Roinn Cumarsáide, Fuinnimh & Acmhainní Nádúrtha
Department of Communications, Energy & Natural Resources

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Geological Survey of Ireland Research Programme
- Short Call 2015, Final Report -

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☒ **GSI Geoscience**	☐ **INFOMAR**	☐ **Tellus**

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Organisation name	University College Dublin
Organisation type:	☒HEI ☐Public Sector (other) ☐Private Sector
Department/section	Civil Engineering – Geotechnical Research
Address	UCD School of Civil Engineering, Newstead Building, University College Dublin, Belfield, Dublin 4, Ireland.

Project Title	Geological Map of the Pre-Glacial Trench, Central Dublin
Contract No.	2015-sc-006
Total financial support requested from GSI (as per proposal)	€25,500

The details presented in this report are a true and accurate reflection of the work undertaken and the associated financial expenditure. All work was carried out within the GSI Terms and Conditions and as per the Contract (unless formally amended).

Signed: Michael Long
Lead Investigator: 29 November 2016

Staff funded by the GSI Short Call Project (add lines if required)

Name	Male/female	Position	Expertise
Stephen Kealy	Male	Researcher / MEngSc student	Engineering Geology

1. Project information:

Title of project	Geological Map of the Pre-Glacial Trench, Central Dublin
Did you make any formal amendment to the project workplan / budget?	☐ yes ☒ no If yes, please specify:

1. Project Information

1.1 Objectives of the Project

The main objective of this project was to generate an interactive three dimensional geological model of the pre-glacial trench found in central Dublin. The model would be fully interactive where geological units could be viewed together as a whole, in relation to one another or in isolation. The scene view would have the ability to rotate in three dimensions.

The overall objectives for the project were as follows:

- Define a study area that would provide sufficient information to produce a model representative of the geology
- Collect and collate all relevant data within the study area
- Create cross sections based on original data
- Review logs and simplify to produce model
- Gain an understanding of the geotechnical properties of the material found in the study area
- Create a master database in gINT Geotechnical Logging Software
- Generate contours for each strata using Surfer contour and mapping software
- Create a georeferenced database for Arcmap
- Produce three dimensional triangulated irregular network files for each stratum
- Generate a three dimensional model in Arcscene

The work carried out to date specific to the deposits found in the preglacial trench was undertaken by Transport Infrastructure Ireland (TII) and to a lesser extent the Geological Survey of Ireland (GSI). The work carried out by TII was focused on the original proposed alignment of the metro north (Fig.1.1). A two dimensional cross section along the route of the metro was produced based on site investigations specific to the job (Fig.1.1).

Farrington (1929) identified the existence of a pre-glacial channel just north of the River Liffey. It is most dominant towards the north of the present channel of the River Liffey near the city centre and returns near the current mouth of the river. Near Houston Station on the west side of the city the channel crosses over the present river course to the south forming a more localised deeper zone. It is unclear whether widely varying sea levels, tectonic movements or some weakness in the underlying rock gave rise to the channel. However from an engineering point of view, it has significant importance in that is it generally filled with deposits of glacial and fluvio-glacial gravels rather than the more normal boulder clays which underlie most of Dublin. Long et al. (2012) discuss some issues and experiences with constructing deep basements within the deposit. However the nature and distribution of the deposits within the trench is poorly understood, hence the motivation for this project. A study of the nature and extent of the deposit is particularly pertinent at the present time due to the proposed construction of Metro North which will pass through the area where the trench is located.

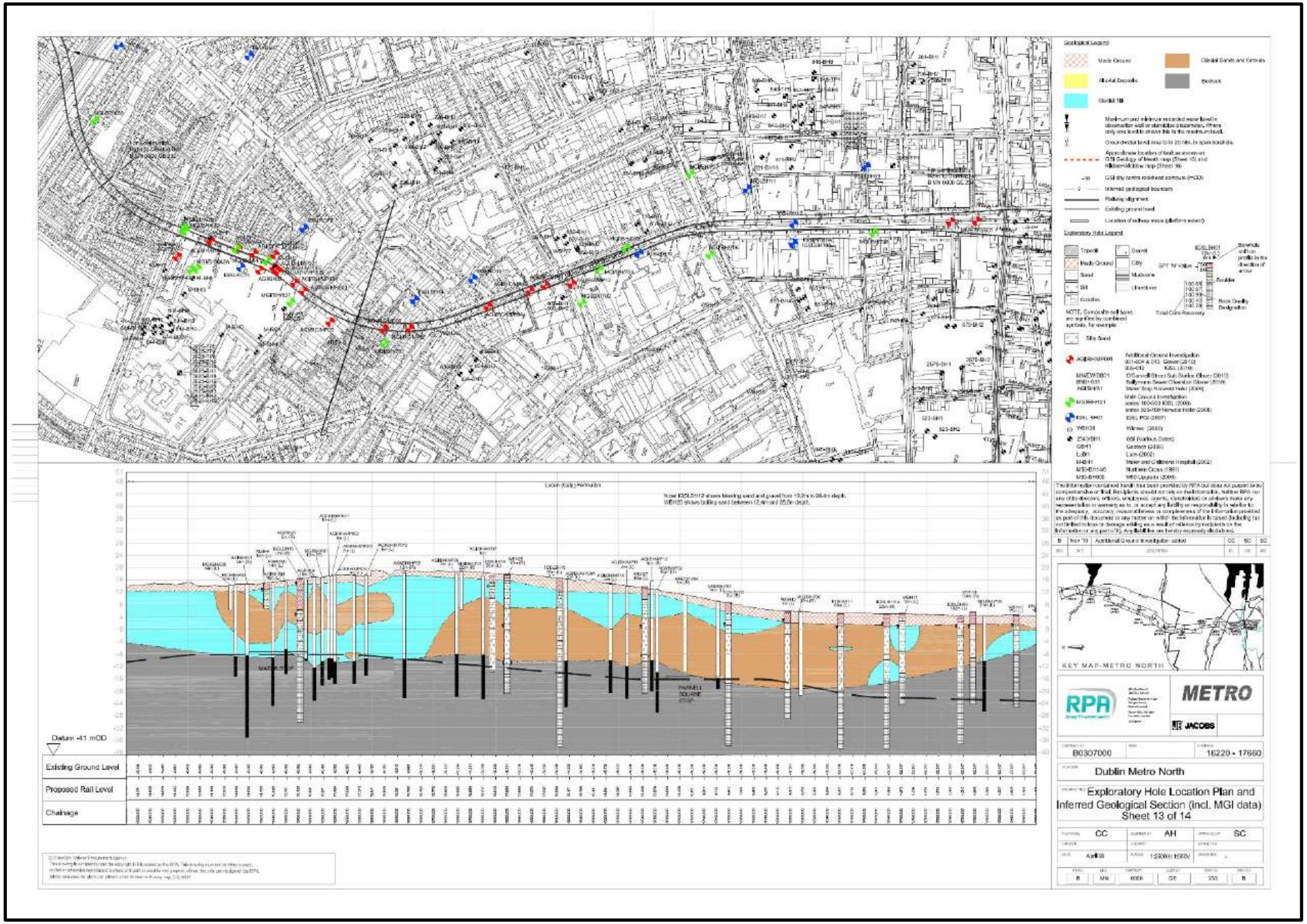


Figure 1.1: Work carried out by TII

The GSI have created models that are related to pre-glacial trench. These include the three dimensional rock-head profile for Dublin and a three dimensional model for the Quaternary deposits found in Dublin.

The model produced for this project is believed to have progressed beyond the state of the art. The previous work carried out specific to the area as mentioned was undertaken by TII where they produced a long cross-section over a narrow area (Fig. 1.1). The model here has taken that information and expanded on it creating a three dimensional section that shows a greater lateral extent of the deposits.

It is difficult to compare the model produced for this project with the GSI's Quaternary model as they have different goals. The GSI's Quaternary model shows the extent of the deposits over the entire Dublin region. The interactive model produced by the GSI allows you to create two dimensional cross-sections where you like throughout the area. The model produced here is more detailed and is over a much smaller scale. This allows for a quicker visualisation of the deposits within the area.

All objectives were met within the allocated timescale.

1.2 Implementaion

At the beginning of the project it was agreed that it should take six months to generate the 3D model (Fig 1.2).

To achieve this the project was broken down into six phases. Phase five and six were carried out simultaneously. Each phase represented a milestone. Progress meetings were scheduled for once a month. The work produced at the time of each meeting was presented. The work was discussed, suggestions and comments were made. On the back of this review future deadlines were created.

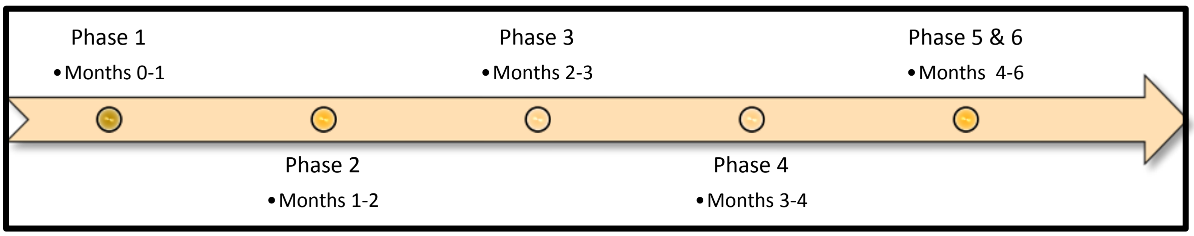


Figure 1.2: Timeline

1.2.1 Phase 1 Data Collection

In Phase 1 the extent of the study area was defined (Fig 1.3), all relevant borehole data was collected and collated and traditional cross sections were hand draw. Fourteen cross-sections were hand drawn to scale and presented in metres below groundlevel (mbgl).

The first major milestone was reached when the extent of the study area was defined and the geology in the area was understood.

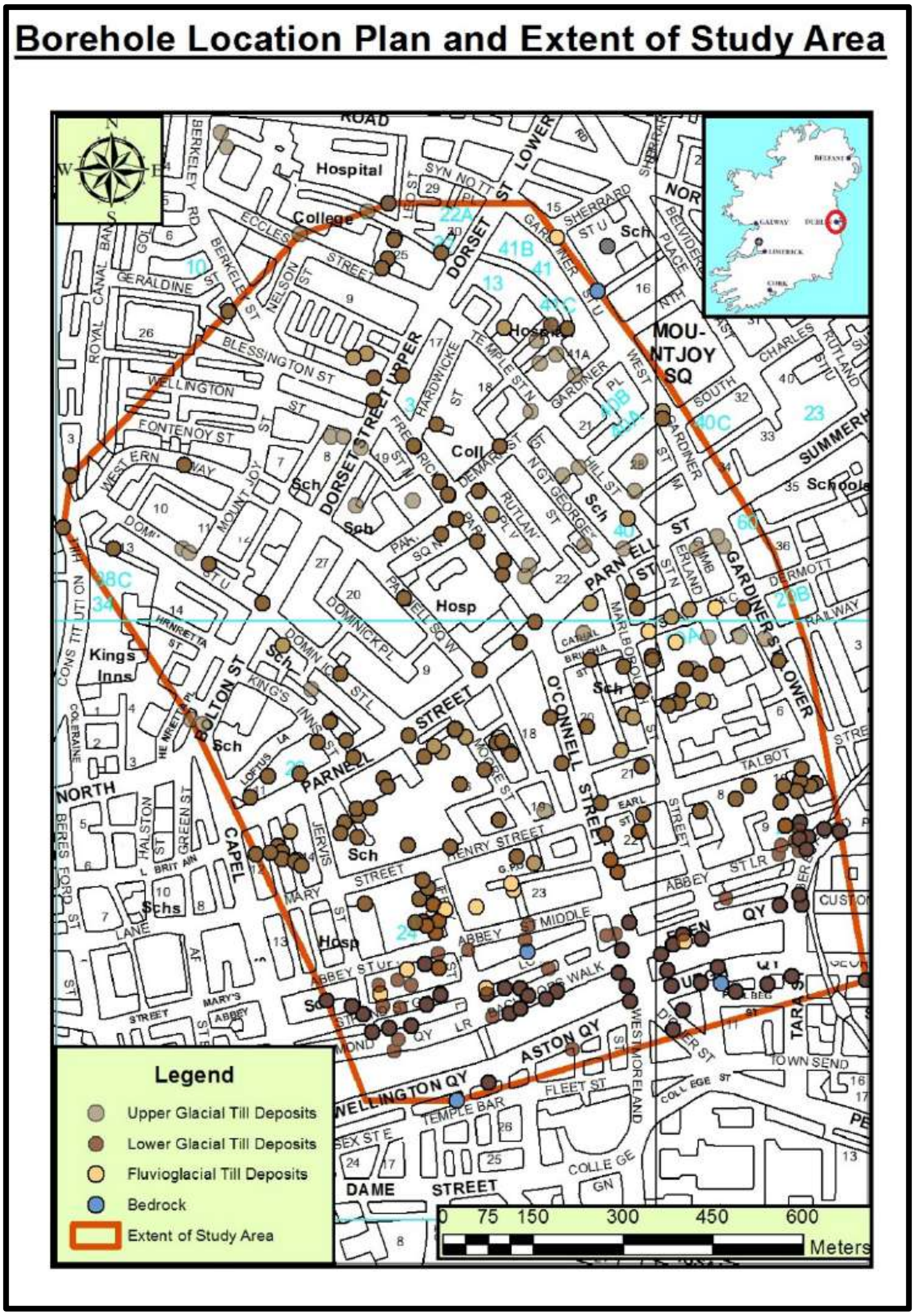
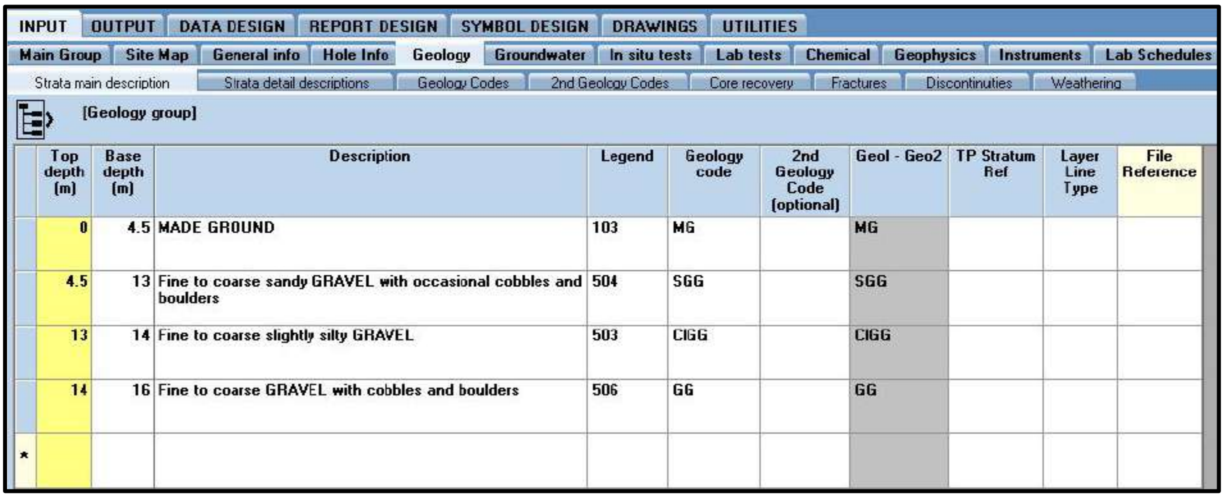


Figure 1.3: Extent of Study Area and Location of Boreholes

1.2.2 Phase 2 Data Entry

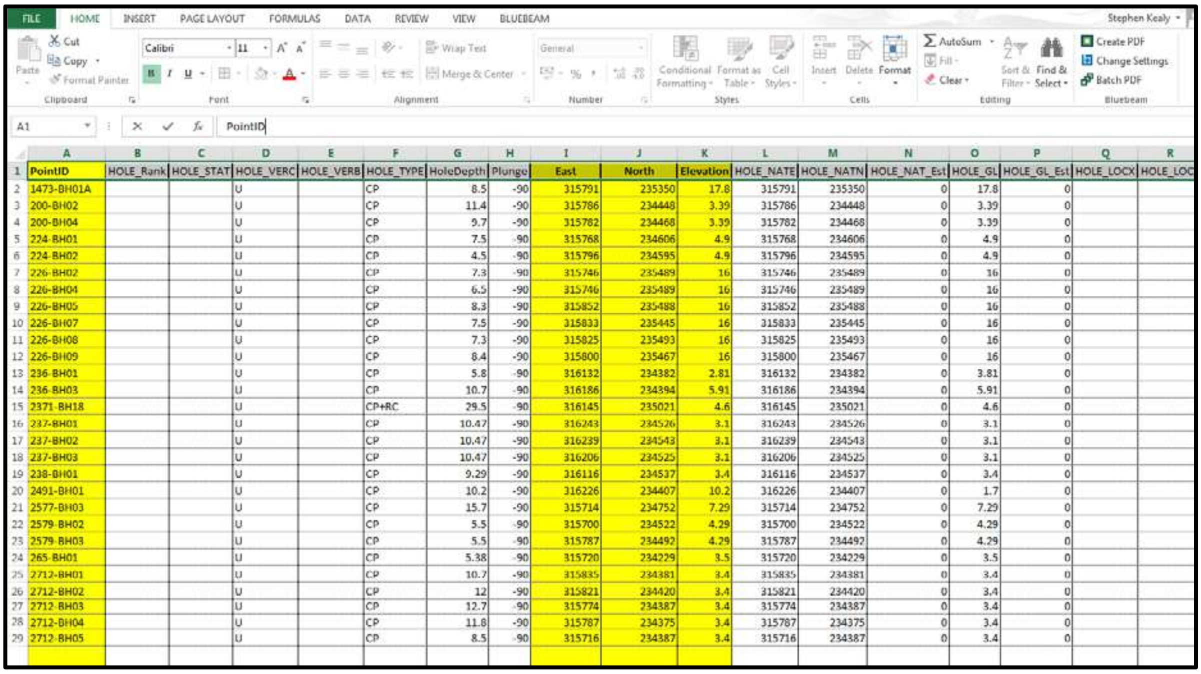
In Phase 2. All the borehole date was inputted into gINT geotechnical software (Fig 1.4) this forms the Master database for the 3D model.



Top depth (m)	Base depth (m)	Description	Legend	Geology code	2nd Geology Code (optional)	Geol - Geo2	TP Stratum Ref	Layer Line Type	File Reference
0	4.5	MADE GROUND	103	MG		MG			
4.5	13	Fine to coarse sandy GRAVEL with occasional cobbles and boulders	504	SGG		SGG			
13	14	Fine to coarse slightly silty GRAVEL	503	CIGG		CIGG			
14	16	Fine to coarse GRAVEL with cobbles and boulders	506	GG		GG			

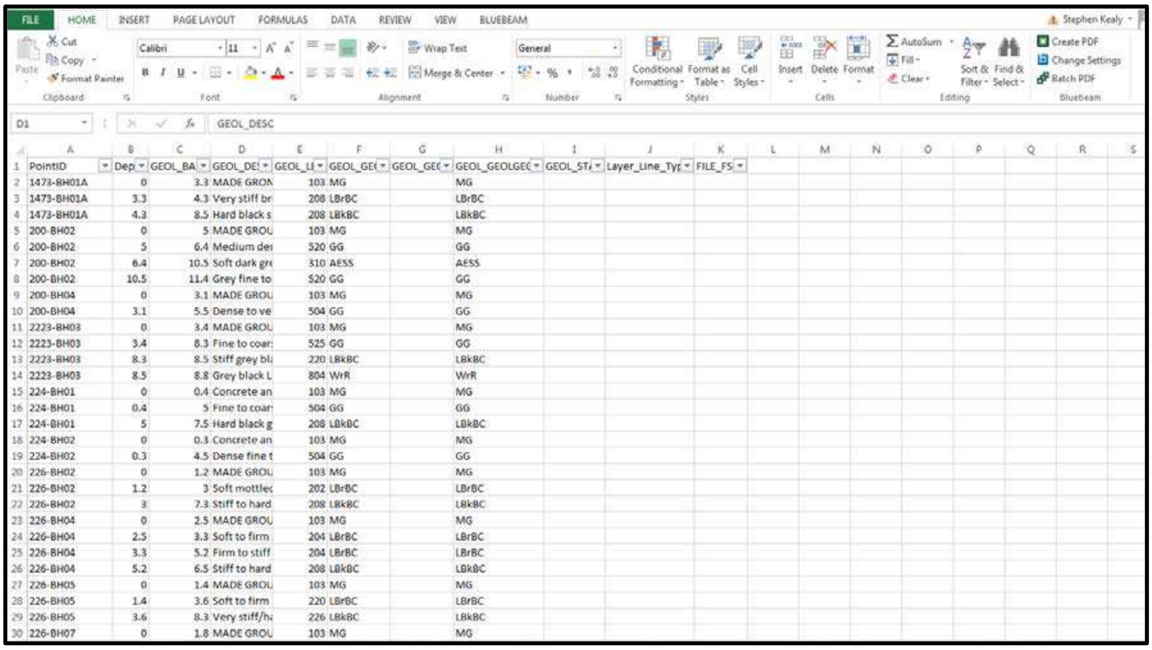
Figure 1.4: gINT logging software interface

The project was then exported in Excel format (Fig 1.5 and Fig.1.5a)



PointID	HOLE_Rank	HOLE_STAT	HOLE_VERC	HOLE_VERB	HOLE_TYPE	HoleDepth	Plunge	East	North	Elevation	HOLE_NATE	HOLE_NATN	HOLE_NAT_Est	HOLE_GL	HOLE_GL_Est	HOLE_LOCX	HOLE_LOC
1473-BH01A			U		CP	8.5	-90	315791	235350	17.8	315791	235350	0	17.8	0		
200-BH02			U		CP	11.4	-90	315786	234448	3.39	315786	234448	0	3.39	0		
200-BH04			U		CP	9.7	-90	315782	234468	3.39	315782	234468	0	3.39	0		
224-BH01			U		CP	7.5	-90	315768	234606	4.9	315768	234606	0	4.9	0		
224-BH02			U		CP	4.5	-90	315796	234595	4.9	315796	234595	0	4.9	0		
226-BH02			U		CP	7.3	-90	315746	235489	16	315746	235489	0	16	0		
226-BH04			U		CP	6.5	-90	315746	235489	16	315746	235489	0	16	0		
226-BH05			U		CP	8.3	-90	315852	235488	16	315852	235488	0	16	0		
226-BH07			U		CP	7.5	-90	315833	235445	16	315833	235445	0	16	0		
226-BH08			U		CP	7.3	-90	315825	235493	16	315825	235493	0	16	0		
226-BH09			U		CP	8.4	-90	315800	235467	16	315800	235467	0	16	0		
236-BH01			U		CP	5.8	-90	316132	234382	2.81	316132	234382	0	3.81	0		
236-BH03			U		CP	10.7	-90	316186	234394	5.91	316186	234394	0	5.91	0		
2371-BH18			U		CP+RC	29.5	-90	316145	235021	4.6	316145	235021	0	4.6	0		
237-BH01			U		CP	10.47	-90	316243	234526	3.1	316243	234526	0	3.1	0		
237-BH02			U		CP	10.47	-90	316239	234543	3.1	316239	234543	0	3.1	0		
237-BH03			U		CP	10.47	-90	316206	234525	3.1	316206	234525	0	3.1	0		
238-BH01			U		CP	9.29	-90	316116	234537	3.4	316116	234537	0	3.4	0		
2491-BH01			U		CP	10.2	-90	316226	234407	10.2	316226	234407	0	1.7	0		
2577-BH03			U		CP	15.7	-90	315714	234752	7.29	315714	234752	0	7.29	0		
2579-BH02			U		CP	5.5	-90	315700	234522	4.29	315700	234522	0	4.29	0		
2579-BH03			U		CP	5.5	-90	315787	234492	4.29	315787	234492	0	4.29	0		
265-BH01			U		CP	5.38	-90	315720	234229	3.5	315720	234229	0	3.5	0		
2712-BH01			U		CP	10.7	-90	315835	234381	3.4	315835	234381	0	3.4	0		
2712-BH02			U		CP	12	-90	315821	234420	3.4	315821	234420	0	3.4	0		
2712-BH03			U		CP	12.7	-90	315774	234387	3.4	315774	234387	0	3.4	0		
2712-BH04			U		CP	11.8	-90	315787	234375	3.4	315787	234375	0	3.4	0		
2712-BH05			U		CP	8.5	-90	315716	234387	3.4	315716	234387	0	3.4	0		

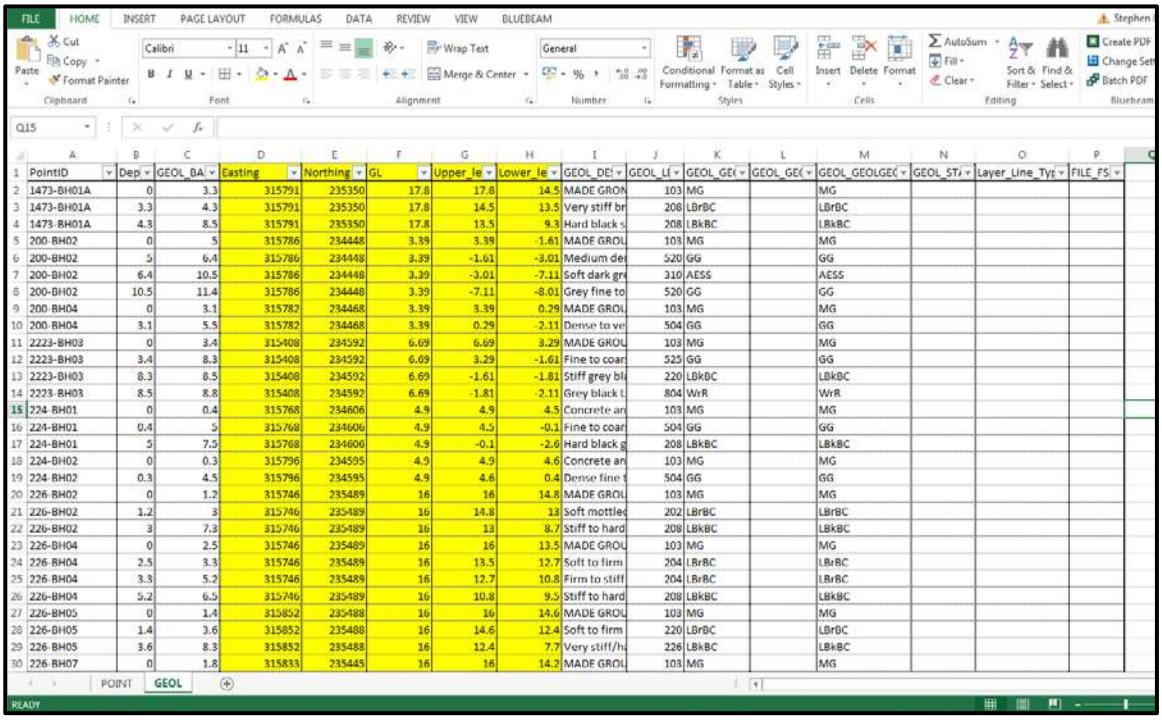
Figure 1.5: Excel sheet showing point data



PointID	Dep	GEOL_BA	GEOL_DE	GEOL_LE	GEOL_GE	GEOL_GE	GEOL_GEOLGE	GEOL_ST	Layer_Line_Typ	FILE_FS
1473-BH01A	0	3.3	MADE GRON	103	MG		MG			
1473-BH01A	3.3	4.3	Very stiff br	208	LBrBC		LBrBC			
1473-BH01A	4.3	8.5	Hard black s	208	LBkBC		LBkBC			
200-BH02	0	5	MADE GROU	103	MG		MG			
200-BH02	5	6.4	Medium der	520	GG		GG			
200-BH02	6.4	10.5	Soft dark gre	310	AESS		AESS			
200-BH02	10.5	11.4	Grey fine to	520	GG		GG			
200-BH04	0	3.1	MADE GROU	103	MG		MG			
200-BH04	3.1	5.5	Dense to ve	504	GG		GG			
2223-BH03	0	3.4	MADE GROU	103	MG		MG			
2223-BH03	3.4	8.3	Fine to coar:	525	GG		GG			
2223-BH03	8.3	8.5	Stiff grey bl:	220	LBkBC		LBkBC			
2223-BH03	8.5	8.8	Grey black L	804	WrR		WrR			
224-BH01	0	0.4	Concrete an	103	MG		MG			
224-BH01	0.4	5	Fine to coar	504	GG		GG			
224-BH01	5	7.5	Hard black g	208	LBkBC		LBkBC			
224-BH02	0	0.3	Concrete an	103	MG		MG			
224-BH02	0.3	4.5	Dense fine t	504	GG		GG			
226-BH02	0	1.2	MADE GROU	103	MG		MG			
226-BH02	1.2	3	Soft mottlec	202	LBrBC		LBrBC			
226-BH02	3	7.3	Stiff to hard	208	LBkBC		LBkBC			
226-BH04	0	2.5	MADE GROU	103	MG		MG			
226-BH04	2.5	3.3	Soft to firm	204	LBrBC		LBrBC			
226-BH04	3.3	5.2	Firm to stiff	204	LBrBC		LBrBC			
226-BH04	5.2	6.5	Stiff to hard	208	LBkBC		LBkBC			
226-BH05	0	1.4	MADE GROU	103	MG		MG			
226-BH05	1.4	3.6	Soft to firm	220	LBrBC		LBrBC			
226-BH05	3.6	8.3	Very stiff/h:	226	LBkBC		LBkBC			
226-BH07	0	1.8	MADE GROU	103	MG		MG			

Figure 1.5a: Excel showing geology data

The coordinate data in the point sheet was combined with the geology sheet (Fig 1.6). This gave each geological unit in each borehole an X,Y and Z coordinate. A Z value was assigned for both the top and bottom of the strata (Fig.1.6).



PointID	Dep	GEOL_BA	Easting	Northing	GL	Upper_le	Lower_le	GEOL_DE	GEOL_LE	GEOL_GE	GEOL_GE	GEOL_GEOLGE	GEOL_ST	Layer_Line_Typ	FILE_FS
1473-BH01A	0	3.3	315791	235350	17.8	17.8	14.5	MADE GRON	103	MG		MG			
1473-BH01A	3.3	4.3	315791	235350	17.8	14.5	13.5	Very stiff br	208	LBrBC		LBrBC			
1473-BH01A	4.3	8.5	315791	235350	17.8	13.5	9.3	Hard black s	208	LBkBC		LBkBC			
200-BH02	0	5	315786	234448	3.39	3.39	-1.61	MADE GROU	103	MG		MG			
200-BH02	5	6.4	315786	234448	3.39	-1.61	-3.01	Medium de	520	GG		GG			
200-BH02	6.4	10.5	315786	234448	3.39	-3.01	-7.11	Soft dark gr	310	AESS		AESS			
200-BH02	10.5	11.4	315786	234448	3.39	-7.11	-8.01	Grey fine to	520	GG		GG			
200-BH04	0	3.1	315782	234468	3.39	3.39	0.29	MADE GROU	103	MG		MG			
200-BH04	3.1	5.5	315782	234468	3.39	0.29	-2.11	Dense to ve	504	GG		GG			
2223-BH03	0	3.4	315408	234592	6.69	6.69	3.29	MADE GROU	103	MG		MG			
2223-BH03	3.4	8.3	315408	234592	6.69	3.29	-1.61	Fine to coar	525	GG		GG			
2223-BH03	8.3	8.5	315408	234592	6.69	-1.61	-1.81	Stiff grey bl	220	LBkBC		LBkBC			
2223-BH03	8.5	8.8	315408	234592	6.69	-1.81	-2.11	Grey black L	804	WrR		WrR			
224-BH01	0	0.4	315768	234606	4.9	4.9	4.5	Concrete an	103	MG		MG			
224-BH01	0.4	5	315768	234606	4.9	4.5	-0.1	Fine to coar	504	GG		GG			
224-BH01	5	7.5	315768	234606	4.9	-0.1	-2.6	Hard black g	208	LBkBC		LBkBC			
224-BH02	0	0.3	315796	234595	4.9	4.9	4.6	Concrete an	103	MG		MG			
224-BH02	0.3	4.5	315796	234595	4.9	4.6	0.4	Dense fine t	504	GG		GG			
226-BH02	0	1.2	315746	235489	16	16	14.8	MADE GROU	103	MG		MG			
226-BH02	1.2	3	315746	235489	16	14.8	13	Soft mottled	202	LBrBC		LBrBC			
226-BH02	3	7.3	315746	235489	16	13	8.7	Stiff to hard	208	LBkBC		LBkBC			
226-BH04	0	2.5	315746	235489	16	16	13.5	MADE GROU	103	MG		MG			
226-BH04	2.5	3.3	315746	235489	16	13.5	12.7	Soft to firm	204	LBrBC		LBrBC			
226-BH04	3.3	5.2	315746	235489	16	12.7	10.8	Firm to stiff	204	LBrBC		LBrBC			
226-BH04	5.2	6.5	315746	235489	16	10.8	9.5	Stiff to hard	208	LBkBC		LBkBC			
226-BH05	0	1.4	315852	235488	16	16	14.6	MADE GROU	103	MG		MG			
226-BH05	1.4	3.6	315852	235488	16	14.6	12.4	Soft to firm	220	LBrBC		LBrBC			
226-BH05	3.6	8.3	315852	235488	16	12.4	7.7	Very stiff/h	226	LBkBC		LBkBC			
226-BH07	0	1.8	315833	235445	16	16	14.2	MADE GROU	103	MG		MG			

Figure 1.6: Excel sheet showing combined point and geology data

In completing Phase 1 the second major milestone was reached where the project now had a master data set.

1.2.3 Phase 3 Contouring

Surfer 8 contour and mapping programme was used to create contours. The base of the strata was used for defining and contouring all strata with the exception of the top of the bedrock. Grid files were created from the Excel spreadsheets previously made for each unit. The X, Y and Z values for each borehole were then used to generate the grid. The Kriging method was used for gridding (Fig: 1.7).

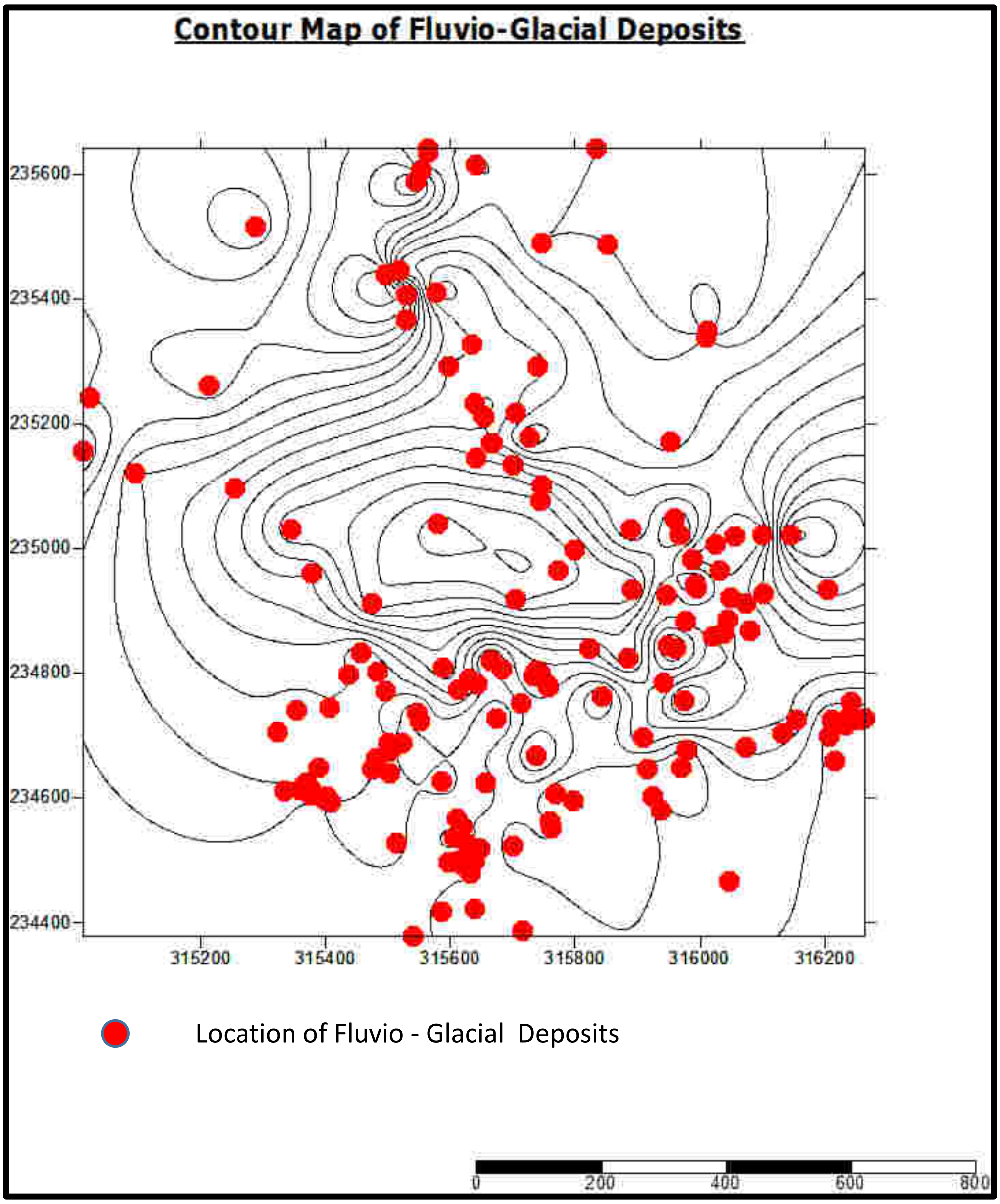


Figure 1.7: Contour Map of Fluvio-Glacial Deposits

Any over extrapolation created in the gridding method was later edited when they were converted to TIN files.

Contour maps were then produced for each unit using the appropriate grid files. These were then exported as a Drawing Interchange Format (DXF).

The third major milestone was reached on completion of Section 3. Contours were produced for each strata which would form the foundation of the TIN files.

1.2.4 Phase 4 Arcmap

Arcmap was used in this project in a number of ways. The primary uses were to geospatially reference all data, create a database of all referenced data to view graphically in ArcMap, produce TIN (triangulated irregular network) files from the DXF files produced in gINT and carry out post map editing.

The DXF contour files were added to the map. The borehole data for each stratum was projected onto the map. This allowed for analysis of the data to make sure that points were matching contours and that the spread of the data was even.

On completion of this phase the fourth milestone was reached. All data was now geo-referenced and available to view graphically in Arcmap.

1.2.5 Phase 5 Modifications

Due to the complexity of the geology modifications to the data needed to be carried out. The area was broken down into seven sections (Figure 1.8). A number of cross sections were then created in gINT to cover the area for each section. When interpreting the cross sections it became apparent there was likely to be significant overlap of the contours. To overcome this each unit was given a point in all boreholes whether or not the unit was found in the borehole. These points were created based on interpretations made from the two dimensional cross-sections (Fig.1.9). This gave more control over the contours rather than letting Surfer carry out extrapolations.

Borehole Location Plan and Modified Sections

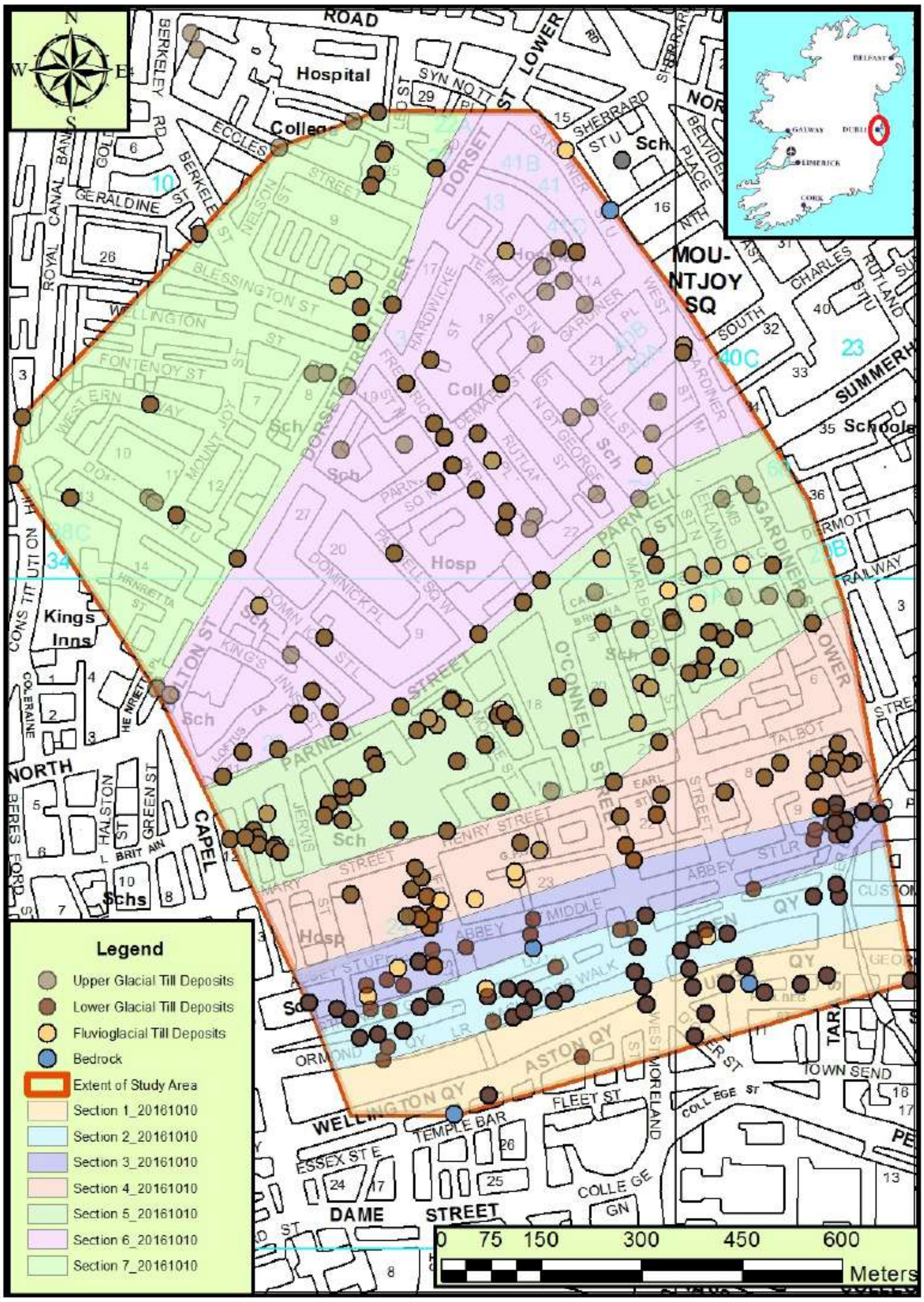


Figure 1.8: Modified Sections

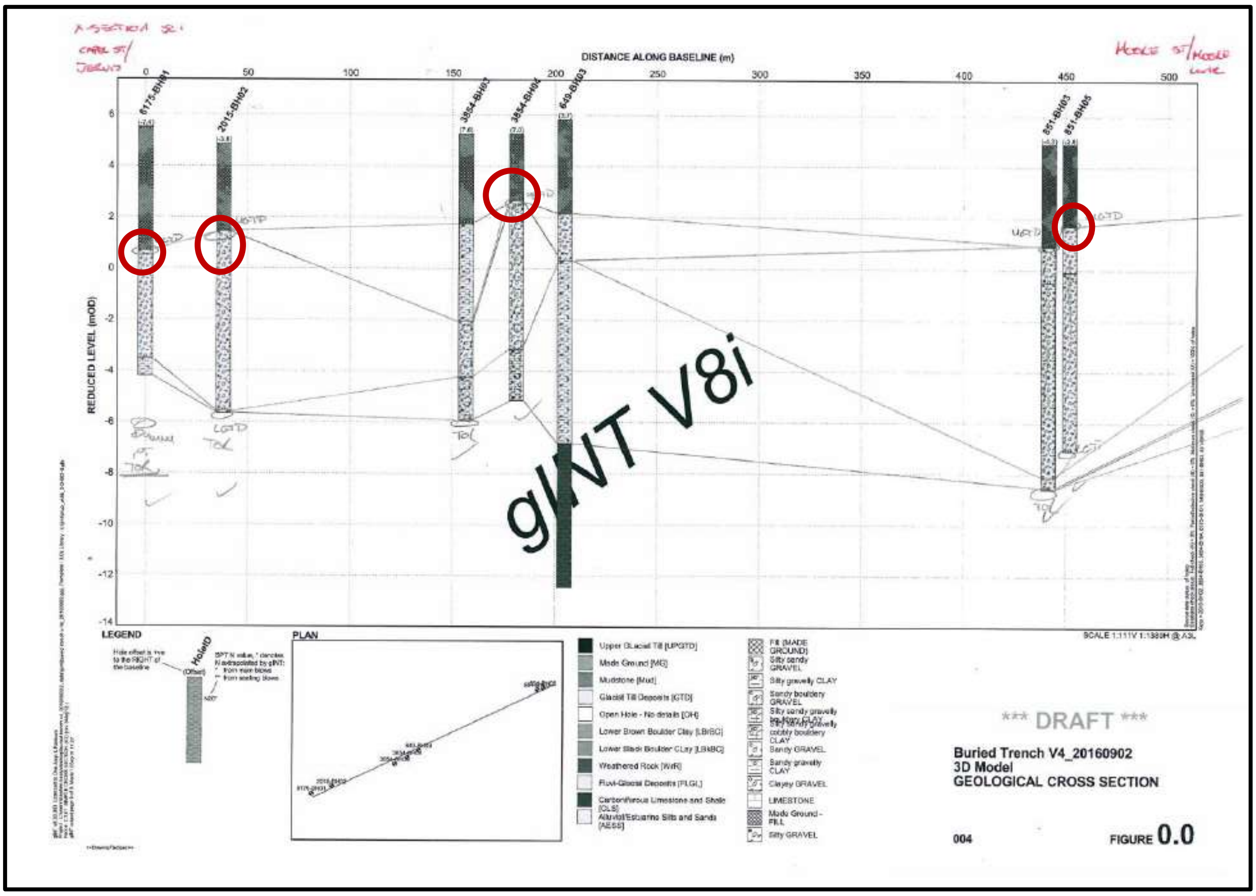


Figure 1.9: gINT cross section showing points created for the Upper GTD

The logs were then changed in gINT to reflect the additional points for contouring. The logs were exported from gINT. The Excel files used for contouring were reviewed and contours for each stratum created.

The contour DXF polylines were then used to create TIN files. A TIN file is a vector-based representation of the physical surface that is going to be created. In this case these surfaces are the bottom of the geological units (with the exception of the bedrock) found in the study area.

The milestone achieved at this point was done so in conjunction with Phase six. The result of which is a complete model.

1.2.6 Phase 6 Arcscene

ArcScene is a visualisation application that is used to view GIS data in three dimensions. Like ArcMap it allows you to overlay many layers of data. These layers can then be viewed in a three dimensional scene.

All boreholes were projected in Irish Grid. The TIN files were then edited to accurately represent the data. To do this shapefiles were created in Arcmap and the TIN file was clipped accordingly.

The TIN files were then reviewed in Arcscene. Minor adjustments needed to be made with regards to some of the contours. These adjustment were made in Surfer and the layers were recreated. The TIN Layers were once again imported into Arscene and the final model was produced. Some post map editing was carried out to annotate the map.

On completion of this in conjunction with Phase 5 the final milestone was reached where the model was now complete (Fig.1.9).

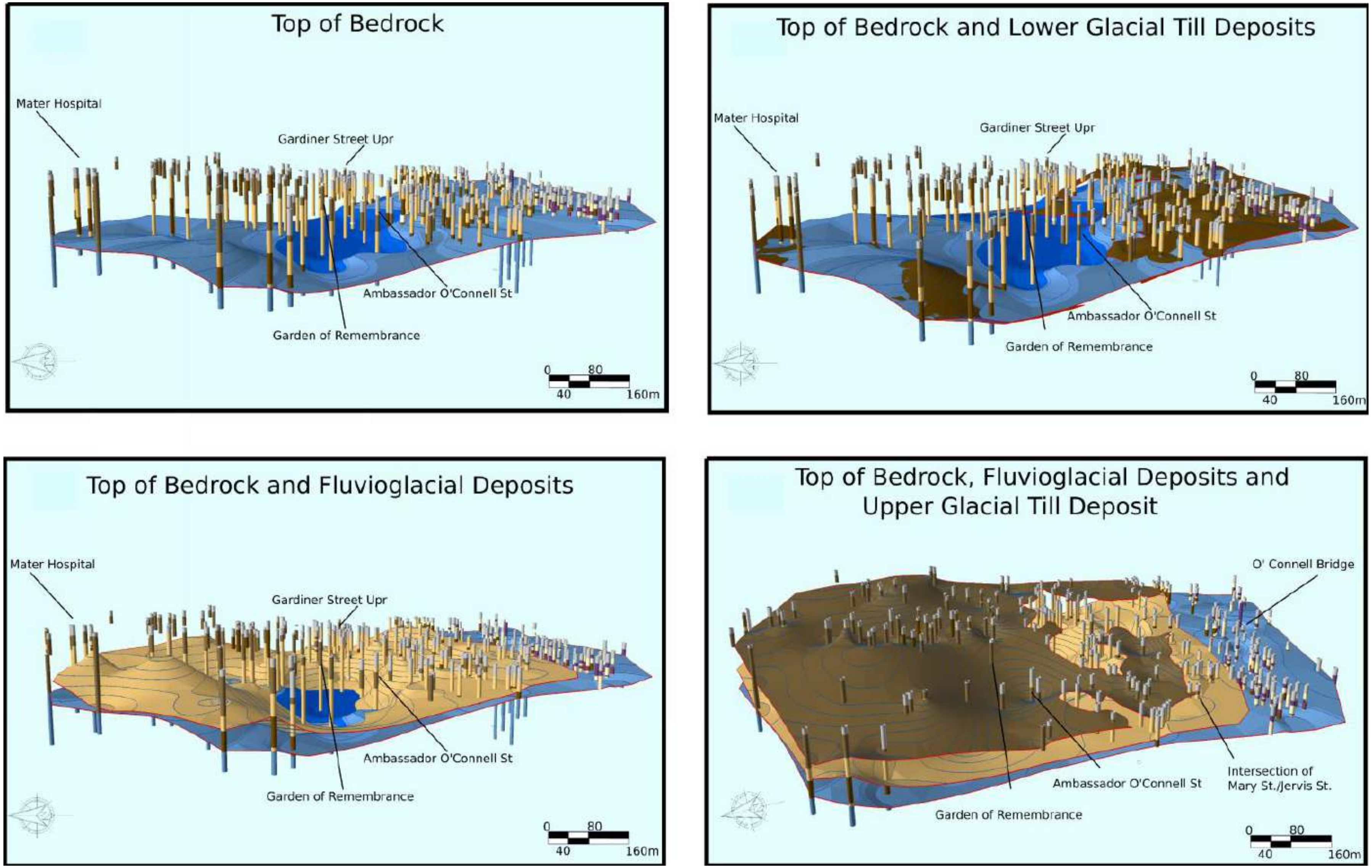


Figure 1.9:Complete Three Dimensional Model

1.3 Outputs

The outputs for the project are as follows:

- a gINT geotechnical database for the boreholes in the area
    - from which geotechnical borehole logs can be generated,
    - cross sections can be generated using the borehole data,
- an understanding of the geotechnical properties of the geology found in the study area,
- a set of two dimensional cross-sections for the entire study area,
- a georeferenced database that can be viewed in Arcmap,
- an interactive three dimensional model of the geology found within the study area (Fig.1.9).

1.4 Impact Value of The Project

One of the immediate impacts of the project is the ease with which the distribution of the Quaternary deposits within the study area can be viewed. The interactive design of the model enables the user to view the deposits from multiple angles and to add or remove layers as they wish. This allows the user to gain a good understanding as to the ground conditions in the area.

The model has been generated from an engineering geology/geotechnical perspective and could greatly enhance a desk-study carried out for engineering purposes. The model would also be very useful when trying to optimise a site investigation where it could give good guidance to targeting boreholes. A request to view and use the data from this project has already been made by a consulting firm with regards to future works within the area. As has been noted previously the line of the proposed Metro North passes through this area.

Due to this model being developed from an engineering geology/geotechnical perspective the future impacts are likely to be the same as the immediate impacts. The process behind developing this model could however be adopted to other geological models. If this were the case the basis of the model could be used in many industries from the mining and quarrying sector to the petroleum sector.

2 Project Expenditure & Deviations From The Budget

Item	*Cost €*
Personnel costs	18000
Student fees	6550
Consumables	0
Travel (incl. Fieldwork)	450
Other (please specify..)	0
Total	**25000**
Contribution (cash & in-kind), if applicable	0
Total requested from GSI	**25000**

3. GSI Funding Programme

3.1 Positive

This project has had the following positive outcomes:

- help understand geology, geological process that led to the formation of the pre-glacial trench,
- understand the nature of the deposits and any sub-layers within the deposits
- understand engineering behaviour of the deposits
- explore the use and applicability of 3D geological mapping using the existing GSI datasets as a basis to build upon and explore both economically and practically the benefits and limitations/constraints of creating a detailed applied geotechnical ground model
- identify additional uses of a detailed 3D geotechnical ground model e.g. preliminary identification of potential settlement receptors as a result of tunnelling in an urban environment.
- provided Master level education to Stephen Kealy. This programme, funded by the GSI, has provided a great opportunity for Stephen to further his education and to

work on a project that will be used at industry level. Without the funding provided by GSI it would not have been possible for him to undertake a Masters. It is a valuable programme and hopefully it continues further.

3.2 Suggestions

To further embellish the programme and to continue efforts into the development of 3D mapping it would be worthwhile to have several meetings or presentations with staff of the GSI that have an interest in the specific research area. It would likely give more focus to the project and develop a more collaborative approach.

4. References

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