Report
on the "Satellite enhanced snowmelt flood and drought predictions for Kabul River basin with surface and groundwater modeling" project

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1) Hydrological modelling of Chitral watershed

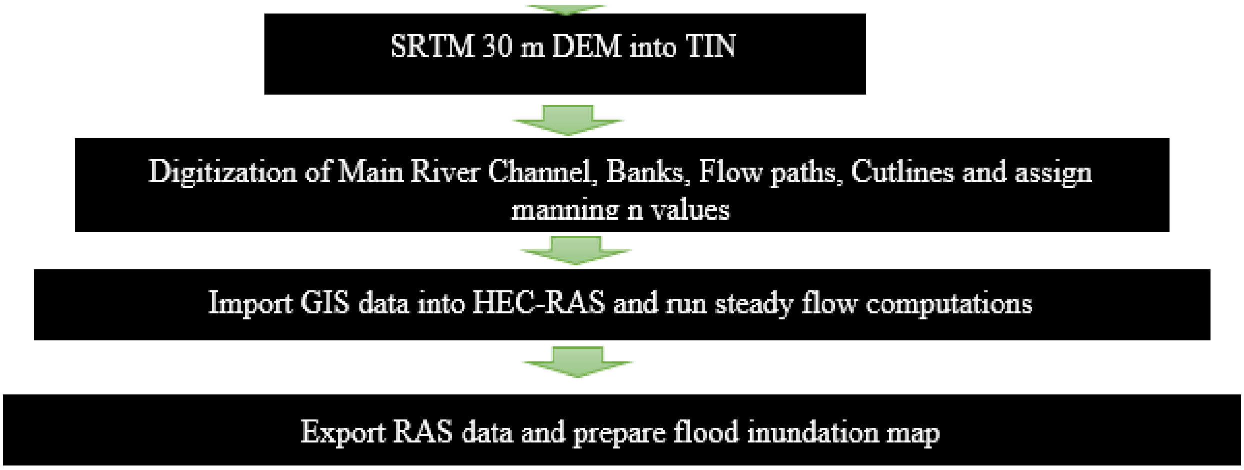
Title: Chitral Basin Watershed Modeling using Arc Hydro based on DEM submitted in peer reviewed impact factor journal

Abstract
In this paper, DEM and stream network are applied to model the Chitral basin watershed in Pakistan with the help of Arc Hydro Tools. The effects of Digital Elevation Model (DEM) reconditioning and threshold value of stream on the accuracy and correctness of watershed modelling and simulation were assessed. To extract drainage networks from DEM, many hydrological algorithms were prepared and for this purpose, D8 algorithm is used on wide scale to define drainage networks and catchments. Regression analysis was also performed on the total catchments and stream threshold values. It is concluded that threshold values of flow accumulation impacts the drainage network extraction; hence resulting in power function y = axb between the total catchments and threshold value. Lower stream threshold value results in more detailed stream network and leads to catchment accuracy.

2) Flood inundation mapping of Golain valley in Chitral using HEC-RAS

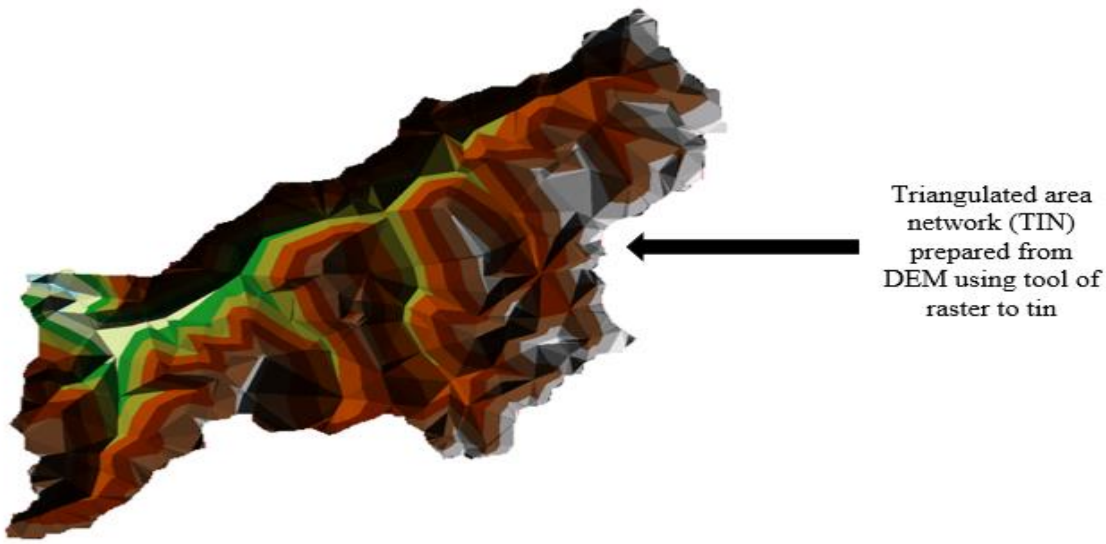
Golain valley is located in the northeast of main town Chitral at a distance of 25 KM between 35^0 53' 08.02" N 72^0 00' 18.88" E latitudes. The main villages of the valley are Rogheli, Istor, Birmogh, Bobakha and Lower Golain (Golain Payeen). There are about 210 households with a total population of about 1700 people in Golain valley. The total length of main Golain valley is nearly 30 KM. It is located on the eastern bank of main Chitral River at an elevation of 7200ft asl. The terrain of the valley is comprised of lofty mountains with steep slopes and deep gorges. The valley is famous for its trout fishes and sweet potato. Subsistence agriculture, orchard raising and livestock are the predominant sources of livelihood of the local population. Besides, presence of glaciers, lakes, rich forests and associated biodiversity also attracts large number of nature loving tourists (both national and international); and as such tourism also supplement local livelihood seasonally. At present due to initiation of mega infrastructural project of Hydle Power station, off-farm labor has also emerged as a significant mean of livelihood for the local communities of Golain. Majority of the local population in Golain belongs to Sunni sect of Islam. Golain valley has been subject to natural disasters since 1970s (available records). However, the intensity and severity of the disasters have increased in recent years especially from 2000 onward. The first GLOF event in Golain valley was witnessed in 1989. In 2000 a heavy flood originated from Golain valley (in Rogheli Gol) and washed away nearly 40 houses in the downstream villages, including village of Koghozi on Chitral Mastuj Road. The link road of valley was also completely destroyed by the floods of 1987, 1989, 2000, 2004, 2008 and 2010.

Methodology In this study the hydraulic modelling was performed using HEC-RAS and steady flow analysis was computed for main golain river. The datasets that were used in this study are SRTM DEM 30m, flow data and landuse shapefile for golain valley. The detailed methodology is mentioned below;

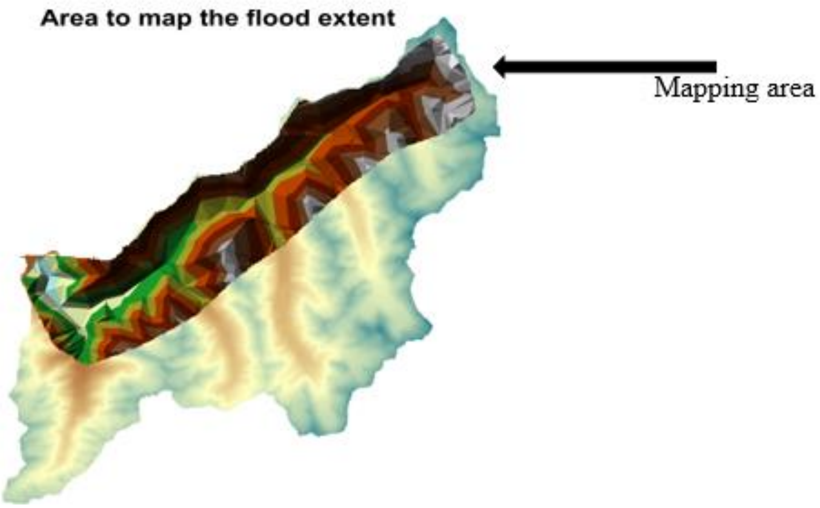


Raster to TIN

The requirement for HEC-RAS to produce flood plain maps is TIN which stands for triangulated irregular network. So, for that raster dataset was converted into TIN, shown below;

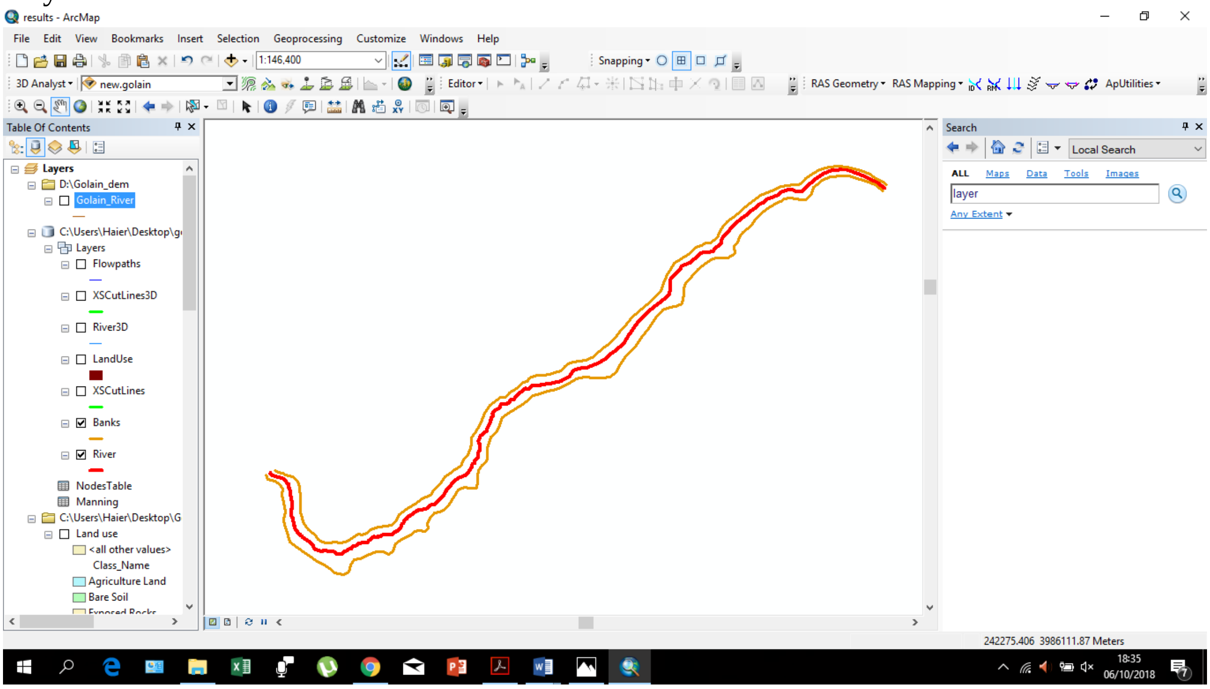


Study Area Identification

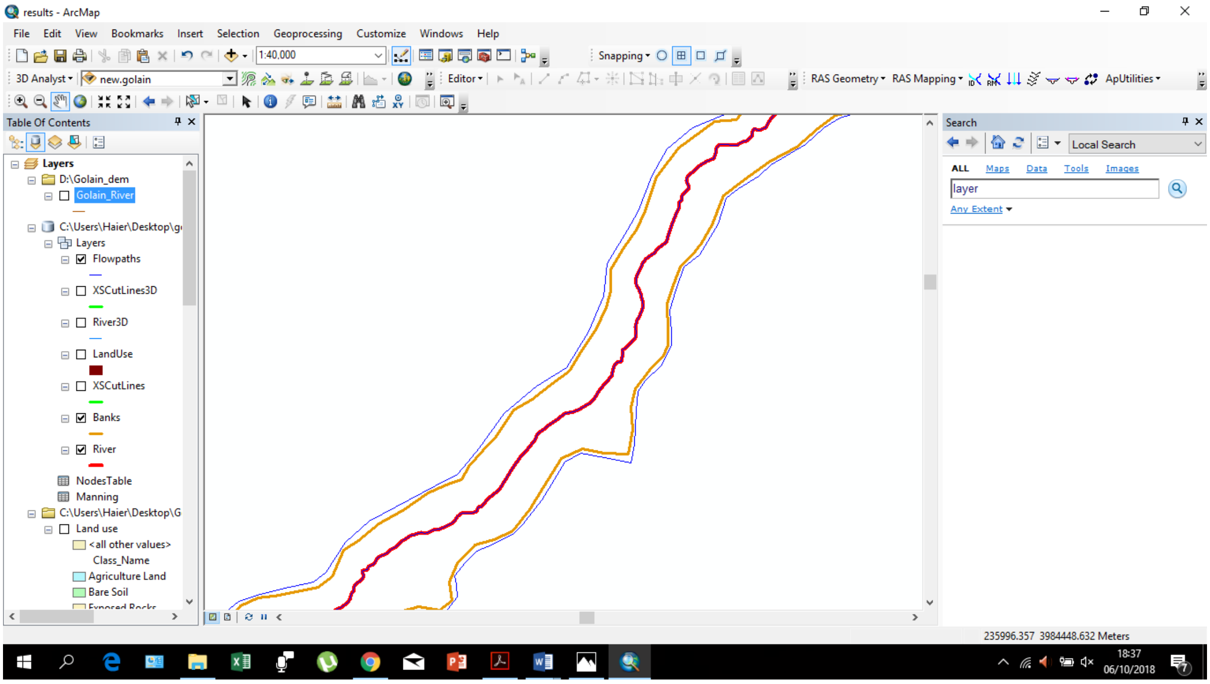


Digitization

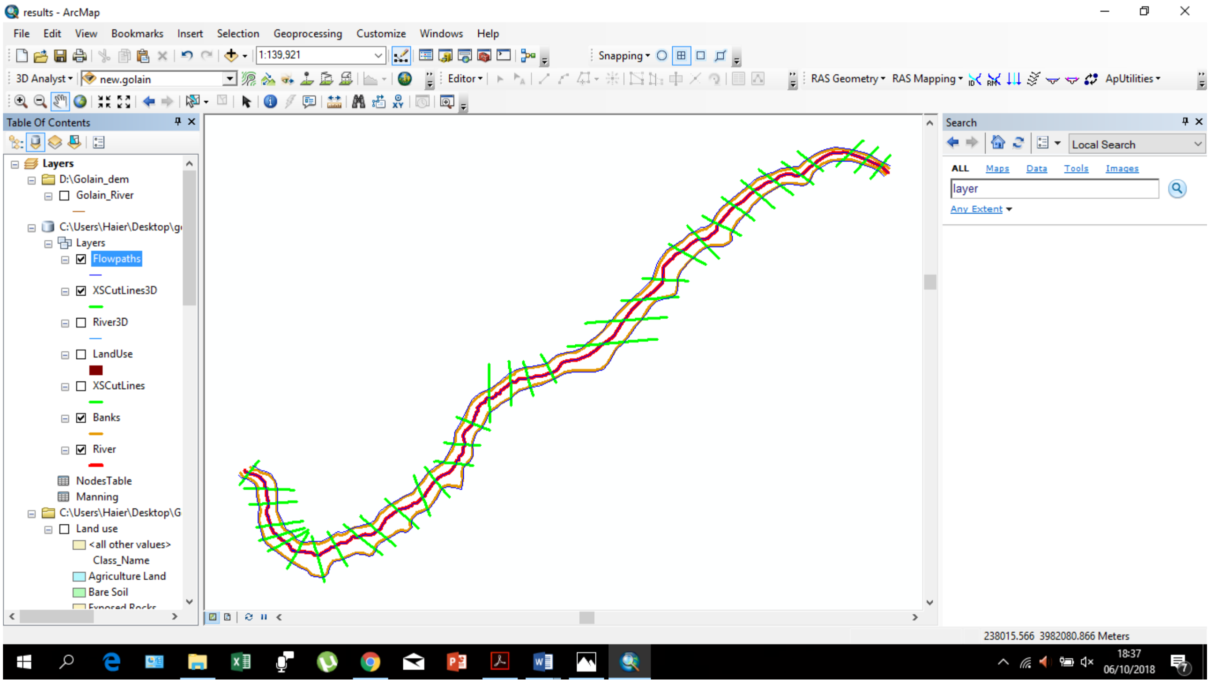
The river centerline is used to establish the river reach network for HEC-RAS. First step was digitization of river. River was digitized from upper stream and ended at lower stream, after then tributaries were digitized in the same sequence as river. River code and Reach code were also assigned. Bank lines are used to distinguish the main channel from the overbank floodplain areas. Information related to bank locations is used to assign different properties for cross-sections. For example, compared to the main channel, overbank areas are assigned higher values of Manning's n to account for more roughness caused by vegetation. Creating bank lines is similar to creating the channel centerline, but there are no specific guideless with regard to line orientation and connectivity - they can be digitized either along the flow direction or against the flow direction, or may be continuous or broken.

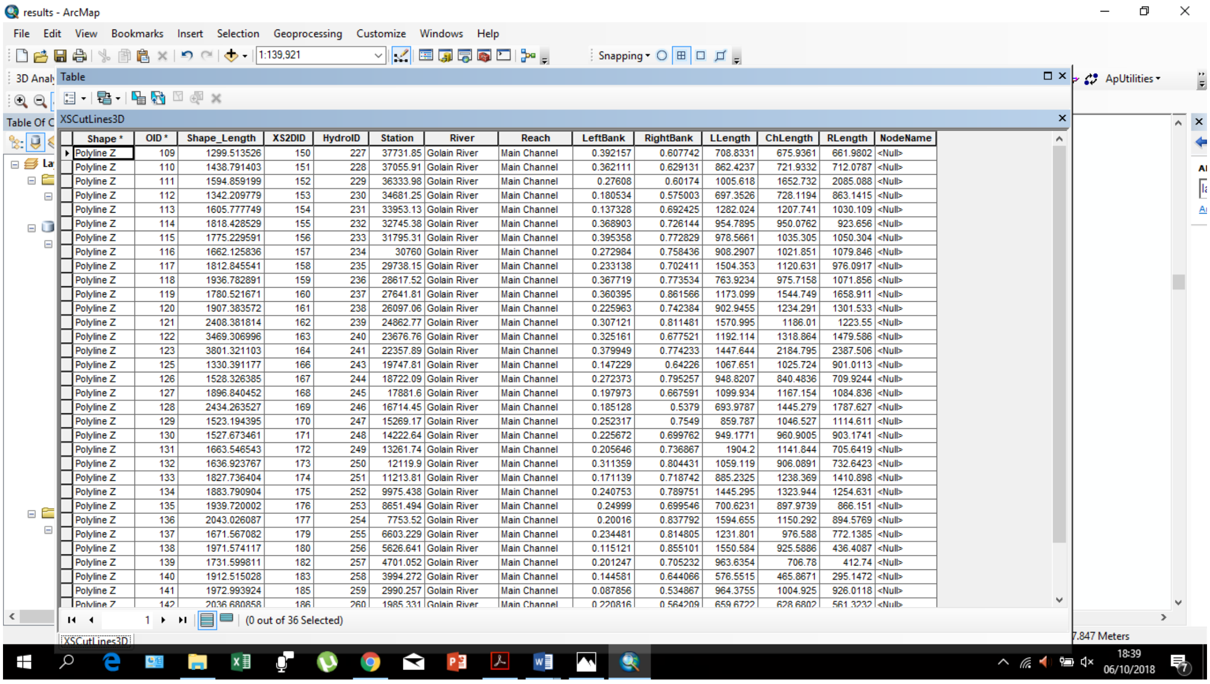


The flowpath layer contains three types of lines: centerline, left overbank, and right overbank. The flowpath lines are used to determine the downstream reach lengths between cross-sections in the main channel and over bank areas. Flow paths were digitized by same procedure as creating banks



Cross-sections are one of the key inputs to HEC-RAS. Cross-section cutlines are used to extract the elevation data from the terrain to create a ground profile across channel flow. The intersection of cutlines with other RAS layers such as centerline and flow path lines are used to compute HEC-RAS attributes such as bank stations (locations that separate main channel from the floodplain), downstream reach lengths (distance between cross-sections) and Mannings n.





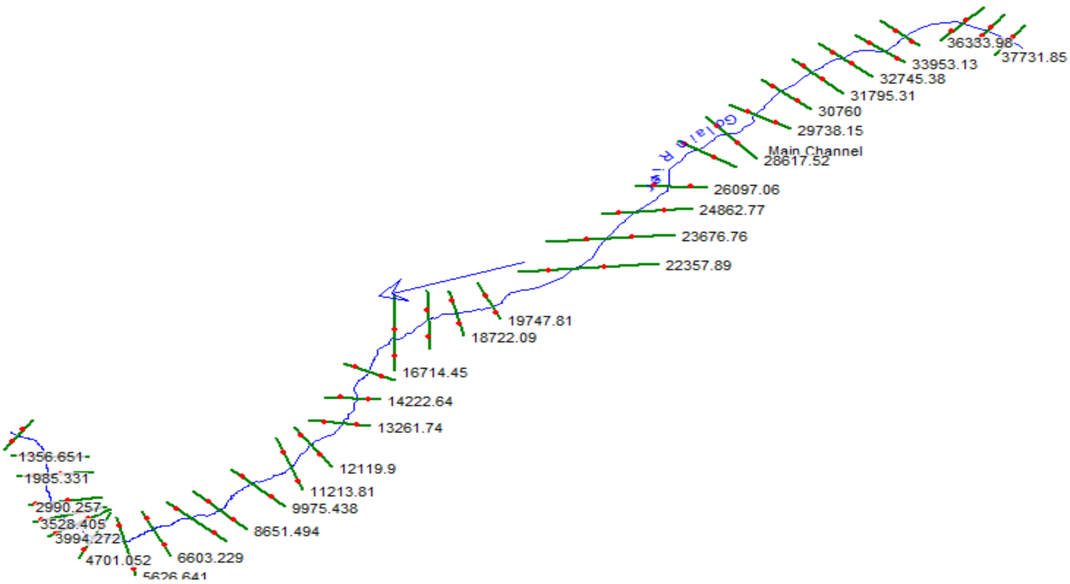
XSCutLines3D

Shape *	OID *	Shape_Length	XS2DID	HydroID	Station	River	Reach	LeftBank	RightBank	LLength	ChLength	RLength	NodeName
Polyline Z	109	1299.513526	150	227	37731.85	Golain River	Main Channel	0.392157	0.607742	708.8331	675.9361	661.9802	<Null>
Polyline Z	110	1438.791403	151	228	37055.91	Golain River	Main Channel	0.362111	0.629131	862.4237	721.9332	712.0787	<Null>
Polyline Z	111	1594.859199	152	229	36333.98	Golain River	Main Channel	0.27608	0.60174	1005.618	1652.732	2085.088	<Null>
Polyline Z	112	1342.209779	153	230	34681.25	Golain River	Main Channel	0.180534	0.575003	697.3526	728.1194	863.1415	<Null>
Polyline Z	113	1605.777749	154	231	33953.13	Golain River	Main Channel	0.137328	0.692425	1282.024	1207.741	1030.109	<Null>
Polyline Z	114	1818.428529	155	232	32745.38	Golain River	Main Channel	0.368903	0.726144	954.7895	950.0762	923.656	<Null>
Polyline Z	115	1775.229591	156	233	31795.31	Golain River	Main Channel	0.395358	0.772829	978.5661	1035.305	1050.304	<Null>
Polyline Z	116	1662.125836	157	234	30760	Golain River	Main Channel	0.272984	0.758436	908.2907	1021.851	1079.846	<Null>
Polyline Z	117	1812.845541	158	235	29738.15	Golain River	Main Channel	0.233138	0.702411	1504.353	1120.631	976.0917	<Null>
Polyline Z	118	1936.782891	159	236	28617.52	Golain River	Main Channel	0.367719	0.773534	763.9234	975.7158	1071.856	<Null>
Polyline Z	119	1780.521671	160	237	27641.81	Golain River	Main Channel	0.360395	0.861566	1173.099	1544.749	1658.911	<Null>
Polyline Z	120	1907.383572	161	238	26097.06	Golain River	Main Channel	0.225963	0.742384	902.9455	1234.291	1301.533	<Null>
Polyline Z	121	2408.381814	162	239	24862.77	Golain River	Main Channel	0.307121	0.811481	1570.995	1186.01	1223.55	<Null>
Polyline Z	122	3469.306996	163	240	23676.76	Golain River	Main Channel	0.325161	0.677521	1192.114	1318.864	1479.586	<Null>
Polyline Z	123	3801.321103	164	241	22357.89	Golain River	Main Channel	0.379949	0.774233	1447.644	2184.795	2387.506	<Null>
Polyline Z	125	1330.391177	166	243	19747.81	Golain River	Main Channel	0.147229	0.64226	1067.651	1025.724	901.0113	<Null>
Polyline Z	126	1528.326385	167	244	18722.09	Golain River	Main Channel	0.272373	0.795257	948.8207	840.4836	709.9244	<Null>
Polyline Z	127	1896.840452	168	245	17881.6	Golain River	Main Channel	0.197973	0.667591	1099.934	1167.154	1084.836	<Null>
Polyline Z	128	2434.263527	169	246	16714.45	Golain River	Main Channel	0.185128	0.5379	693.9787	1445.279	1787.627	<Null>
Polyline Z	129	1523.194395	170	247	15269.17	Golain River	Main Channel	0.252317	0.7549	859.787	1046.527	1114.611	<Null>
Polyline Z	130	1527.673461	171	248	14222.64	Golain River	Main Channel	0.225672	0.699762	949.1771	960.9005	903.1741	<Null>
Polyline Z	131	1663.546543	172	249	13261.74	Golain River	Main Channel	0.205646	0.736867	1904.2	1141.844	705.6419	<Null>
Polyline Z	132	1636.923767	173	250	12119.9	Golain River	Main Channel	0.311359	0.804431	1059.119	906.0891	732.6423	<Null>
Polyline Z	133	1827.736404	174	251	11213.81	Golain River	Main Channel	0.171139	0.718742	885.2325	1238.369	1410.898	<Null>
Polyline Z	134	1883.790904	175	252	9975.438	Golain River	Main Channel	0.240753	0.789751	1445.295	1323.944	1254.631	<Null>
Polyline Z	135	1939.720002	176	253	8651.494	Golain River	Main Channel	0.24999	0.699546	700.6231	897.9739	866.151	<Null>
Polyline Z	136	2043.026087	177	254	7753.52	Golain River	Main Channel	0.20016	0.837792	1594.655	1150.292	894.5769	<Null>
Polyline Z	137	1671.567082	179	255	6603.229	Golain River	Main Channel	0.234481	0.814805	1231.801	976.588	772.1385	<Null>
Polyline Z	138	1971.574117	180	256	5626.641	Golain River	Main Channel	0.115121	0.855101	1550.584	925.5886	436.4087	<Null>
Polyline Z	139	1731.599811	182	257	4701.052	Golain River	Main Channel	0.201247	0.705232	963.6354	706.78	412.74	<Null>
Polyline Z	140	1912.515028	183	258	3994.272	Golain River	Main Channel	0.144581	0.644066	576.5515	465.8671	295.1472	<Null>
Polyline Z	141	1972.993924	185	259	2990.257	Golain River	Main Channel	0.087856	0.534867	964.3755	1004.925	926.0118	<Null>
Polyline Z	142	2036.680858	186	260	1985.331	Golain River	Main Channel	0.220816	0.564209	659.6722	628.6802	561.3232	<Null>

(0 out of 36 Selected)

Importing Geometry data file into HEC-RAS

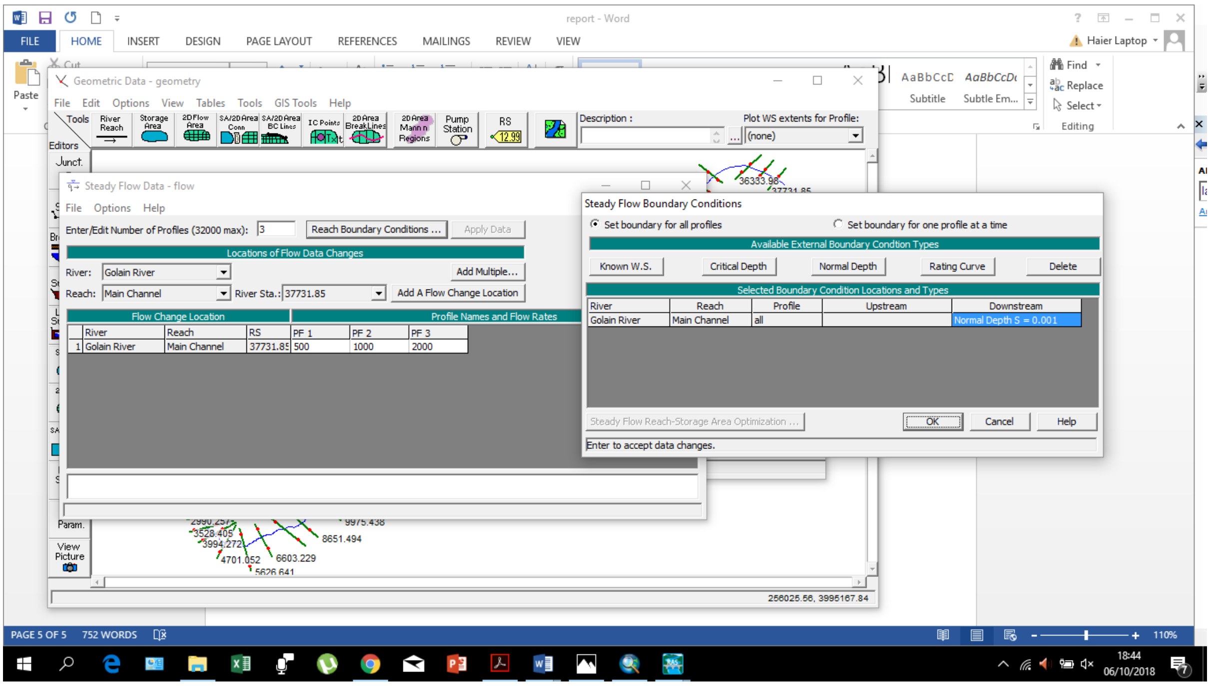
Then the data was imported to the Hec-RAS. Quality check was performed on the data to make sure no erroneous information was imported from GIS. All the geometric data was edited In the Geometric editor toolbar in Hec_RAS



HEC-RAS view of study area

Flow data and boundary conditions

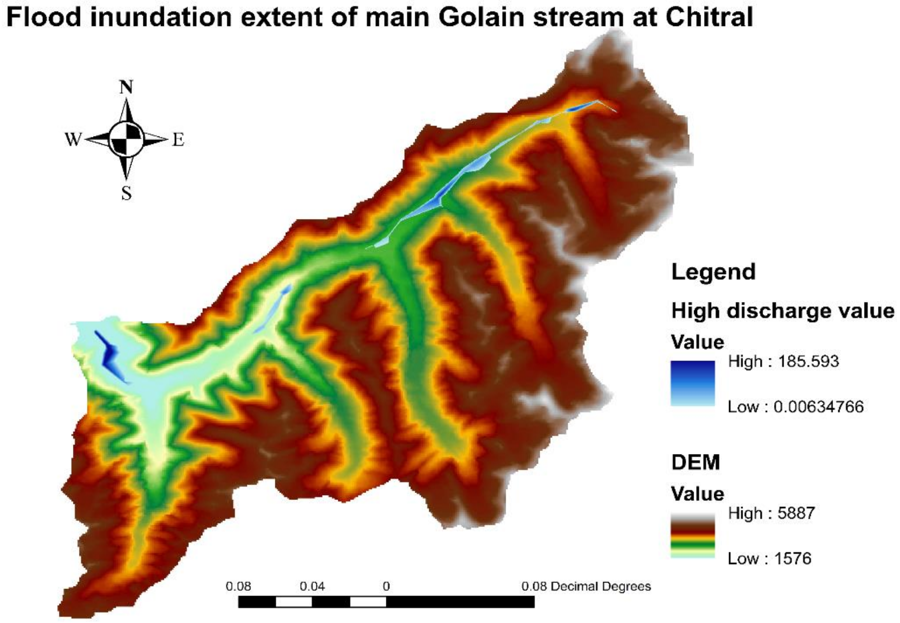
Flows are typically defined at the most upstream location of each river/tributary, and at junctions. There are situations where you need to define flows at additional locations, so for this purpose following details were entered

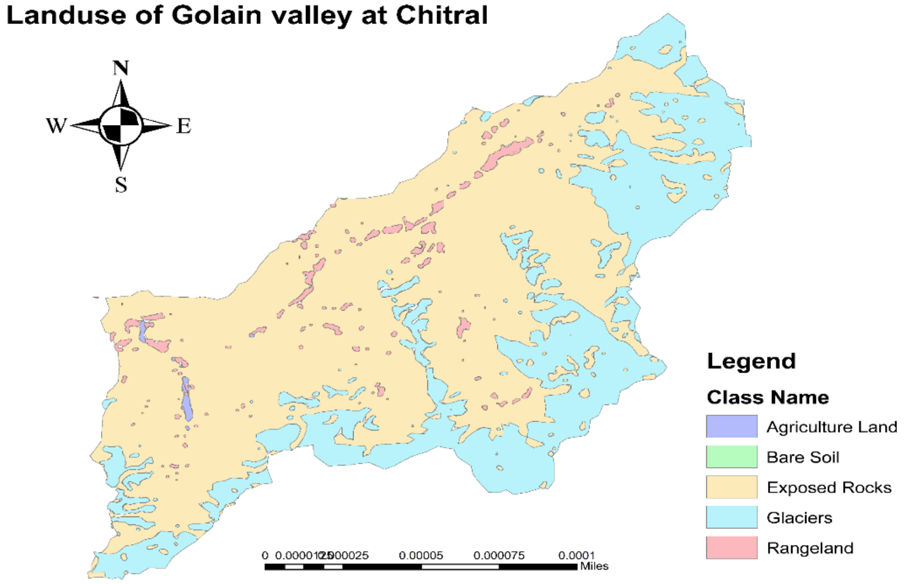


Mapping in Golain valley Chitral

After successfully running the steady flow computations in HEC-RAS we now export back this data into Arcmap for preparing maps, and the post processing of HEC-RAS.xml file is done through GeoRas. RAS mapping will create a bounding polygon, which basically defines the analysis extent for inundation mapping, by connecting the endpoints of XS Cut Lines.

After the analysis extent is defined, we are ready to map the inundation extent. The area with positive results (meaning water surface is higher than the terrain) is flood area, and the area with negative results is dry. All the cells in water surface grid that result in positive values after subtraction are converted to a polygon, which is the final flood inundation polygon.





Conclusions

Steady flow simulation was performed in HEC-RAS. Three flood profiles were generated in this study that is low, medium and high. But only PF 3 with discharge of 2000 cusecs was used in computations. The flood extent map produced using HEC-RAS analysis represents a flood extent area on DEM. This is essential in planning mitigation/evacuation operations as it gives simple analysis on which settlements are going to be submerged and to what area should the population be relocated as it gives the extents of the flood coverage. Based on results produced in the wake of flood modeling, the authorities can plan mitigation strategies beforehand to lower the risk of flooding. Planning of evacuation operations will also be made easy with the aid of flood coverage maps.