



GIS Applications in the Mosul Dam Safety

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Introduction

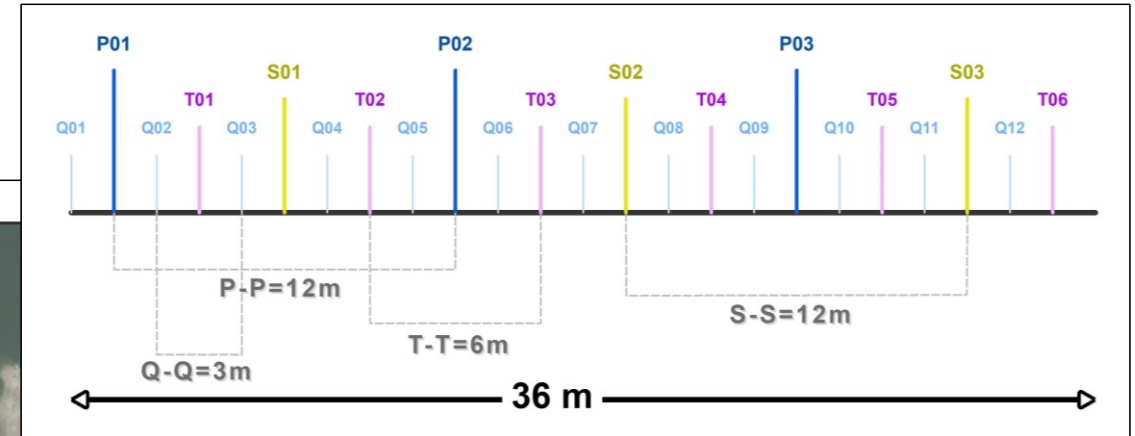
Mosul Dam consists of complex geological foundations contains water soluble materials, including gypsum and anhydrite, which can dissolve, forming voids and networks of seepage pathways beneath the dam that could threaten the stability of the foundation.

As part of the original design, a gallery was constructed at the base of the dam that allows workers to drill into the foundation and pump in grout, which consists of a mixture of cement, water, and bentonite, a type of clay.

Mosul Dam has had a maintenance grouting program in place since construction was completed.



Dam Axis is divided into several sections for grouting, in the grouting gallery and crest, The Length of section is 36m, contain 3 lines (Upstream, Midstream & Downstream), the Boreholes sequence is as follows:





Mosul Dam GIS

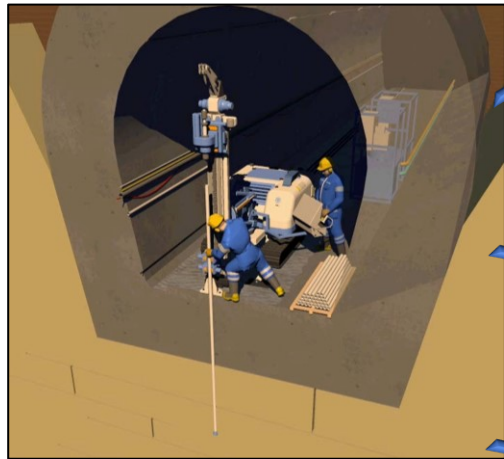
Mosul Dam has a large database in Drilling and Grouting operations, Piezometers rate, Sensor instrumentations, Exploratory Holes Information and Geological information, It is difficult to manage and analyse this data, must be used special programs for that.

The GIS program is used in Mosul Dam for managing, collecting and analysing this data through custom python scripts tools and methods for the purpose of representing the data in 2D Plan, 2D Profile and 3D modeling.



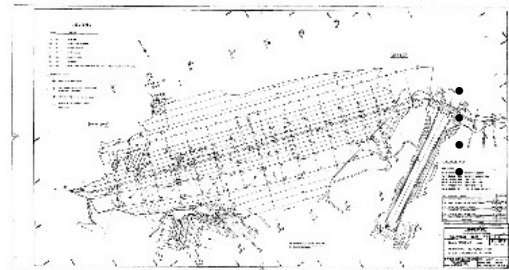
Mosul Dam GIS Data Infrastructure

Construction Data Generation

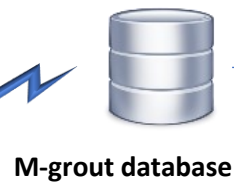


- Drilling & Grouting
- WPT, Flow Rates, Artesian Pressures
- QA Observations & Notes
- Core Log

Historical Documents



- As built
- Historical Grouting Information
- Instrumentation Data
- Boring Logs and Installation Diagrams



M-grout database



QA database



IDAT database (Pz)



Intranet

GIS Data

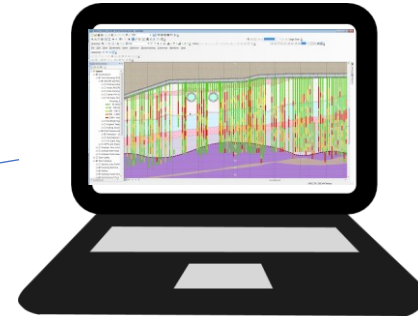


- Geoprocessing
- Visualization
- Custom Tools

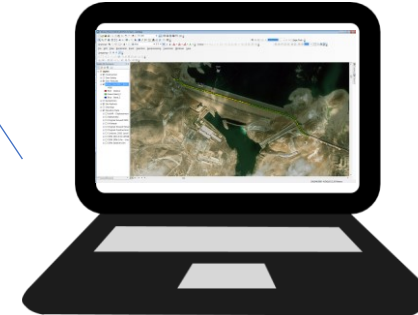
3D View



2D Profile



2D Plan





Topics

- Drilling & Grouting Analysis Data
- Instrumentation Piezometers Process in ArcGIS
- Core log (gINT Data) conversion and processing



• Drilling & Grouting Analysis Data

Output Data

Input Data

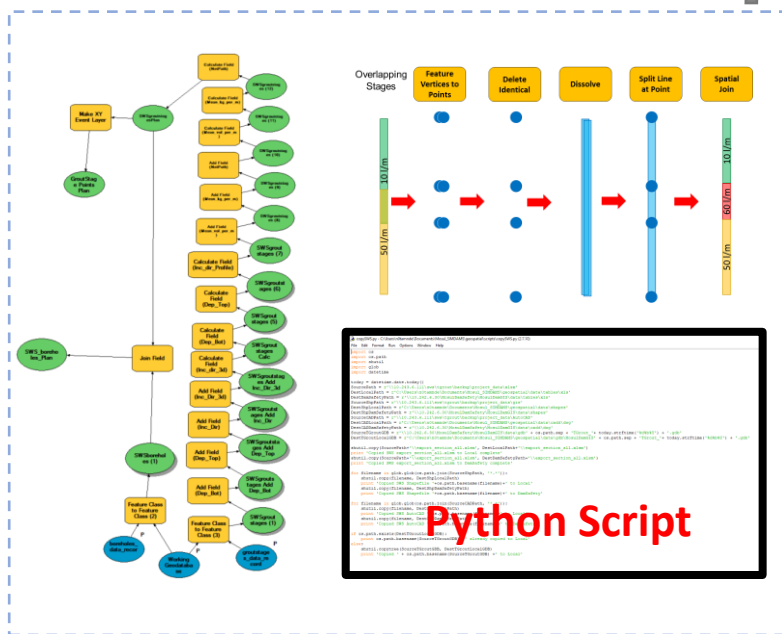
ID	DATE	DEPTH	DIAMETER	STAGE	STATUS
03S-U-P01_02_40	1129 13 42	842 P42 M042	338 38	1 ZONESTAGE	COMPLETED
03S-U-P01_02_40	1129 13 42	842 P42 M042	338 38	2 ZONESTAGE	COMPLETED
03S-U-P01_02_40	1129 13 42	842 P42 M042	338 38	3 ZONESTAGE	COMPLETED
03S-U-P01_02_40	1129 13 42	842 P42 M042	338 38	4 ZONESTAGE	COMPLETED

export_section_all.xlsx

ID	DATE	DEPTH	DIAMETER	STAGE	STATUS		
02S-U-Q07_18 90	02S-U-Q07	18 90	307306 2740	4055240 80	338 1348	817 83394	-1.099547
02S-U-Q07_17 80	02S-U-Q07	17 80	307307 2717	4055240 345	338 141	816 14178	-1.099911
02S-U-Q07_16 80	02S-U-Q07	16 80	307308 2694	4055240 690	338 147	815 14356	-1.099513

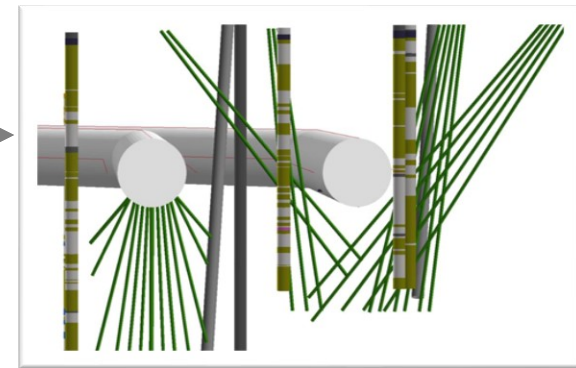
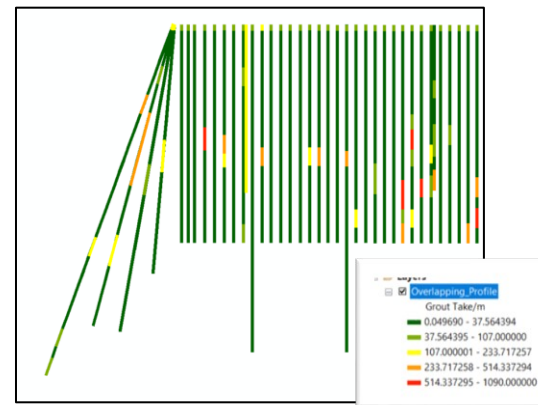
BoreholesCoordinatesMaster.xlsx

Processing



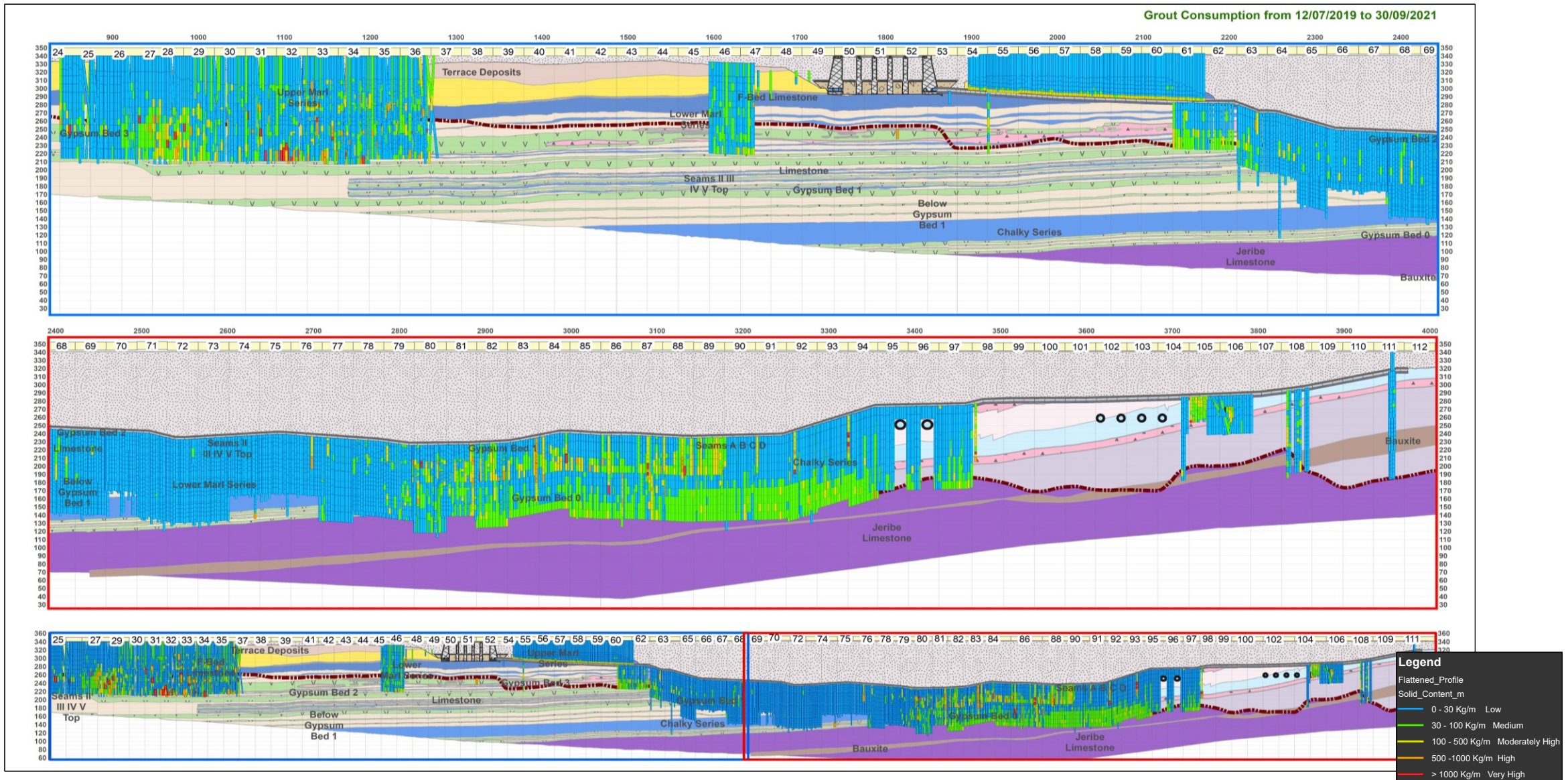
GIS Data

- Name
- Old
- TGrout.gdb
- gINT_Features.gdb
- Mgrout_04Mar2021.gdb
- Mgrout_31Dec2020.gdb
- Mosul_Dam_Cross_Sections.gdb
- Mosul_Dam_Features.gdb
- Mosul_Dam_Features_3d.gdb
- Mosul_Dam_Raster.gdb
- Mosul_Dam_Tables.gdb
- QA_Issues_Communication.gdb
- QA_Issues_MoWR.gdb
- TGrout_03Aug2019.gdb
- TGrout_04Aug2019.gdb
- TGrout_30Aug2019.gdb



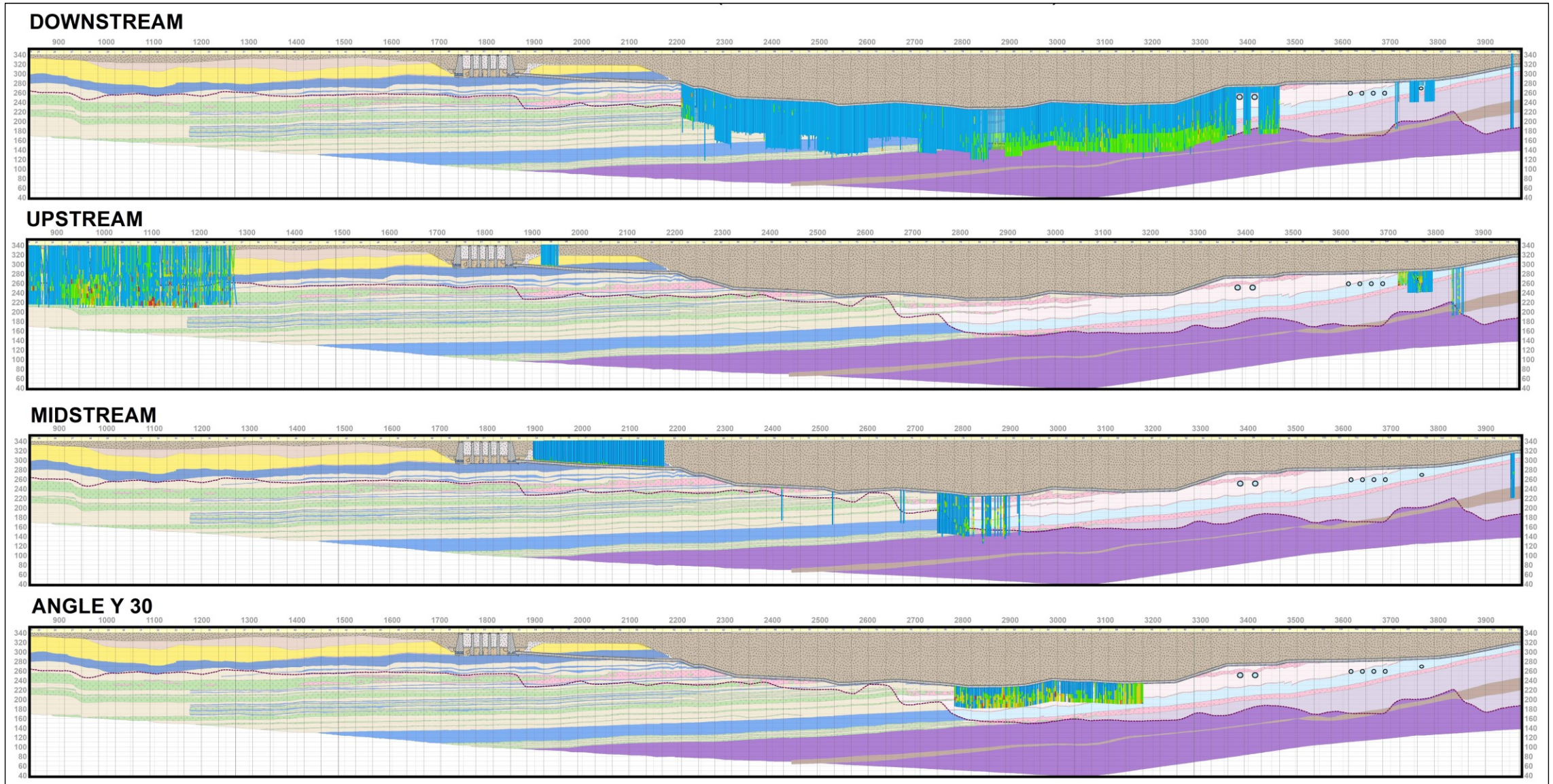


Geological profile with Grouting Boreholes appear grout takes



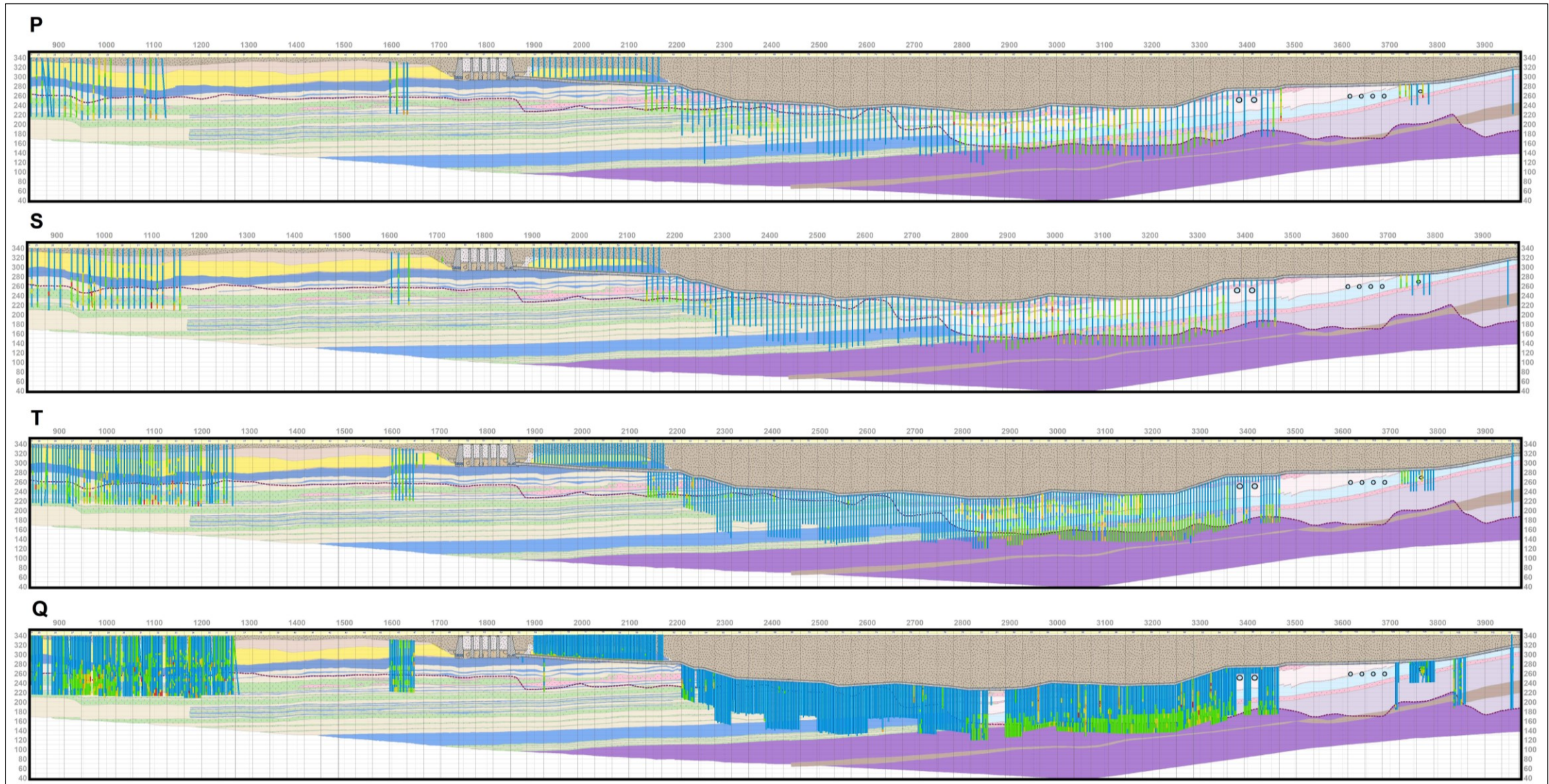


View DUMMY Grouting profile



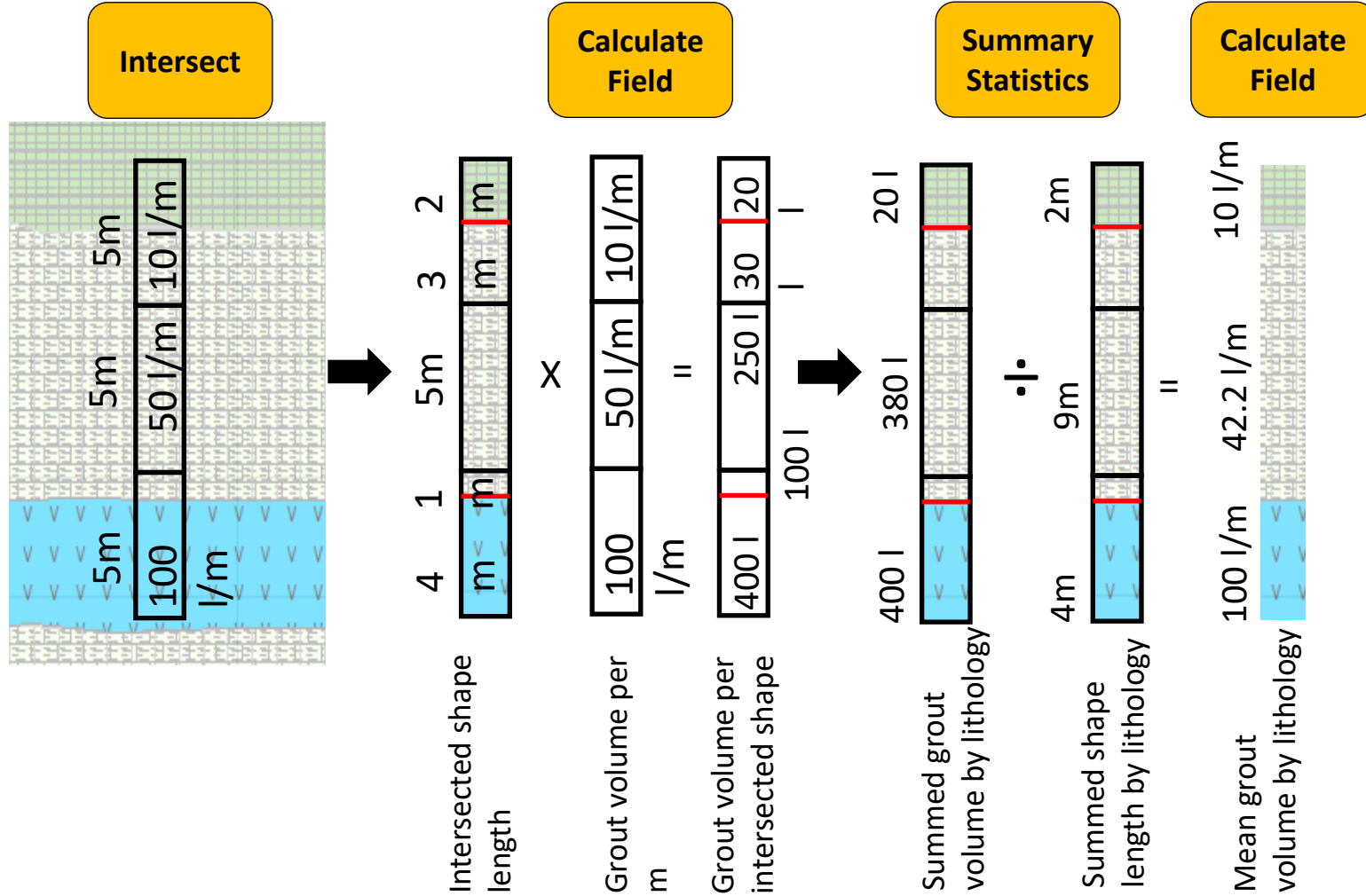


View PSTQ Grouting profile





Determine Mean Grout Volume By Lithology



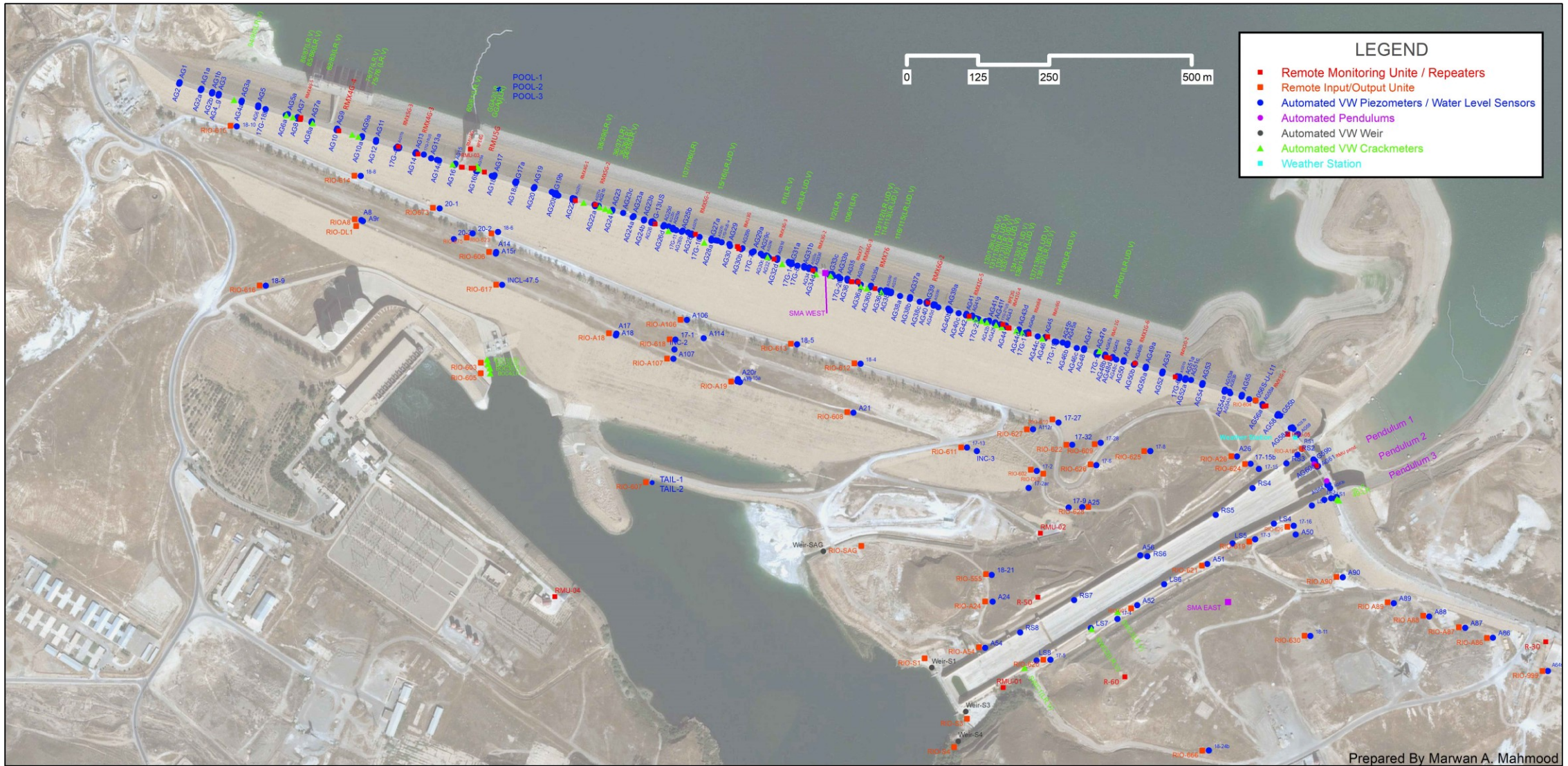


Total Kilograms of Solid Injected by Geological layers from (13 July 2019 - 31 Dec 2020)

Sections	(16-24)	(25-39)	(40-47)	(48-53)	(54-62)	(63-71)	(72-75)	(76-88)	(89-92)	(93-105)	(106-128)	(129-136)
Formations	Left Bank Extention	Fuse Plug	West Saddle Dam	Spillway	Grouting Tunnel	Left Abutment	Left Valley	Deep Valley	Riverbed	Right Valley	Right Abutment	Far Right Abutment
OB		64,086.43										
UM		222,144.35										
F-Bed		163,836.96		161.27	712.54							
LM04		292,025.65			1,959.84	932.61						
LST-1		2,666.45			167.26	17.43						
LST-2		1,797.32			350.25	671.98						
GB3		305,473.29		5,498.45	392.51	5,416.91						
LM03		256,417.54			1,959.18	5,631.05						
LST-3		6,056.48			46.89	610.28						
LST-4		7,914.61			368.05	950.62						
GB2		11,041.62			1,228.37	23,596.90						
LM02						38,211.01	11,536.65	42,480.32	310.63			
GB1						8,233.81	3,855.11	62,373.47	17.52	2,299.08		
LM01						11,424.47	4,980.83	135,767.25	440.90			
UGB						2,508.12	1,171.10	52,502.66	80.44			
LM0						19,998.07	15,368.74	507,595.06	47,111.78	92,549.77	5,386.55	
GB0						370.92	5,361.96	66,907.74	12,032.12	23,079.60	3,748.07	
Je						6.24	10.59	105,939.02	71,968.11	6,903.50	22,547.53	
Ba										35.84	5,542.20	
Ja											4,979.49	
Total		1,333,460.69		5,659.72	7,184.88	118,580.43	42,284.97	973,565.52	131,961.50	124,867.79	42,203.84	

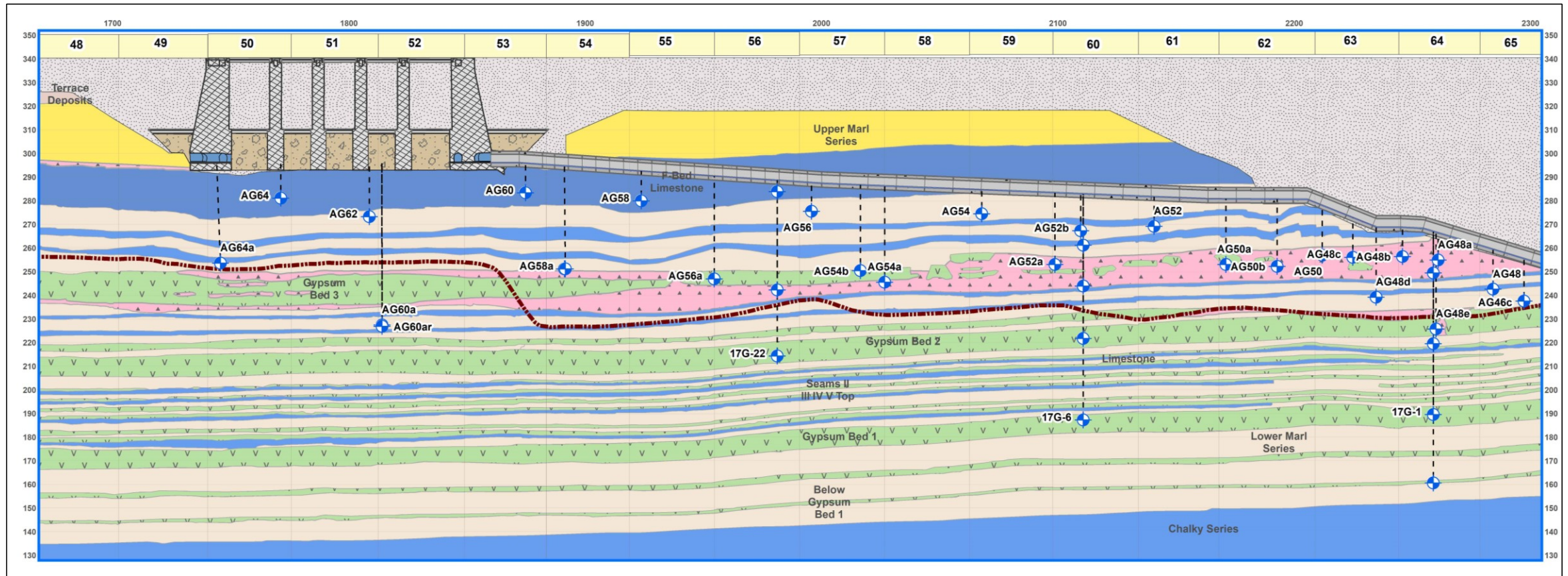


Instrumentation Piezometers Process in GIS



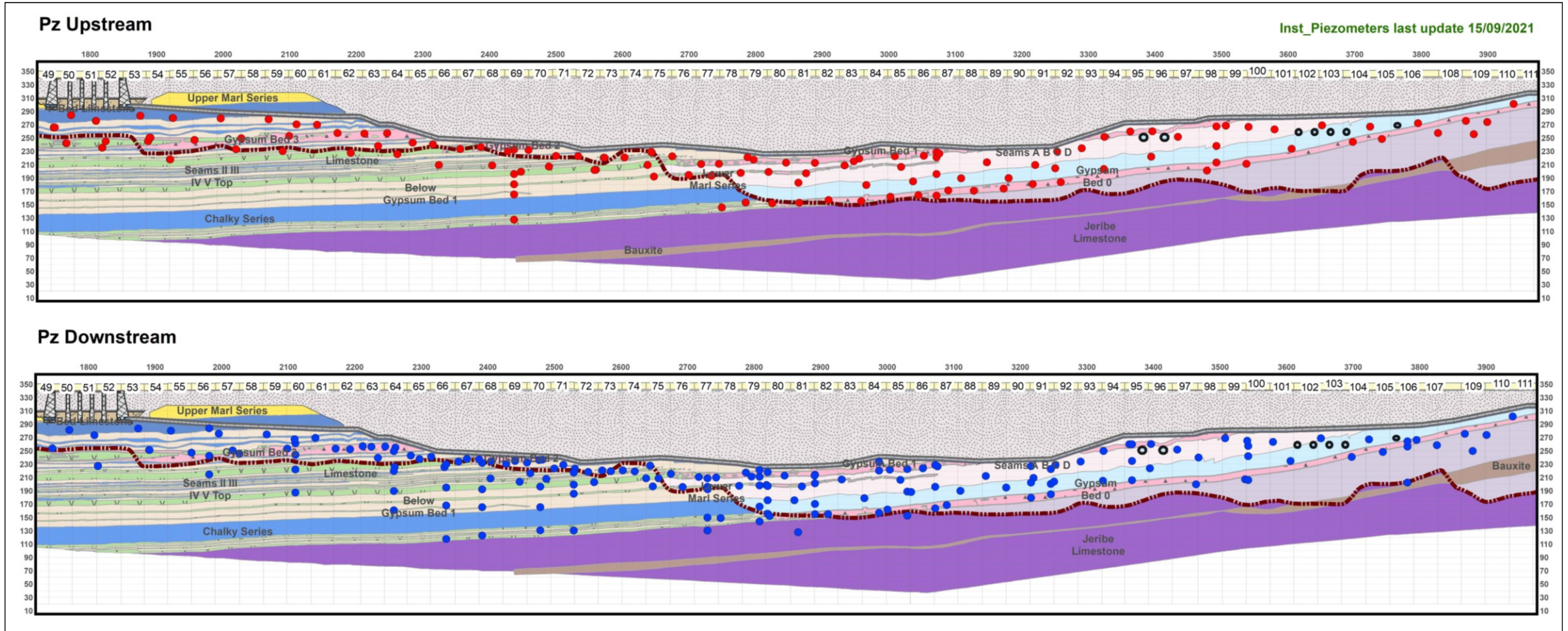


Mosul dam profile showing sensors location by geological layers



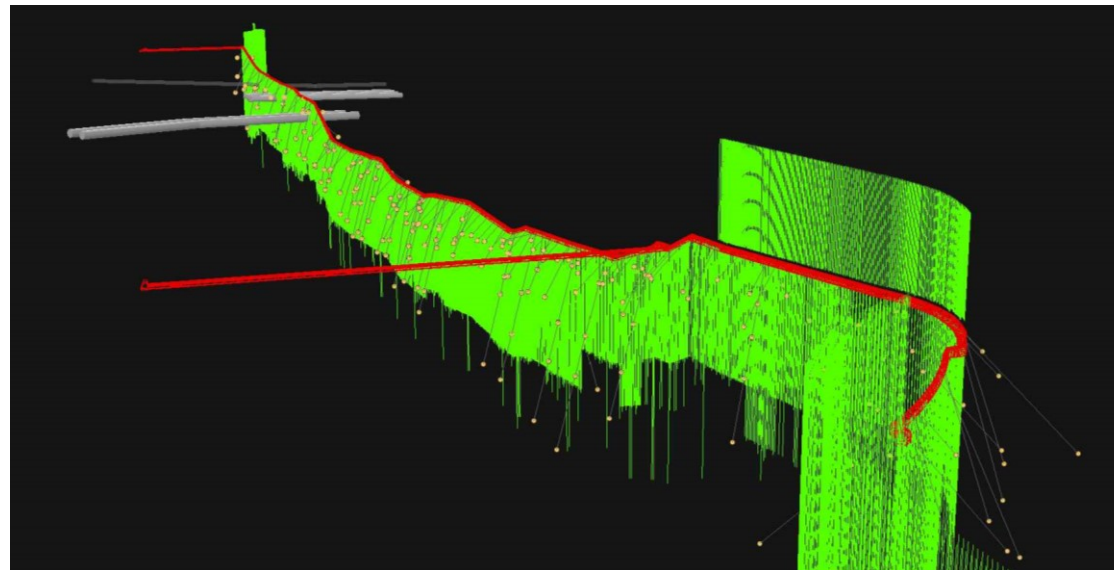
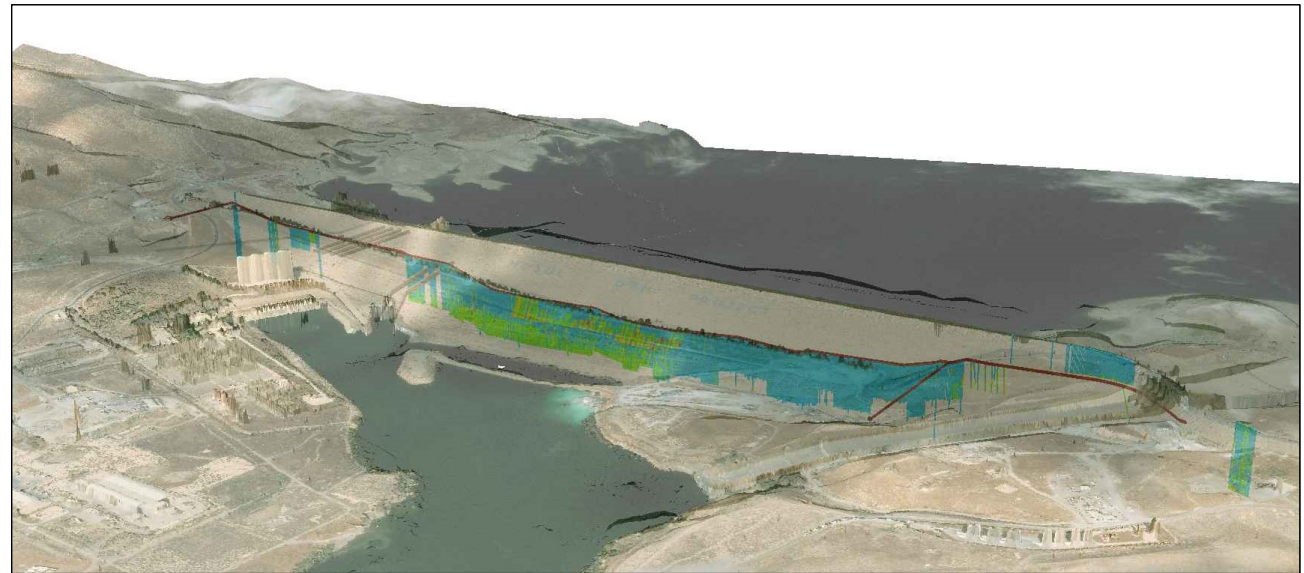


Geological profile showing sensors location for upstream and downstream location of the dam axis





3D model for Piezometers sensor and grouting curtain

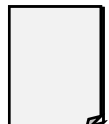




Core log (gINT Data) Processing

The Special tools in ArcGIS program are used to manipulate tabular data of gINT database for core log (MS Access, Excel, or CSV) to produce GIS features.

Paper Logs



gINT program



Convert Data

Well ID	Depth (m)	Stage	Material	Start Elevation (m)	End Elevation (m)	Remarks
0000000001	100	5	Uptillage	45	80.00	Start Trench
0000000002	25	4	Uptillage	20	45	Start Trench
0000000003	50	5	Uptillage	15	45	Start Trench
0000000004	75	4	Uptillage	10	45	Start Trench
0000000005	100	3	Uptillage	5	45	Start Trench
0000000006	125	2	Uptillage	0	45	Start Trench
0000000007	150	1	Uptillage	-5	45	Start Trench
0000000008	175	0	Uptillage	-10	45	Start Trench
0000000009	200	0	Uptillage	-15	45	Start Trench
0000000010	225	0	Uptillage	-20	45	Start Trench
0000000011	250	0	Uptillage	-25	45	Start Trench
0000000012	275	0	Uptillage	-30	45	Start Trench
0000000013	300	0	Uptillage	-35	45	Start Trench
0000000014	325	0	Uptillage	-40	45	Start Trench
0000000015	350	0	Uptillage	-45	45	Start Trench
0000000016	375	0	Uptillage	-50	45	Start Trench
0000000017	400	0	Uptillage	-55	45	Start Trench
0000000018	425	0	Uptillage	-60	45	Start Trench
0000000019	450	0	Uptillage	-65	45	Start Trench
0000000020	475	0	Uptillage	-70	45	Start Trench
0000000021	500	0	Uptillage	-75	45	Start Trench
0000000022	525	0	Uptillage	-80	45	Start Trench
0000000023	550	0	Uptillage	-85	45	Start Trench
0000000024	575	0	Uptillage	-90	45	Start Trench
0000000025	600	0	Uptillage	-95	45	Start Trench
0000000026	625	0	Uptillage	-100	45	Start Trench
0000000027	650	0	Uptillage	-105	45	Start Trench
0000000028	675	0	Uptillage	-110	45	Start Trench
0000000029	700	0	Uptillage	-115	45	Start Trench
0000000030	725	0	Uptillage	-120	45	Start Trench
0000000031	750	0	Uptillage	-125	45	Start Trench
0000000032	775	0	Uptillage	-130	45	Start Trench
0000000033	800	0	Uptillage	-135	45	Start Trench
0000000034	825	0	Uptillage	-140	45	Start Trench
0000000035	850	0	Uptillage	-145	45	Start Trench
0000000036	875	0	Uptillage	-150	45	Start Trench
0000000037	900	0	Uptillage	-155	45	Start Trench
0000000038	925	0	Uptillage	-160	45	Start Trench
0000000039	950	0	Uptillage	-165	45	Start Trench
0000000040	975	0	Uptillage	-170	45	Start Trench
0000000041	1000	0	Uptillage	-175	45	Start Trench
0000000042	1025	0	Uptillage	-180	45	Start Trench
0000000043	1050	0	Uptillage	-185	45	Start Trench
0000000044	1075	0	Uptillage	-190	45	Start Trench
0000000045	1100	0	Uptillage	-195	45	Start Trench
0000000046	1125	0	Uptillage	-200	45	Start Trench
0000000047	1150	0	Uptillage	-205	45	Start Trench
0000000048	1175	0	Uptillage	-210	45	Start Trench
0000000049	1200	0	Uptillage	-215	45	Start Trench
0000000050	1225	0	Uptillage	-220	45	Start Trench
0000000051	1250	0	Uptillage	-225	45	Start Trench
0000000052	1275	0	Uptillage	-230	45	Start Trench
0000000053	1300	0	Uptillage	-235	45	Start Trench
0000000054	1325	0	Uptillage	-240	45	Start Trench
0000000055	1350	0	Uptillage	-245	45	Start Trench
0000000056	1375	0	Uptillage	-250	45	Start Trench
0000000057	1400	0	Uptillage	-255	45	Start Trench
0000000058	1425	0	Uptillage	-260	45	Start Trench
0000000059	1450	0	Uptillage	-265	45	Start Trench
0000000060	1475	0	Uptillage	-270	45	Start Trench
0000000061	1500	0	Uptillage	-275	45	Start Trench
0000000062	1525	0	Uptillage	-280	45	Start Trench
0000000063	1550	0	Uptillage	-285	45	Start Trench
0000000064	1575	0	Uptillage	-290	45	Start Trench
0000000065	1600	0	Uptillage	-295	45	Start Trench
0000000066	1625	0	Uptillage	-300	45	Start Trench
0000000067	1650	0	Uptillage	-305	45	Start Trench
0000000068	1675	0	Uptillage	-310	45	Start Trench
0000000069	1700	0	Uptillage	-315	45	Start Trench
0000000070	1725	0	Uptillage	-320	45	Start Trench
0000000071	1750	0	Uptillage	-325	45	Start Trench
0000000072	1775	0	Uptillage	-330	45	Start Trench
0000000073	1800	0	Uptillage	-335	45	Start Trench
0000000074	1825	0	Uptillage	-340	45	Start Trench
0000000075	1850	0	Uptillage	-345	45	Start Trench
0000000076	1875	0	Uptillage	-350	45	Start Trench
0000000077	1900	0	Uptillage	-355	45	Start Trench
0000000078	1925	0	Uptillage	-360	45	Start Trench
0000000079	1950	0	Uptillage	-365	45	Start Trench
0000000080	1975	0	Uptillage	-370	45	Start Trench
0000000081	2000	0	Uptillage	-375	45	Start Trench
0000000082	2025	0	Uptillage	-380	45	Start Trench
0000000083	2050	0	Uptillage	-385	45	Start Trench
0000000084	2075	0	Uptillage	-390	45	Start Trench
0000000085	2100	0	Uptillage	-395	45	Start Trench
0000000086	2125	0	Uptillage	-400	45	Start Trench
0000000087	2150	0	Uptillage	-405	45	Start Trench
0000000088	2175	0	Uptillage	-410	45	Start Trench
0000000089	2200	0	Uptillage	-415	45	Start Trench
0000000090	2225	0	Uptillage	-420	45	Start Trench
0000000091	2250	0	Uptillage	-425	45	Start Trench
0000000092	2275	0	Uptillage	-430	45	Start Trench
0000000093	2300	0	Uptillage	-435	45	Start Trench
0000000094	2325	0	Uptillage	-440	45	Start Trench
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0000000096	2375	0	Uptillage	-450	45	Start Trench
0000000097	2400	0	Uptillage	-455	45	Start Trench
0000000098	2425	0	Uptillage	-460	45	Start Trench
0000000099	2450	0	Uptillage	-465	45	Start Trench
0000000100	2475	0	Uptillage	-470	45	Start Trench

process

From Table
Borehole To 3D
Borehole To Profile
Points to Section

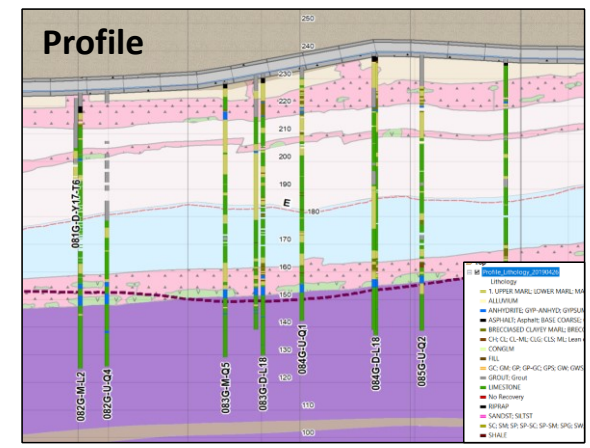
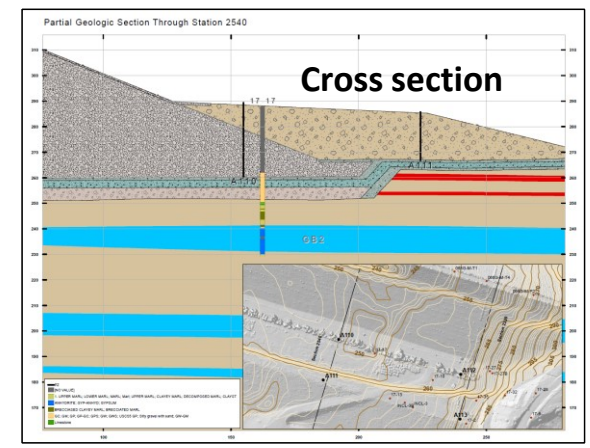
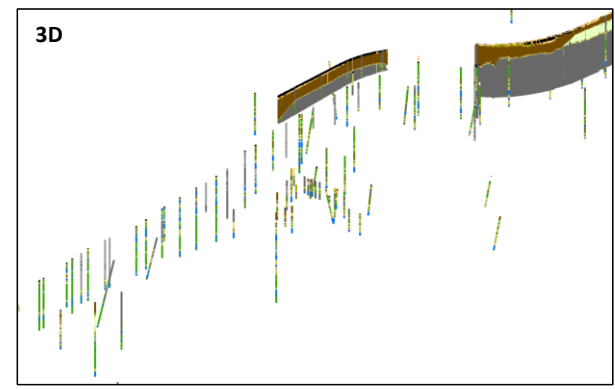
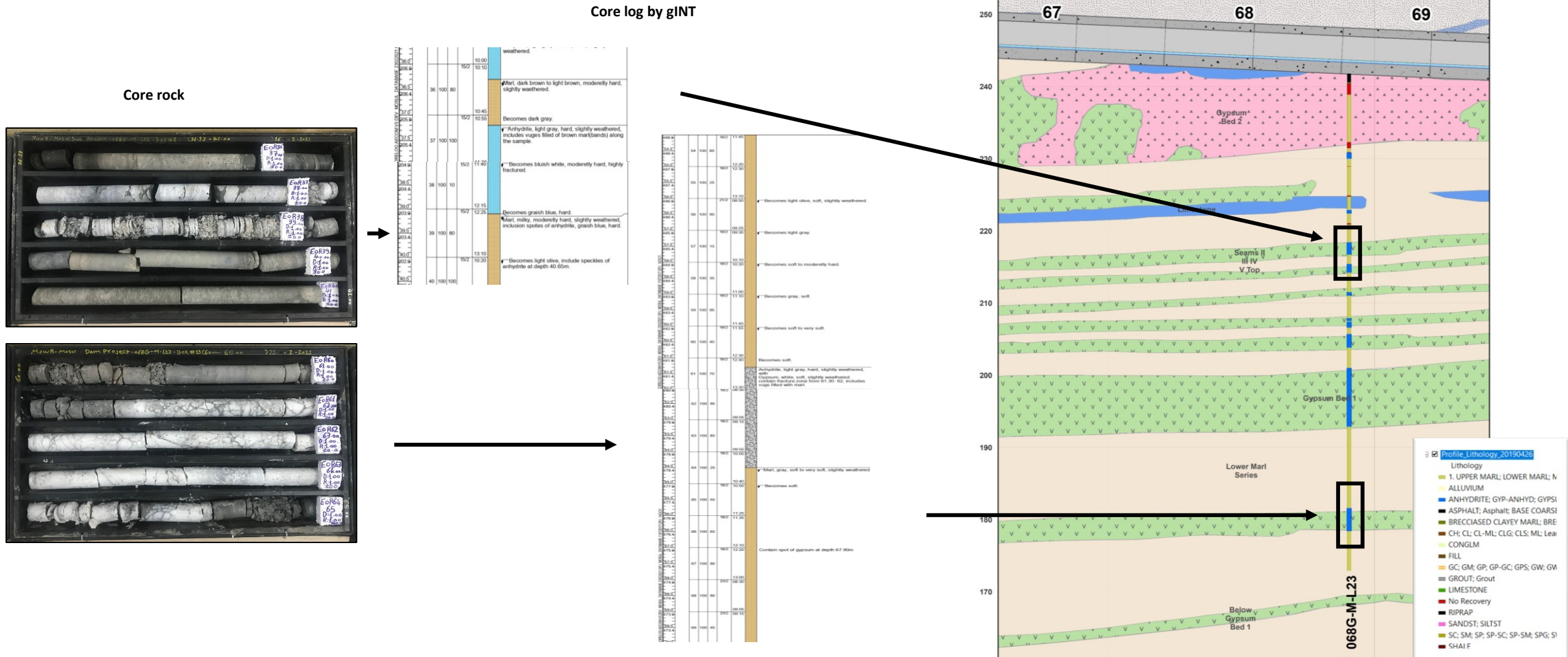




Diagram showing the process of converting data from the field work to gINT program, and then processing it in the ArcGIS for one of the borehole





Thanks