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Computerized Procedure to Analyze the Geometry of Dam Reservoirs - Case of Makhiil Proposed Resevoir

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Computerized Procedure to Analyze the Geometry of Dam Reservoirs - Case of Makhool Proposed Reservoir, Iraq

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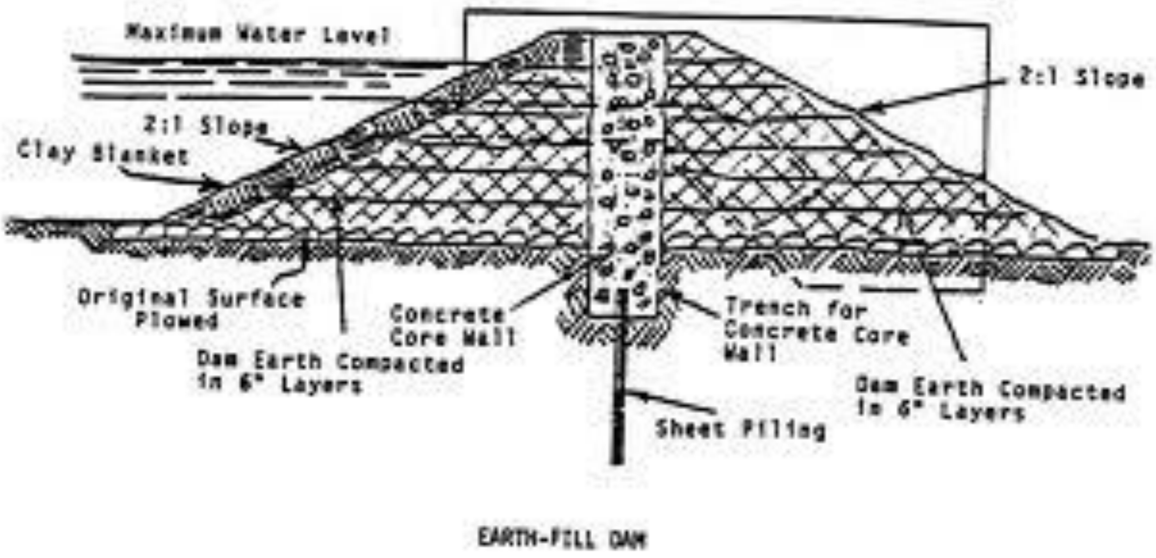
Currently, all the specialists in the field of water resources, politicians, decision makers, and the media, talking about a severe water crisis in Iraq, and the Middle East countries.

While, the real crisis, is the very bad management of water resources in these countries.



Makhul Dam , is one of the proposed dams on Tigris River basin in north of Iraq, it is located after the connection of Tigris River with two main tributaries, Great Zab and Lower Zab, thus, construction of the dam, would lead to control the water surplus in the river and its main tributaries.

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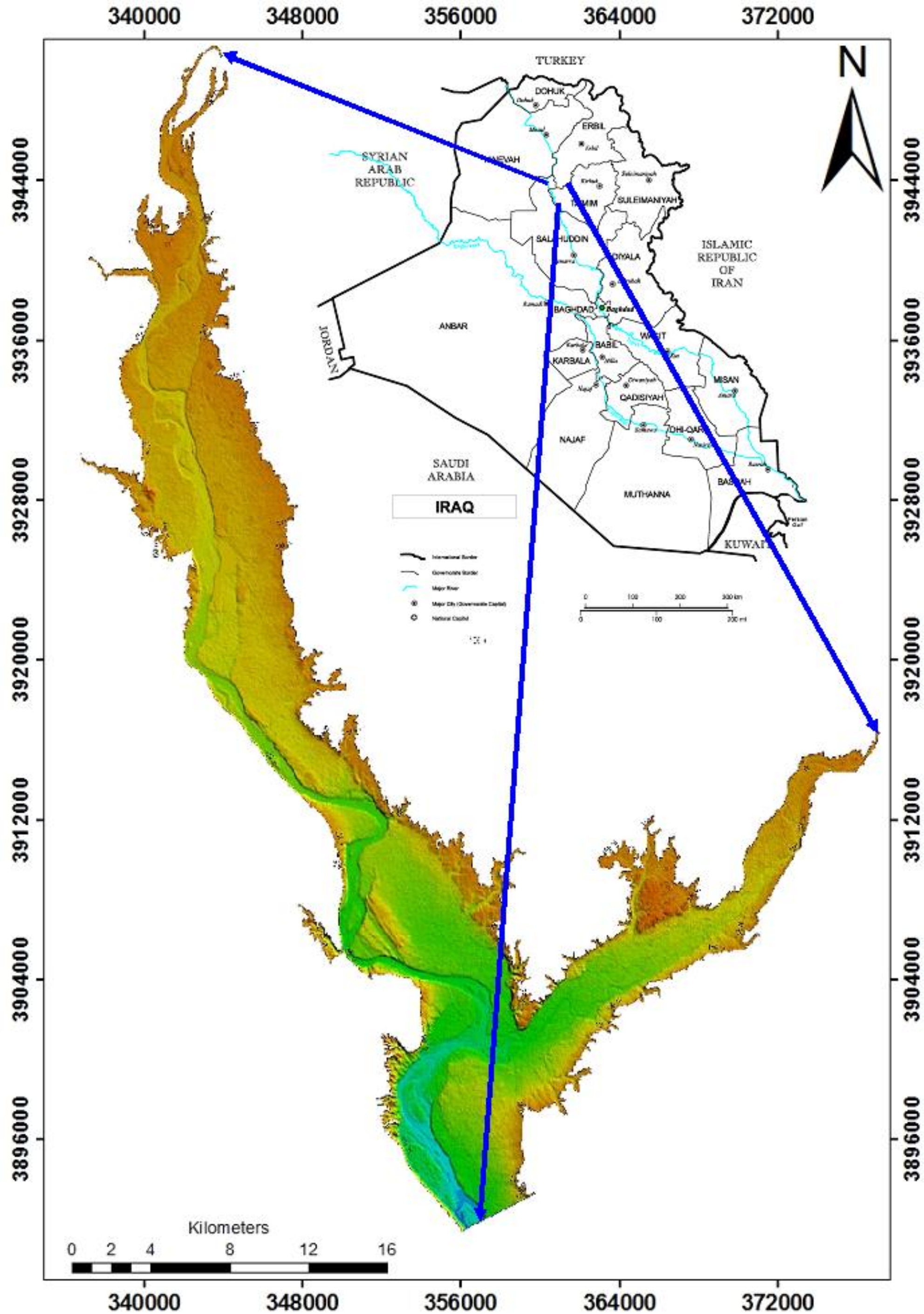
The study of geometrical elements, which representative by capacity (negative volume) of the reservoir, the planner area (area of evaporation), an area of the bottom of reservoir (wetted area), shape, and areas of islands and bays corresponding to the water levels, represents the most important information used to determine the optimum level of the reservoir, this study represents a database for the designer when designing the dam and its structures, and it supports the decision to construct the dam.



Study area is geographically located in the northeastern part of the province of Salahuddin, 30 kilometers northeast of the city of Baiji, and the same distance south of the connection of the Tigris with the Lower Zab River.

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The cease in construction of the dam, since 2003, is an opportunity to accomplish complementary studies using GIS to take an advantage of the great progress in this field, and provide the digital elevations data, during the last two decades which were not available during the completion of initial studies, which was completed in the nineties of the last century

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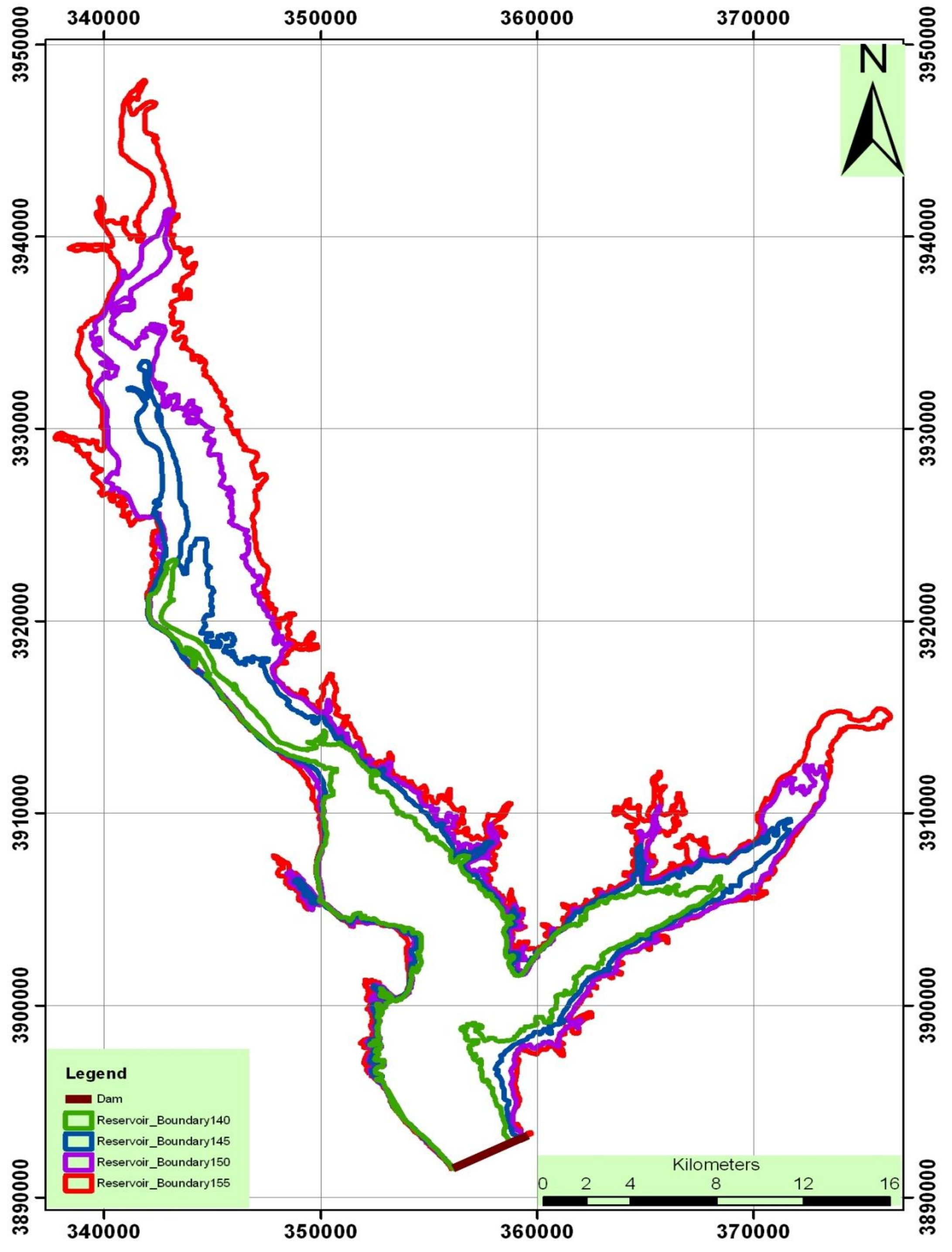
The study aims to analyze the spatial elements of geomorphological phenomena, for proposed selected, and analyze the geometric variables such as storage volume, the surface area, the submersed area, the depth of the water column and the shape. In addition, the study try to optimize the changes that occur on land-use at every level, and the relationship of these elevations with the outcrops of geological formations representing the bottom of the reservoir, and then compare different elevations to choose the optimal level.



Methodology:

The coordinates of the two end points of the dam were determined in the field using Global Positioning System (GPS) and projected on a digital elevation model of the area.

The digital elevation data, were separated for the 33 selected levels (from 140 to 156 m.a.s.l, with contour interval (0.5m), using Digitizing Tool of Global Mapper 13.

The selected topographical sections for the bottom of the reservoir plotted using (Global Mapper Path Profile)

Digital data files exported as image JPG-files, for later processing using ArcGIS.

The data of every level exported as SURFER grid files, to extract the longitudinal, areal, and volumetric geometric elements.

All levels layers imported to ArcGIS, to export them as images files in the same scale, for the purpose of comparison between the 33 levels.

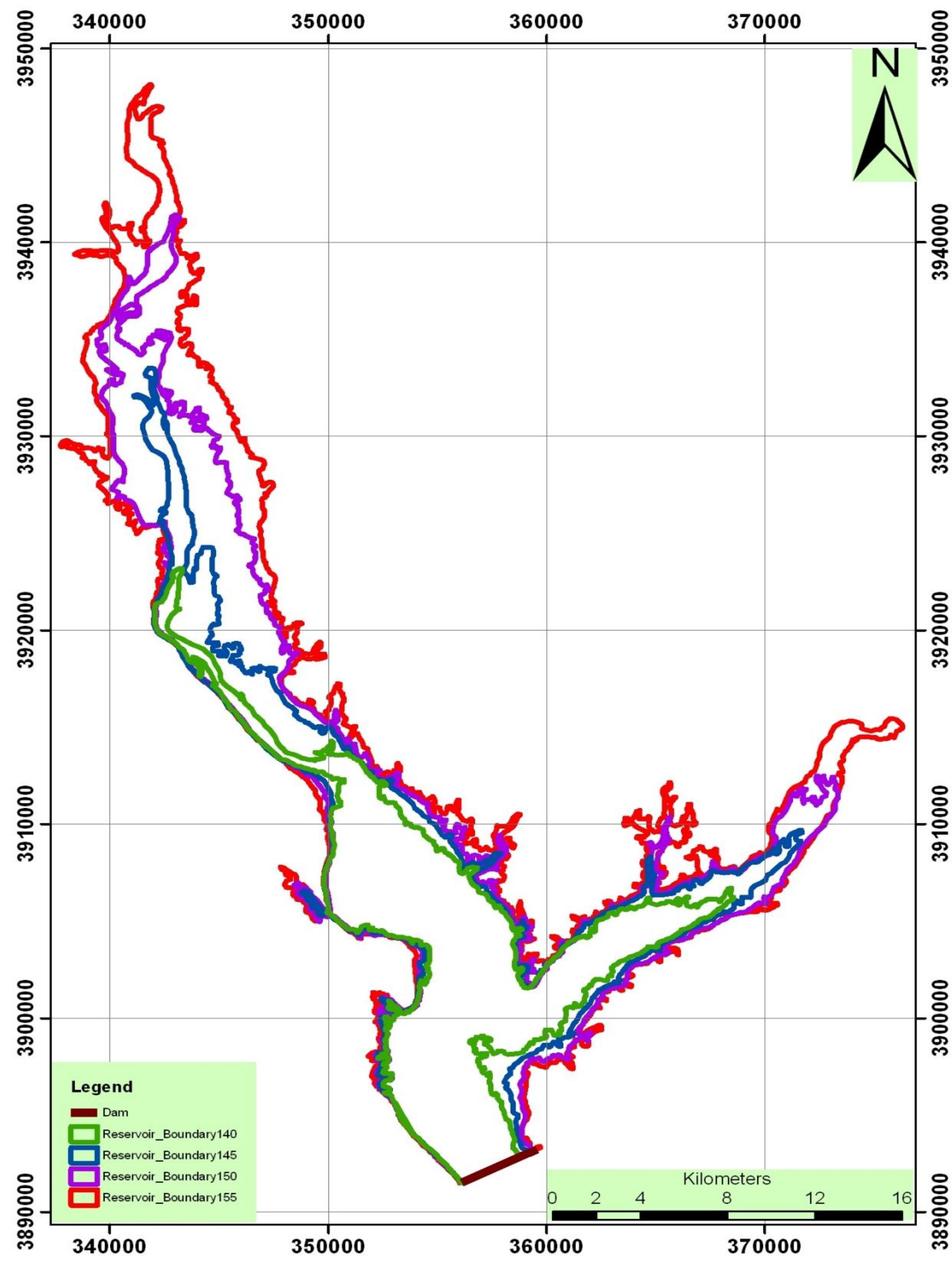
Geological maps were georeferenced using ArcGIS, and imported with layers of reservoir boundaries in four selected levels, to discuss the relationship between the boundaries of the reservoir at every selected level with the geological formations outcrops which will be submerged.

The residential areas have been identified using GPS, and projected on the boundaries of the four selected levels in the same layout view, to identify the villages which will be submerged at every level.

The geometric elements data of the reservoir, which acquired from SURFER grid data reports, were tabulated as EXCEL datasheet, and the relationships among these elements were graphically represented, to determine the optimal water level.

Discussion:

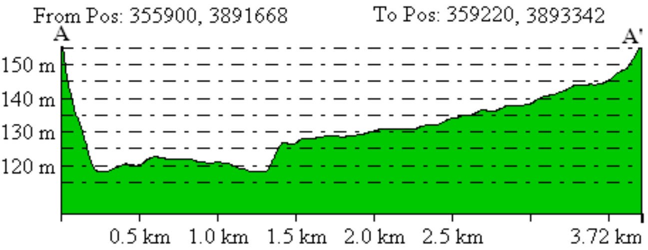
The importance of this work is to predict the geometric characteristics of the reservoir, before the construction of the dam.

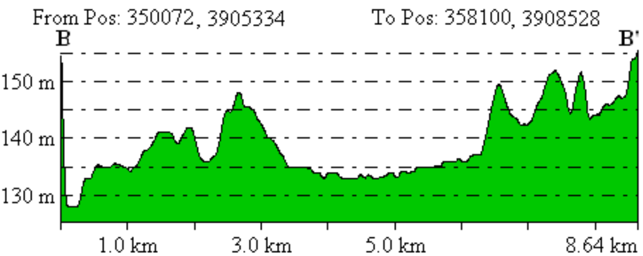


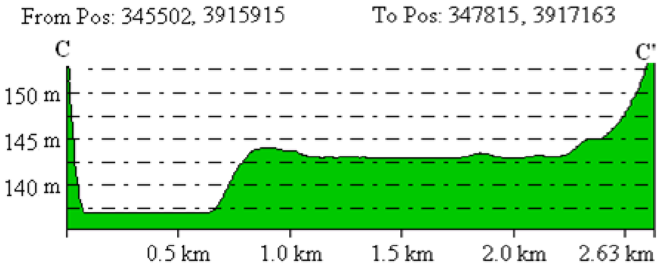
The visual comparison between the extensions of 33 selected level for the reservoir, reveals that the reservoir in each level consists of two semi-separated parts.

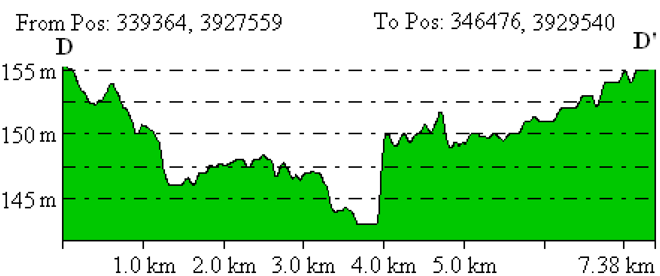
In addition, gradually growth of reservoir body with the growth of level, associated with no sudden changes in the shape of reservoir, except some simple changes, as in the case of levels 145 and 150 m.

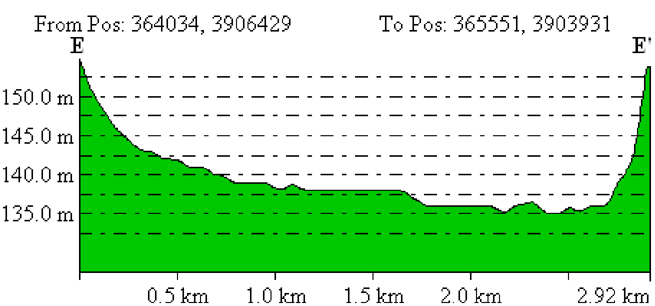
The cross and longitudinal topographic sections to the bottom of the reservoir, give a clear vision for the places of breadth of the reservoir, variations of depths, slope of the river.

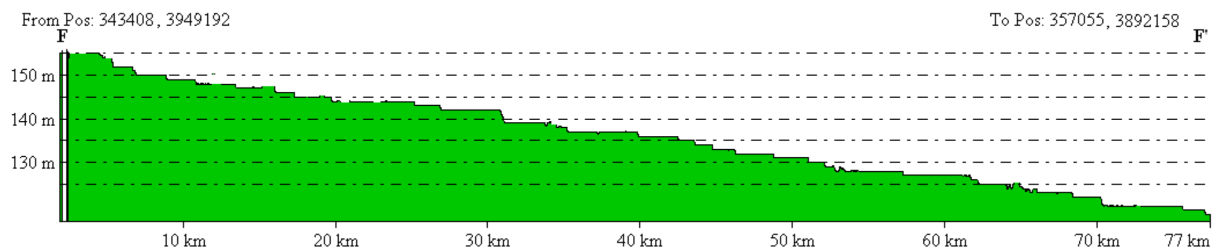


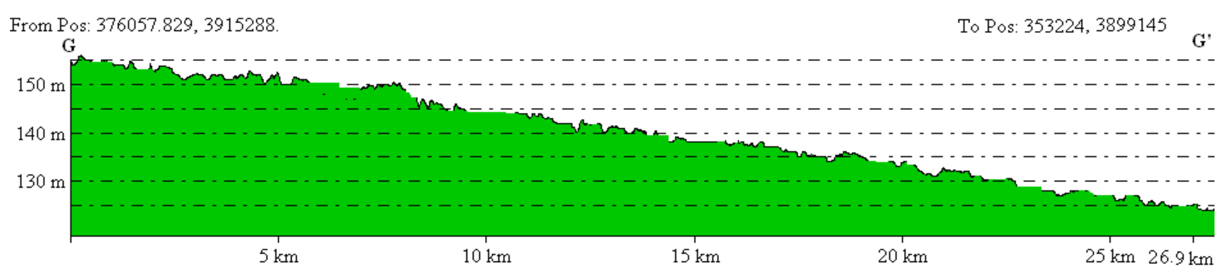




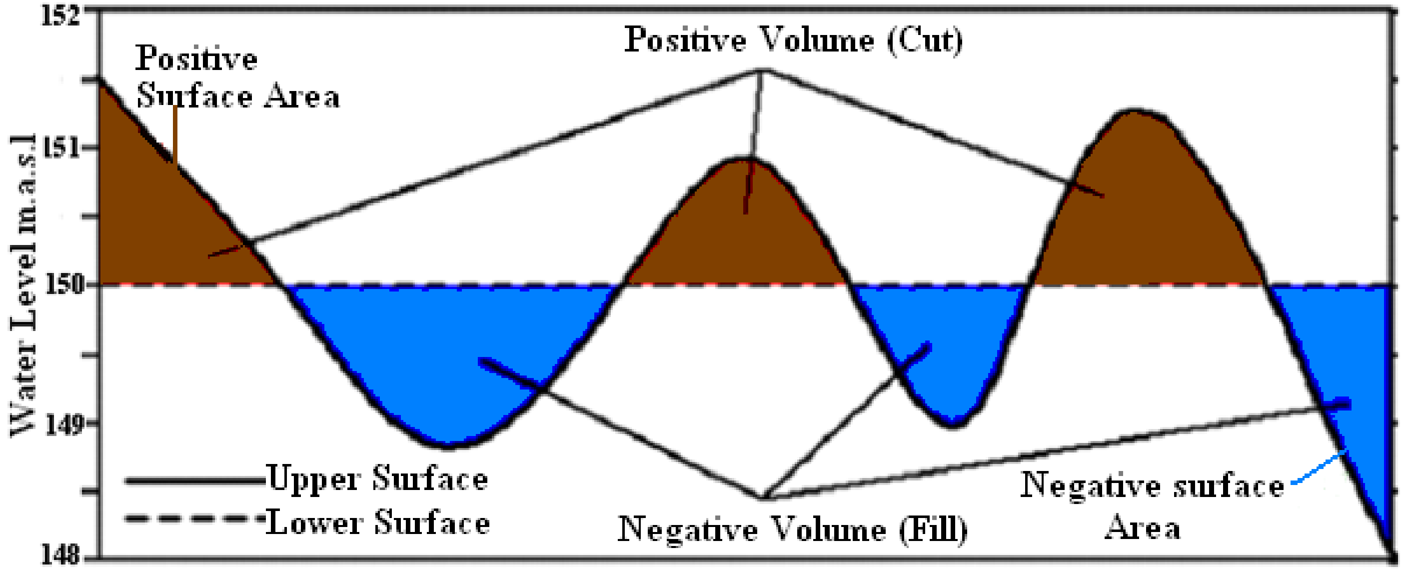


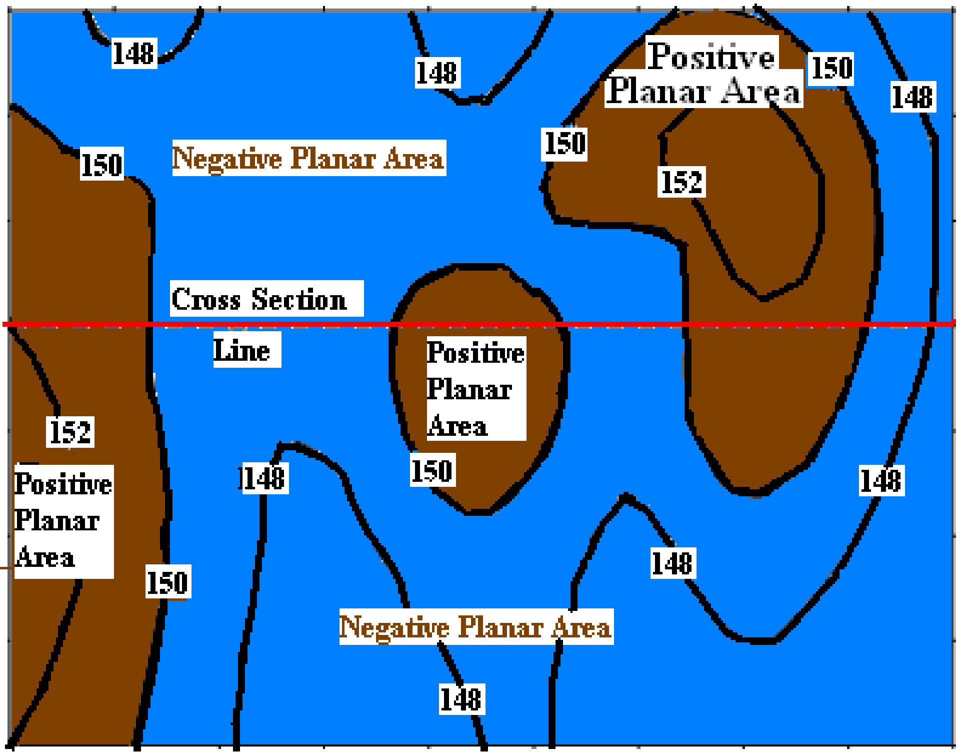


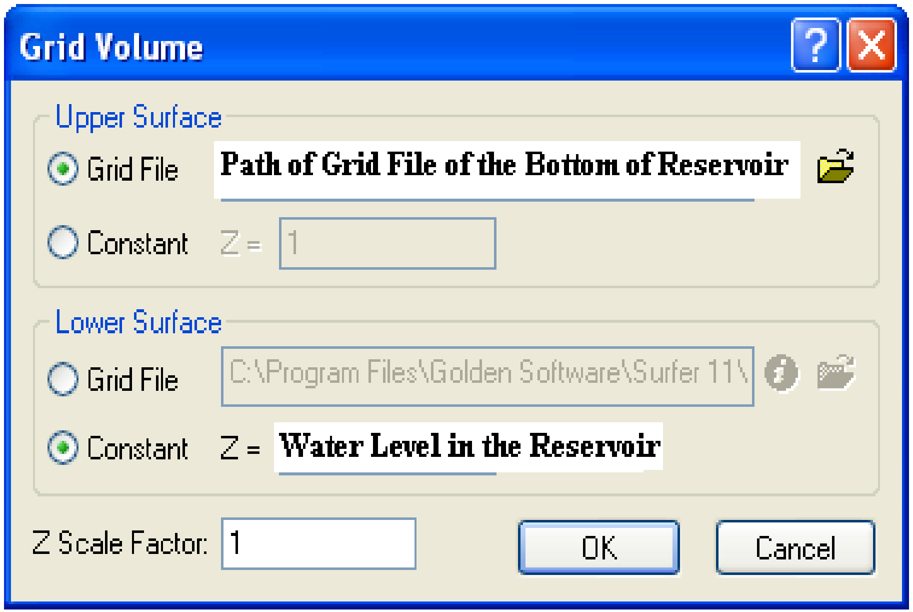




Level-Volume-Area relationships:







Geometric elements values corresponding for each elected water levels, in metric units, and adopted the names as contained in the Grid Volumetric Report

Elveation	Positive Volume PV [Cut] m^3:	Negative Volume NV [Fill] m^3:	Positive Planar Area PPA [Cut] m^2:	Negative Planar Area NPA [Fill] m^2:	Positive Surface Area PSA [Cut] m^2:	Negative Surface Area NSA [Fill] m^2:
140	13802662	944774671	4290218	124228890	4292004	124272972
140.5	11880760	1009638258	3787122	128803177	3788672	128849292
141	10338721	1076557155	3543942	132667611	3545409	132717981
141.5	8854757	1145591094	2990932	137070509	2992210	137123847
142	7565338	1215297693	2480796	140590938	2481872	140643577
142.5	6855814	1289724792	2872100	147053504	2873148	147111103
143	5603415	1365486406	2277682	151510756	2278521	151569774
143.5	9231128	1446535663	4456609	159502110	4457921	159565079
144	7252476	1528787221	3685834	164584590	3686909	164650402
144.5	7701164	1616251582	4637265	173046390	4638641	173117477
145	5620034	1705310284	3782757	177953270	3783875	178027529
145.5	4500431	1798584348	4193841	185981033	4194789	186058955
146	4221789	1895305295	4040211	191782921	4041160	191866899
146.5	2775481	1995980838	2812843	200674641	2813534	200761971
147	1688674	2099411703	1854946	206055004	1855506	206146303
147.5	1227788	2207744282	1628689	213913548	1629146	214008310
148	1225754	2317637816	1412392	220395944	1412721	220491382
148.5	1063774	2433628085	1776629	229580023	1777169	229680536
149	922837	2551658233	1284082	235720486	1286021	235827007
149.5	2022324	2677036687	2402683	246188265	2404999	246305904
150	1304819	2804519335	1683481	256148194	1685896	256267572
150.5	1157305	2937899559	1271142	265171897	1273517	265295576
151	802491	3074961211	835177	270783868	837262	270914867
151.5	683168	3214477841	802818	277739651	804587	277870654
152	508255	3355942758	552868	284451946	554472	284588364
152.5	550497	3504690599	890051	293085894	891648	293228274
153	926577	3655725792	671730	299667615	673572	299819459
153.5	811729	3810226834	573174	308003442	575035	308158320
154	2043419	3969381815	1007644	315383707	1010717	315549004
154.5	2369137	4133532584	1523649	325780448	1526875	325950860
155	2071227	4300388370	1459508	334303782	1462587	334478659
155.5	1635348	4474148280	1175067	345744154	1177745	345924755
156	6360288	4653889034	3427017	356078777	3430723	356277885

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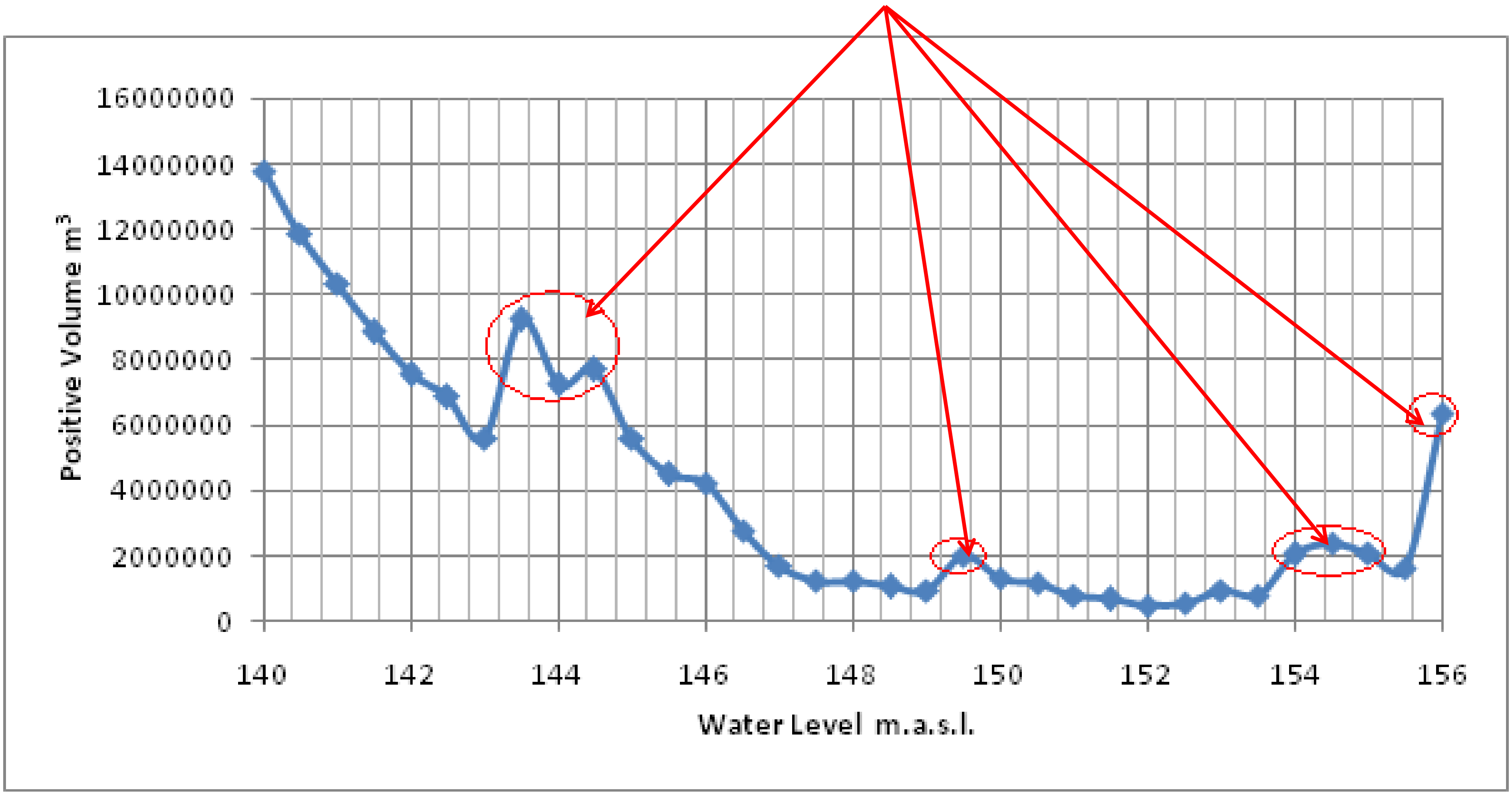
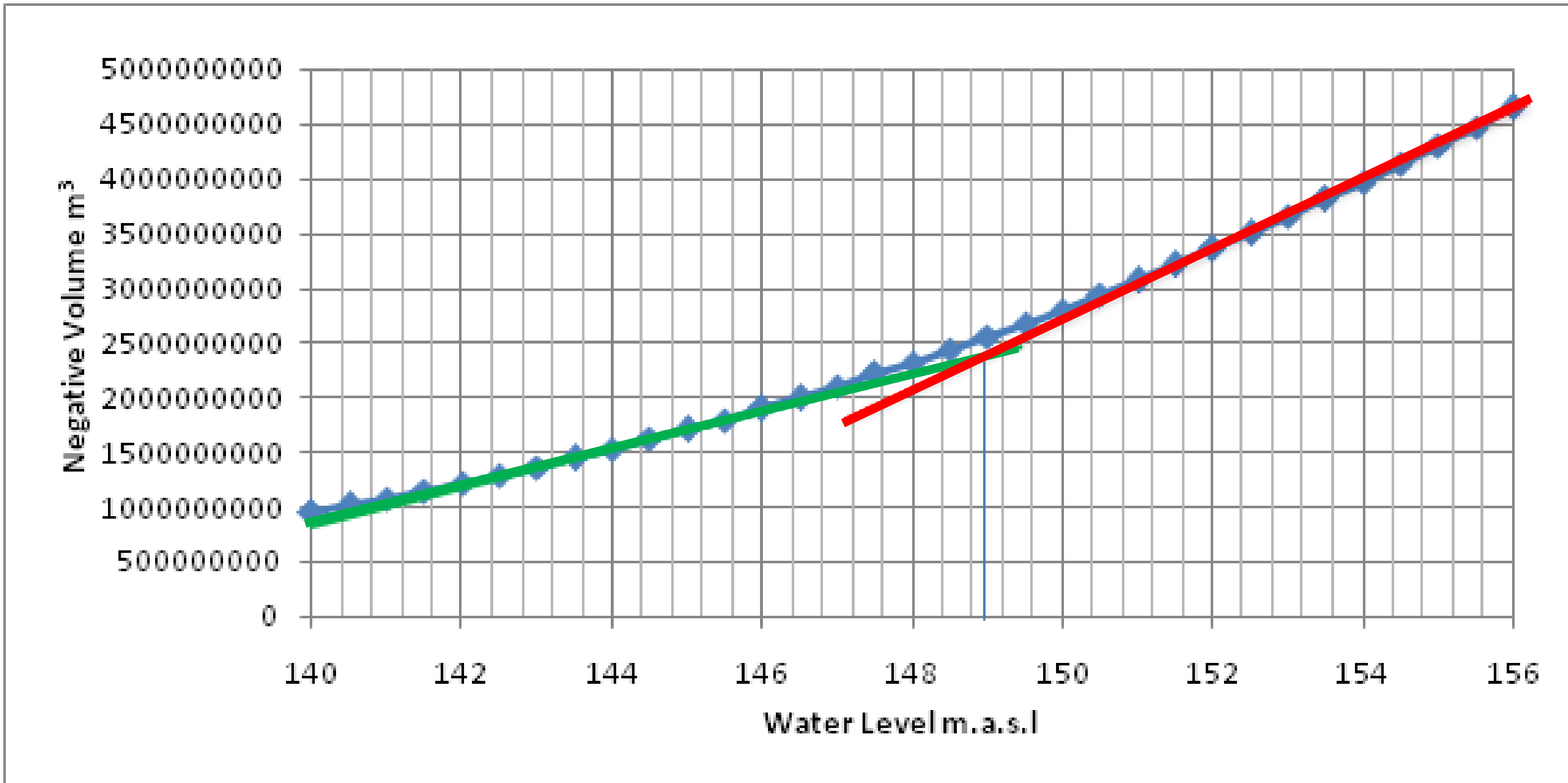
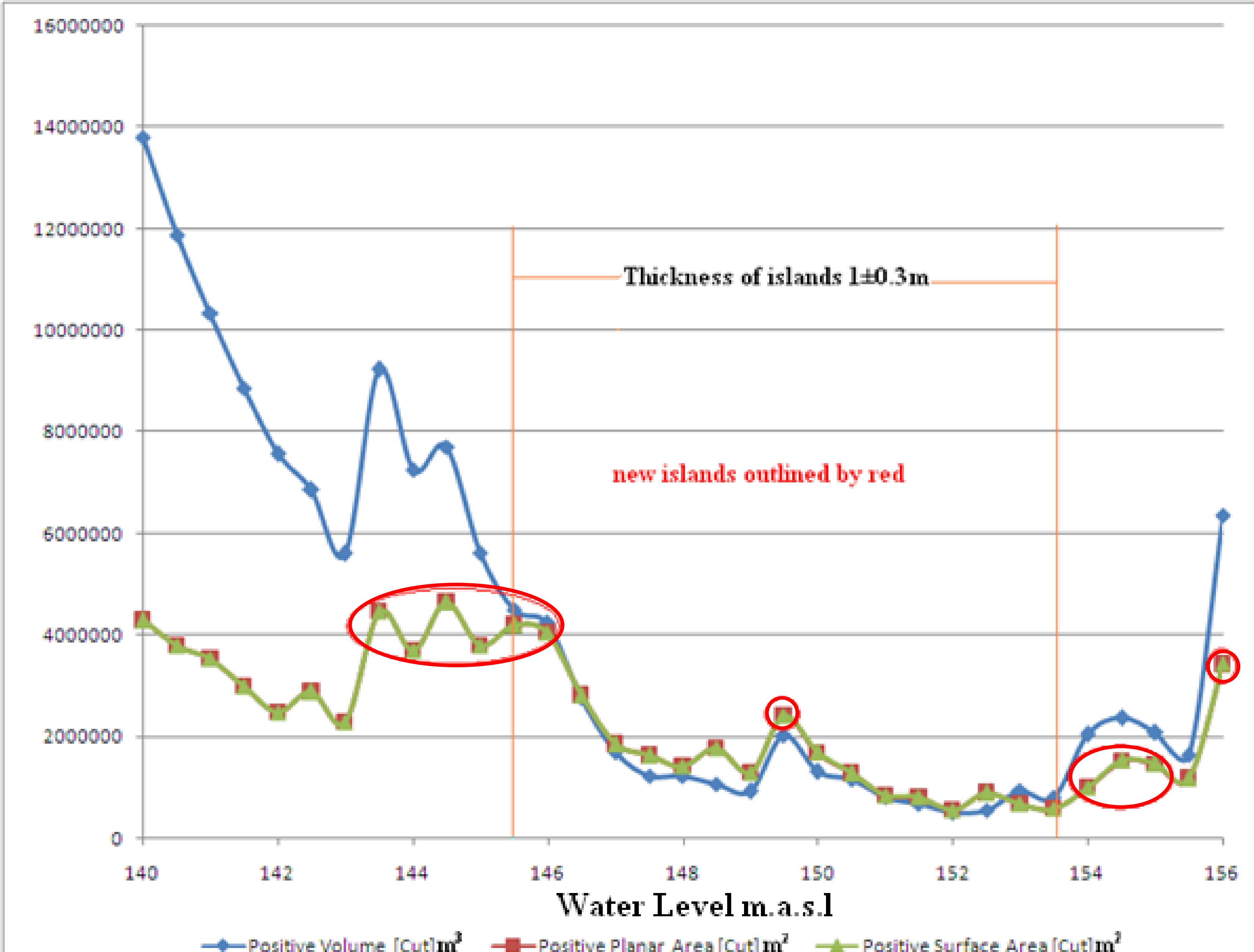
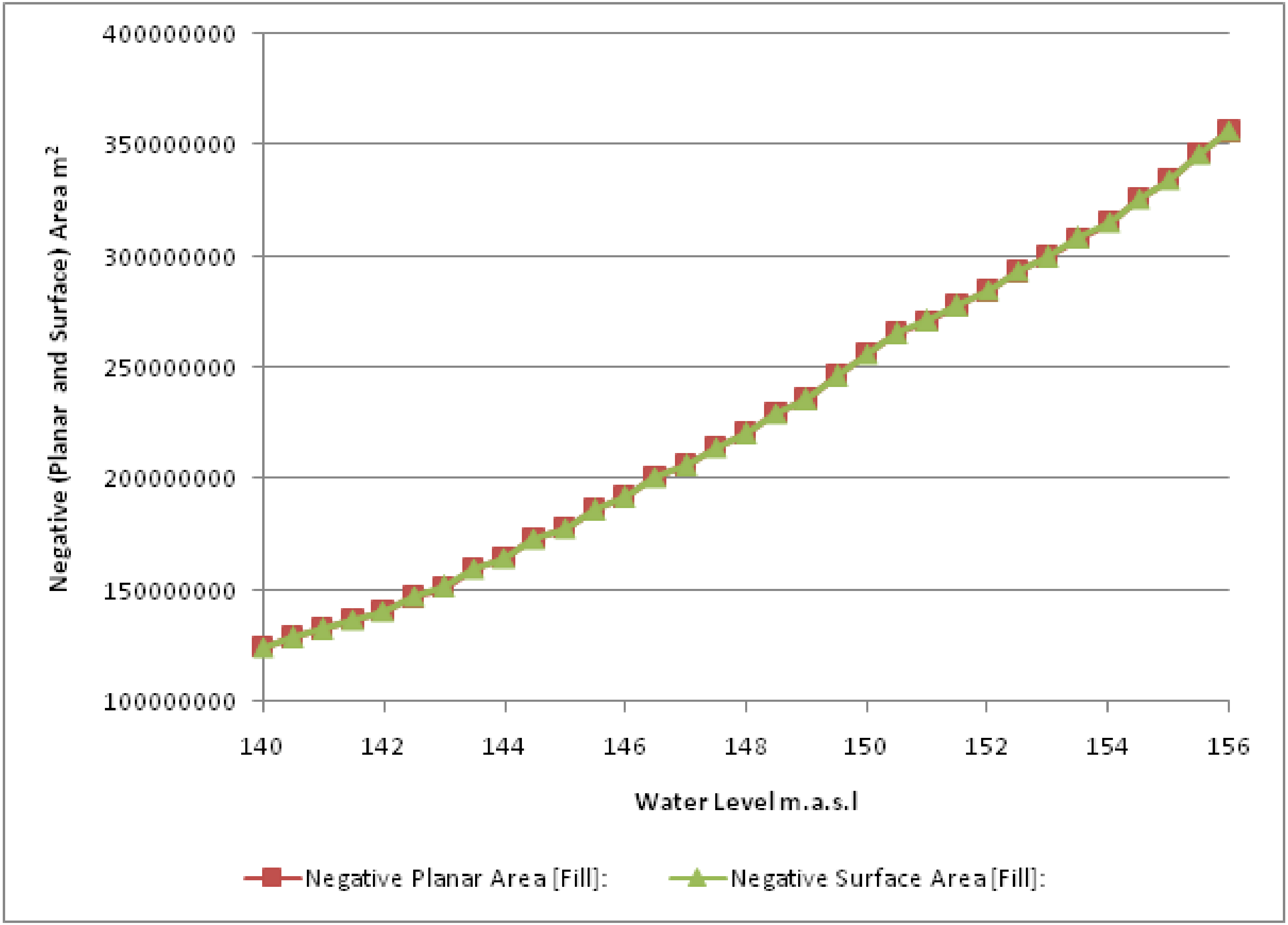




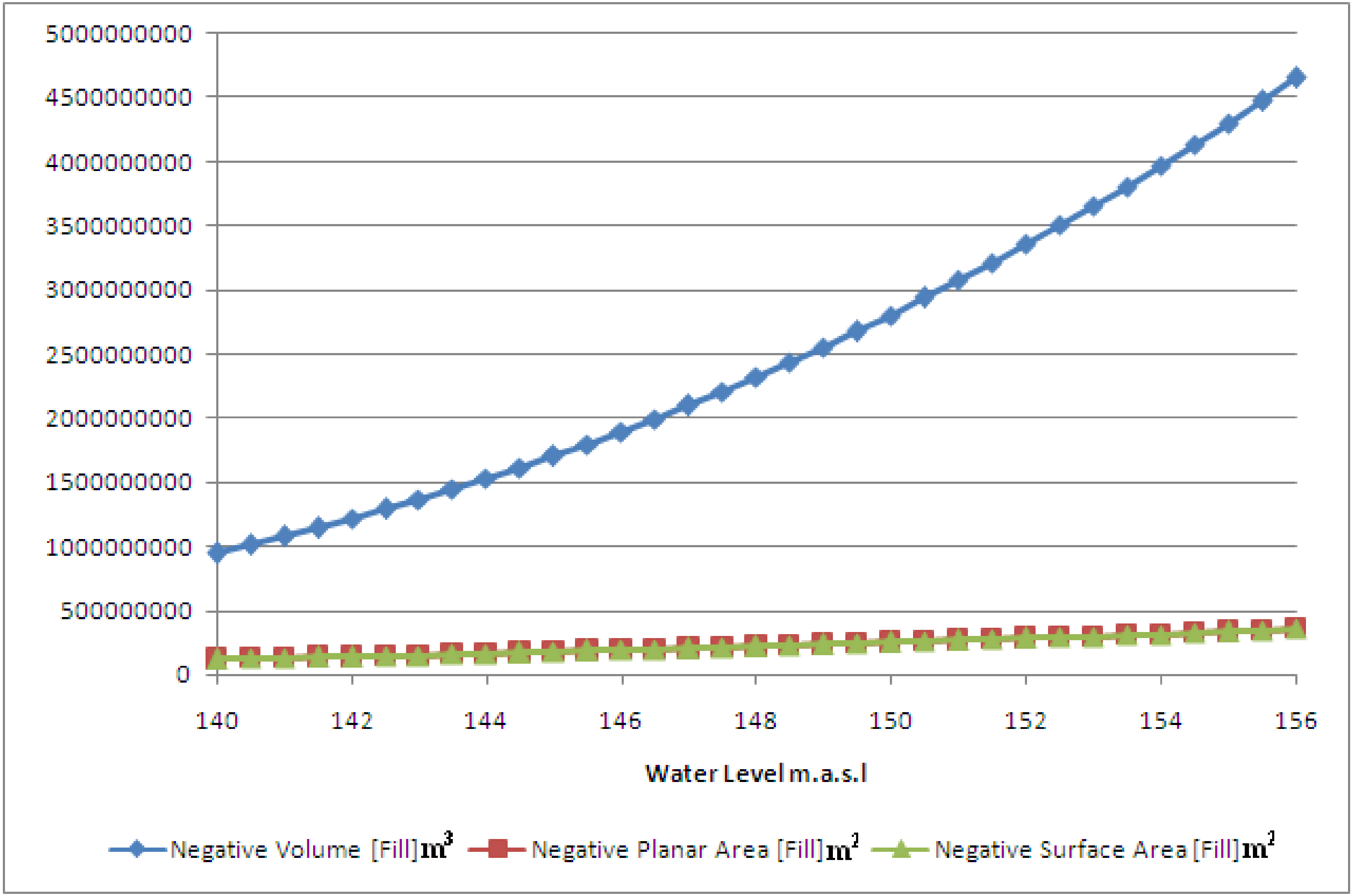
5000000000
4500000000
4000000000
3500000000
3000000000
2500000000
2000000000
1500000000
1000000000
500000000
0
Negative Volume m3
140
142
144
146
148
150
152
154
156
Water Level m.a.s.l



16000000
14000000
12000000
10000000
8000000
6000000
4000000
2000000
0
140
142
144
146
148
150
152
154
156
Thickness of islands 1±0.3m
new islands outlined by red
Water Level m.a.s.l
Positive Volume [Cut] m³
Positive Planar Area [Cut] m²
Positive Surface Area [Cut] m²



Negative (Planar and Surface) Area m²
400000000
350000000
300000000
250000000
200000000
150000000
100000000
140
142
144
146
148
150
152
154
156
Water Level m.a.s.l
Negative Planar Area [Fill]:
Negative Surface Area [Fill]:


5000000000
4500000000
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1500000000
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140
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150
152
154
156
Water Level m.a.s.l
Negative Volume [Fill] m3
Negative Planar Area [Fill] m2
Negative Surface Area [Fill] m2

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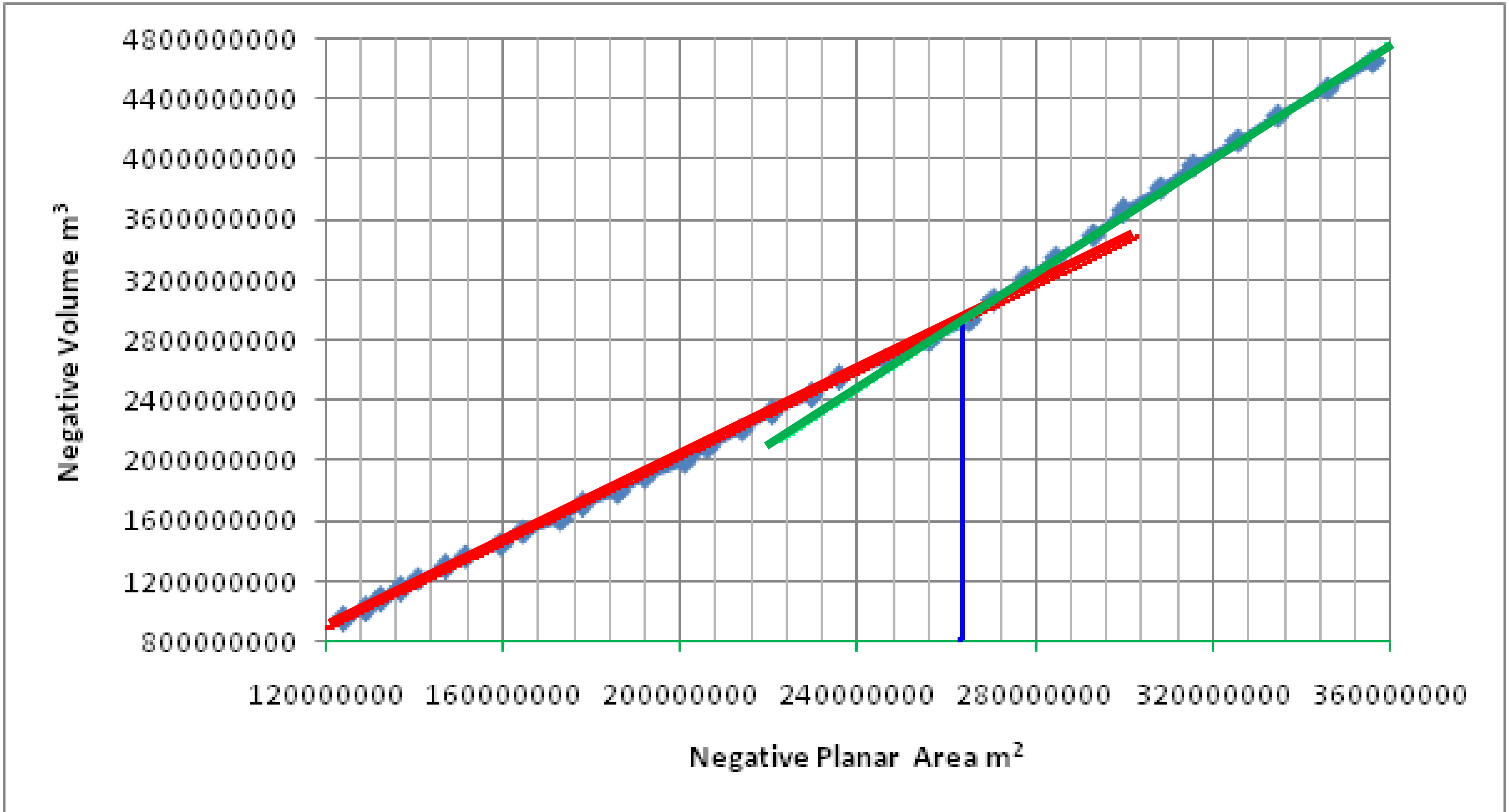
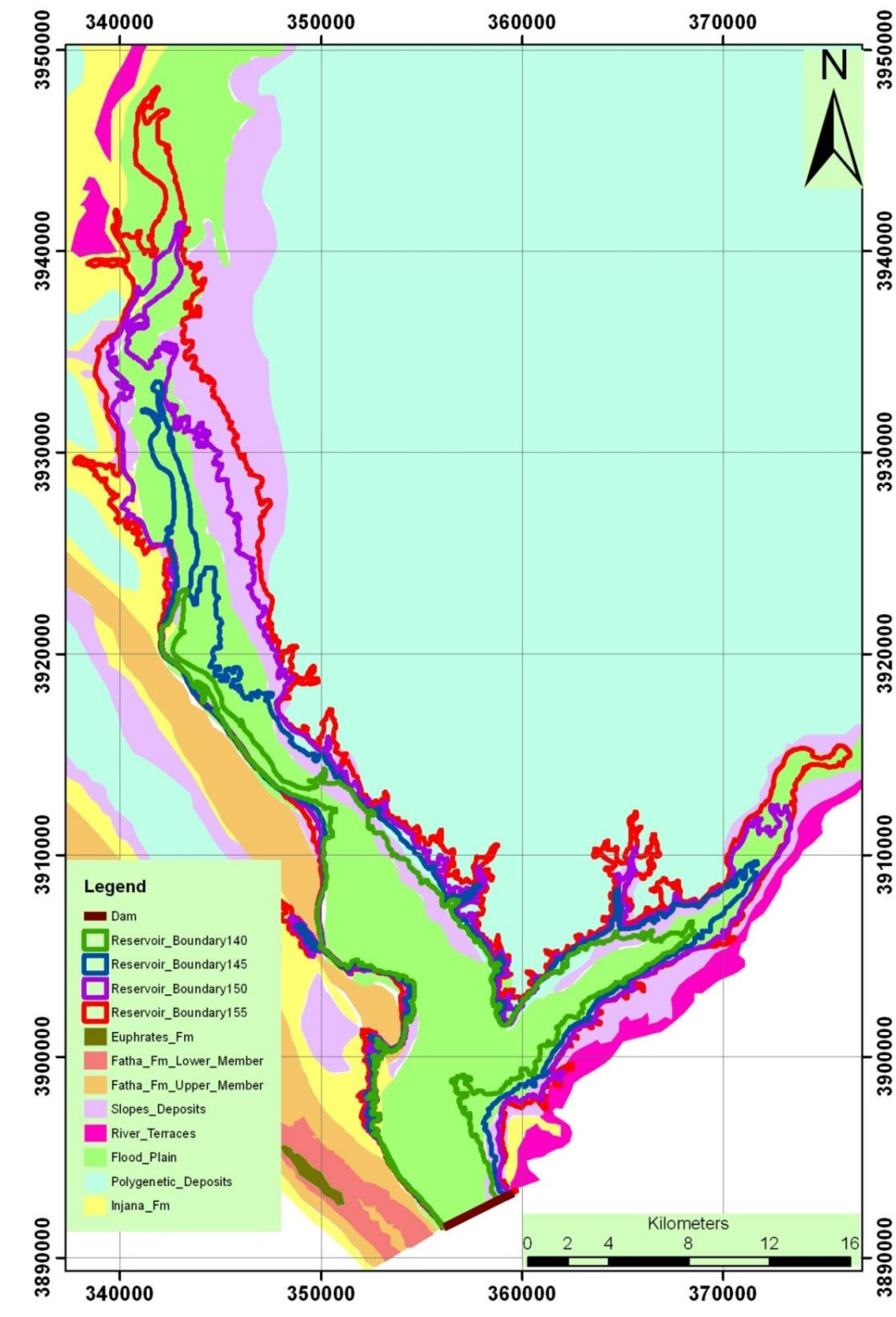
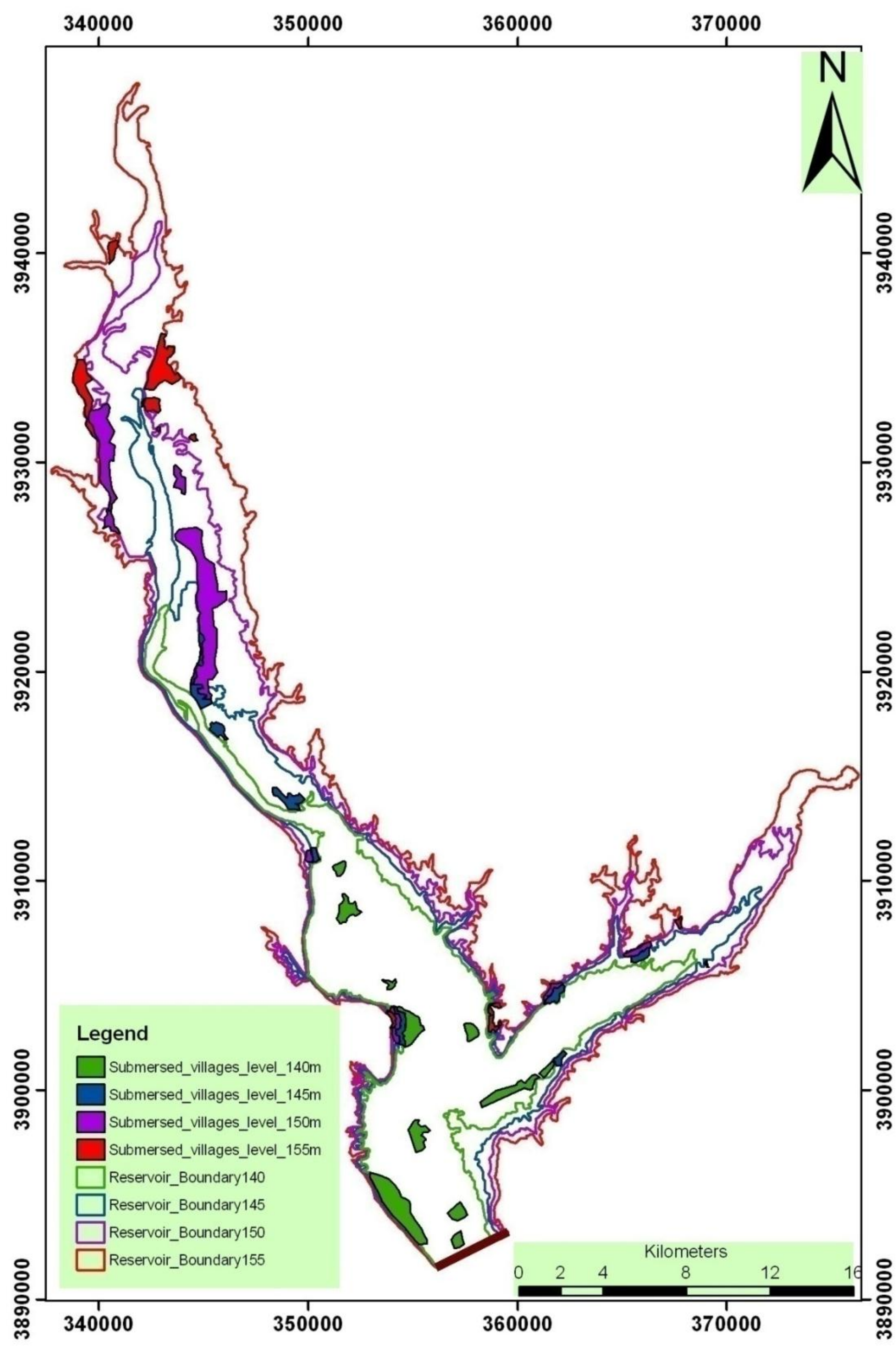




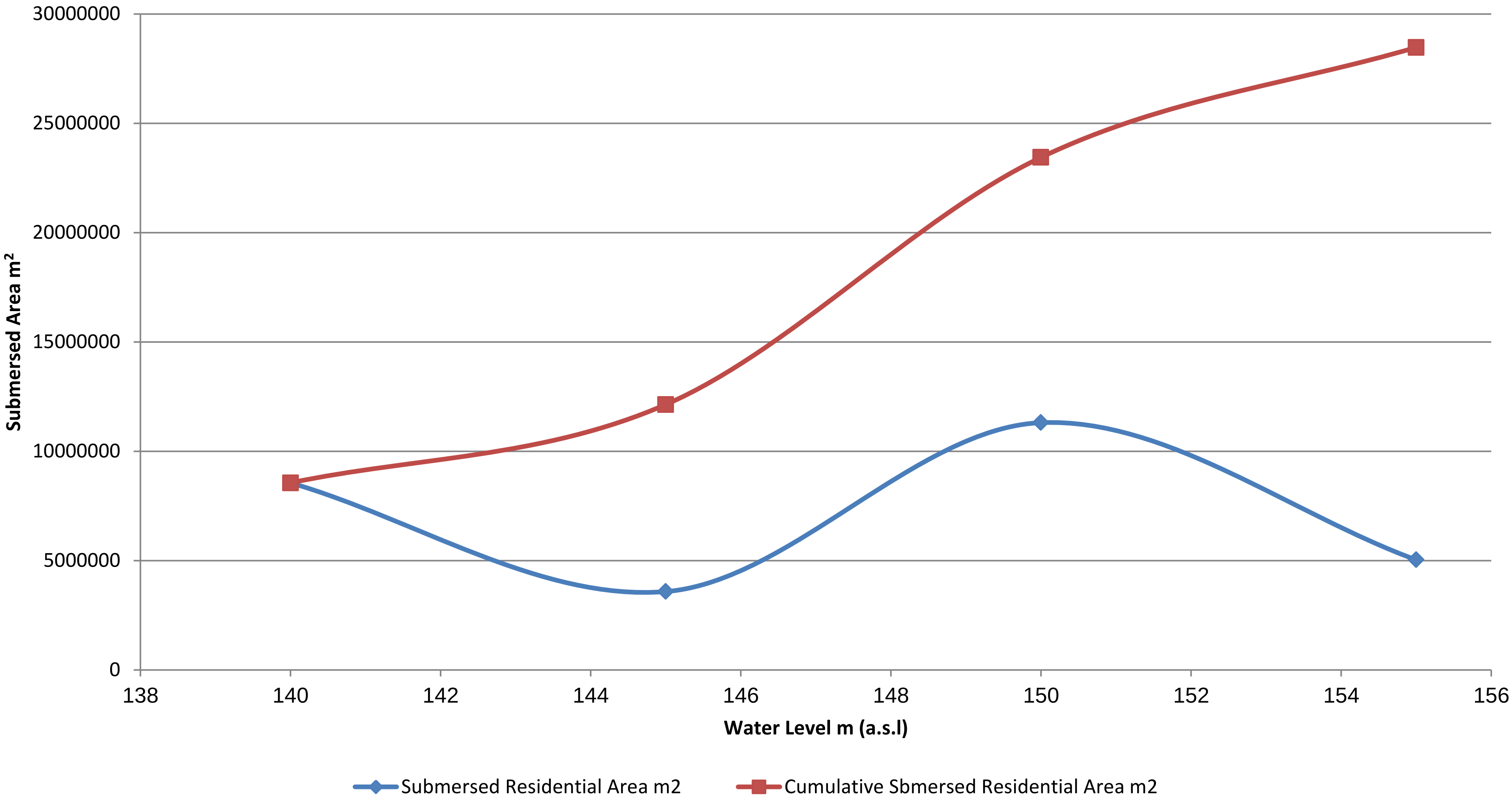
Geological map of the study area (extracted from the geological map of GEOSURV, 1993), explains the effect of the four selected submergence water-levels (140, 145, 150 and 155 m (a.s.l.)) on the outcrops of geological formations.

Table 2. the areas of submersed villages under four selected water levels

Water Level / No.	Submersed Villages Area (m^2) under level 140m	Submersed Villages Area (m^2) under level 145m	Submersed Villages Area (m^2) under level 150m	Submersed Villages Area (m^2) under level 155m
1	Msahhag 2942638	Upper Ghraib 209974	Shineen 22586	Nimesa 103386
2	Sabti 312993	South Shmet 330621	Mid Shmet 323390	Mid Shmet 47108
3	Wradiah 478144	South Sabbadhiyah 401959	North Sabbadhiyah 235470	Zab 373111
4	Shajara 822588	Shati Jidir 709225	Sdrea 6491500	Jaghayfah 81232
5	Lower Ghraib 1086256	Hugna 382811	Nayfah 457014	Tala'a 23434
6	Mid Ghraib 220078	West Sdera 883313	West Sifinah 27535	East Sifenah 436944
7	Old Zab 398358	East Namil 183225	East Jmela & Khusum 3205319	Heachal 2019452
8	Lower Sbaih 779615	Mid Zuiyah 478141	Centre Namil 147895	Horyah 323857
9	Higher Sbaih 268101		Mid Zuiyah 393611	Baajah & East Sharqat 1468996
10	Rawyeen 145120			West Zuiyah 153861
11	East Zuiyah 1099573			
Total Area 28468434	8553464	3579268	11304320	5031382



The extensions of areas of submersed villages under four selected water levels; (green under 140m; Blue under 145m; violet under 150m; and red under 155m.



•The area of submersed villages increased rapidly around the water level 150 m (a.s.l.), which makes the immersion of villages is a key factor in the selection of optimum level, which leave the selection of optimum level to decision-makers.

Conclusions:

•**The visual comparison** between the extensions of 33 selected level for Makhool dam reservoir, reveals that the reservoir in each level consists of **two semi-separated parts**, and these parts conjugate in the original estuary of lower Zab River in Tigris, and **the elongation of reservoir along the path of Tigris River more than that of Zab River.**

•The comparisons between the extensions of the selected levels reflect that there are **no significant changes in width and shape near the dam.**

•**There are no sudden changes in the shape of reservoir with the changes of levels,** except some changes, as is the case of levels 145 and 150 meters, and this is in harmony with the topographic reality, that the river banks rising gradually between levels 140 to 155 m (a.s.l.), except for some minor exceptions.

•The depth of reservoir fluctuated from location to another, and **the depth near the western bank more than the eastern one**, along the main part of the reservoir.

•The relationship between **PV, PPA, and PSA,** with water level, showed **decreasing** of these geometric elements with the **increase in water level** in general, with some simple exceptions as increasing at the levels 143.5-144.5m, 149.5m, 154-155m, and a sharp increase in the level of 156m, this exceptional increase due to the appearance of new islands within the reservoir. This is an important determinant in the future uses of the land, especially islands areas that will appear on these levels.

•The relationship between the **NV**, with the water level, which showed increasing of NV with the level in general, and divided the trend of increasing to two main stages, First stage start with the beginning of storage and end at level 147 m, the increase is lowest than next stages, then followed by transitional stage between levels 147 m to 151 m, most of the islands submersed and the storage moving from the floodplain of the river to the first river terrace which classified as slopes deposits, then the increase in volume sharpest after level 151 meters, and the reservoir would be more broadly along the reservoir within the borders of the river terrace.

•The direct relationship between the **NPA** and **NV**, noting that clear relative increase in the volume of storage compared with the flat surface area, especially when the water level of 150.5 m, the increase above this level, relatively larger than before this water level.

•**The height of islands, when the water level below 145 m (a.s.l.), more than the height of the islands of next levels**, which very shallow islands (about one meter).

•The **topography of the floodplain and river terraces** which represent the main parts of proposed reservoir **has low roughness.**

•**Rising of water levels in the reservoir, especially in the advanced stages of storage, lead to contact of reserved water with outcrops of geological formations that require special treatments such as cement and other injection materials that prevents leakage.**

Recommendations:

- Applying the methods used in this study, on other proposed reservoirs.

- Using of high resolution digital elevation data in future studies, especially in small-sized reservoirs

- Depending the result of the geometric data analysis in this study by the designer of the dam.

Thank you for your attention!