to evaluate the actual condition of watersheds requires a more in-depth look. Therefore, three watersheds were reviewed in detail (Zama, Gol Kowt, and Dalwat Kot). Results confirm the above conclusions, but also show there is variability across the landscape and help define contributing conditions.

The Zama watershed has the most serious situation in terms of slope erosion, probably due to overgrazing of steeper slopes and the occurrence of the most erodible soils. It probably has the highest sedimentation rates, but also probably has the highest water delivery (it has a higher proportion of large perennial streams than either Gol Kowt and Dalwat Kot). Gol Kowt and Dalwat Kot probably have a higher potential for irrigation dam effectiveness, because soils are likely to be less erosive and there is less active erosion, but a lower water delivery.

All three watersheds have wide-spread and large-scale erosion and sedimentation problems. Their nature and extent probably preclude massive efforts in structural improvements, such as gully control structures. Access is poor, and accepting that the problems estimated here are minimums (due to the nature of our remote sensing methods), the planning of individual check dam locations, design, and implementation would have to be on a massive scale to affect watershed conditions that are heavily influenced by geomorphic controls.

Therefore, the primary recommended watershed treatment is a wide-area, low intensity, long term erosion/productivity improvement system: grazing management. It has worked in the past in Afghanistan, and is effective, both in theory, and on the ground. It should be based on established utilization standards and a livestock distribution system as proposed by the Natural Resource Conservation Service. It is "low tech", so should be implementable without engineering and design. It relies on the strongest social system in Afghanistan (the local Shura's and communities). Its implementation should have a minimum start-up time, as

it is just modifying a system that has been in place for centuries rather than imposing a new one. The local farmers and communities can implement it over a wide area to help address wide-area watershed problems. Revegetation of these slopes can be relatively rapid, and will significantly affect soil erosion by reducing bare soils and strengthening root systems to resist gullying.

This will probably result in the need for supplemental feeding, which could be accomplished by hay cropping. Regardless of the method, funding will be needed to help the farmers with feeding and herd or flock management. It will require funding for the local organizations such as the Afghan Conservation Corps (ACC) to help monitor and patrol, install erosion control structures, as well as to re-seed barren areas, and build fencing as necessary. Afghan agricultural scientists could be used to obtain local data, interpret it, and help set up local administration. The effectiveness of the Afghan Conservation Corps and the scientific community has been demonstrated. This reduces the need for U. S. monitoring and control.

Streambank stabilization, gully-control structures, and other point-source controls are also beneficial, and should be installed near settlements, both to provide local sediment control, and to show their effectiveness to local inhabitants. They can also be specified and built in areas where local farmers and herders are concerned about rapid gully erosion. Flood stabilization structures are also beneficial to protect local farmland on the Depositional zone, as well as near the larger streams in the Transport and Collection zones.

Also recommended is reduction of deforestation in the forested, easternmost watersheds. Since security is difficult to maintain in the critical areas, it is difficult to restore the deforested areas directly. However, monitoring using remote-sensing and aerial patrols for enforcement could help reduce its incidence.

Finally, continued study is recommended. This project relied on a combination of remotely-sensed data, high-tech modeling, aerial interpretation, with ground-truth provided by a variety of ground observations and literature. It was necessary because of the difficulty of ground-based investigation. Since a remote-sensing approach has been successful in the past, and on-the-ground situations have gotten more critical, we should continue to emphasize this method of obtaining project focus and feasibility.

Anecdotal information abounds on the poor watershed conditions and irrigation water supply problems in Afghanistan. Though this study was based on remotely sensed data, with limited direct ground-truth, it provides a consistent and systematic evaluation of “where, when, who, how much, and why,” with its accuracy based on what is known both directly and indirectly. It helped place some side-boards on the nature and extent of the watershed problems in Afghanistan, and should help focus future efforts on the most cost-efficient solutions.

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