APPENDIX A14

UISCE ÉIREANN : IRISH WATER

06.07.2017

Greater Dublin Drainage Project

Assessment of timing/phasing of diversion of North Fringe Sewer to GDD

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Background:

The GDD project envisages the future diversion of the North Fringe Sewer (NFS) from the Ringsend catchment to the GDD. This report assesses issues relevant to the timing of this work, in particular should it be included in Phase 1, should elements be included in Phase 1, or should it be deferred. In any event the construction of the orbital sewer facilitates the interception of a portion of the flow currently discharging to the Ringsend catchment (via the Sutton Pumping Station).

The principal issues to be considered are:

1. Flooding and environmental risks associated with the current North Dublin Drainage System / North Fringe Sewer, particularly in relation to the operation of the Sutton Pumping Station under current and future flows; and the extent to which any such risk may be mitigated by diversion of the NFS.
2. Planning risks associated with the decision to include or otherwise, including impact on the scale of the Phase 1 WWTW.
3. Impact on capital and operational costs (relating to both Ringsend and GDD), including transfer (pumping) costs.

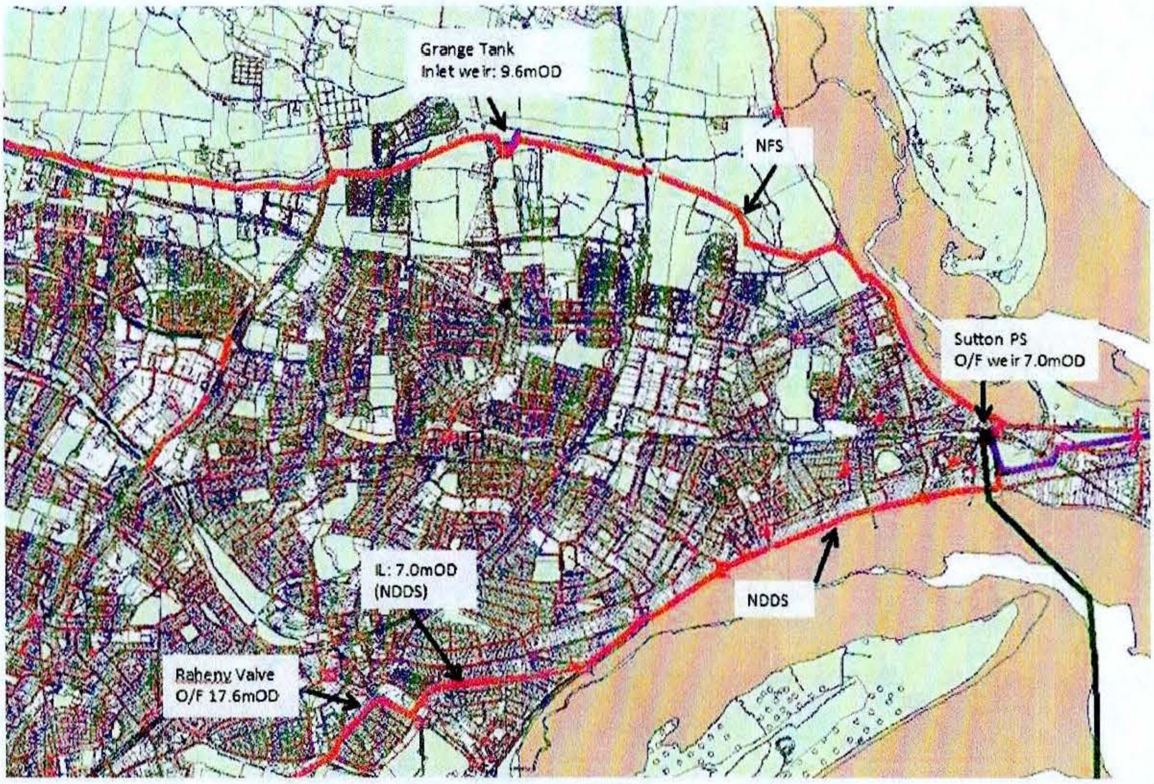
Within the above subjects consideration is given to options to mitigate risks.

The original NDDS discharged untreated sewage at the nose of Howth. In the early 2000's a pumping station was constructed in Sutton which intercepted the NDDS flow. This station also received flow from the newly constructed NFS. The sewage is pumped to Ringsend for treatment via an 11km pipeline across the bay. Excess flows during storm events overflow to the original outfall.

While the NFS flow comprises some flows diverted from the NDDS, it also services new development areas. Accordingly the capacity of the combined NDDS and NFS to deliver flow to the Sutton Pumping Station exceeds the capacity of the storm overflow (via the original NDDS outfall).

Both the NDDS and the NFS can surcharge and operate at pressure sewers in the vicinity of the pumping station and the overall design has had regard for this;

1. The wet well is constructed to a level of 10.00m OD (soffit of well roof slab), which is above the surrounding ground level of 3.8m OD.
2. At high level the NFS becomes surcharged to cause overflow to the Grange Storm Tank, some 4 km upstream of the pumping station. The overflow weir to the storm tank is currently set at approximately 9.5m OD. If this tank fills the settled storm water will discharge to the Mayne River.


Grange Tank
Inlet weir: 9.6mOD
NFS
Sutton PS
O/F weir 7.0mOD
IL: 7.0mOD
(NDDS)
NDDS
Raheny Valve
O/F 17.6mOD

Risk and Environment:

The principal risks associated with the Pumping Station and Operation of the Current Networks are:

1. Damage to structure or operation of the pumping station caused by excessive surcharge.
2. Flooding from the pumping station
3. Flooding from manholes on the pressurised sewer sections.

Environmental impacts associated with protection against such risks are associated with the overflows that are provided for in the design:

1. Overflow from Pumping Station to the Howth Outfall
2. Overflow from the Grange Tank to the Mayne River
3. Overflows from the NDDS at Raheny Valve House and elsewhere.

Drawings showing the layout of the Pumping Station are in Appendix A.
The intended operation of the system is shown in the schematic drawing in Appendix B.

Current Irish Water Projects:

1. A TOR for a Drainage Area Plan for the North Fringe Sewer is currently at tender. Following award it is expected that this will take 18 months to complete. In the meantime our assessment is limited to the use of the current 2002 model, as updated (see next section).
2. A contract has been awarded to JB Barrys for a detailed assessment of condition, performance and risk in the main pumping stations in the Dublin Drainage System, comprising the Main Lift Pumping Station (MLPS, Ringsend) and the Sutton Pumping Station. This contract is focussing on the MLPS in the first case. It is expected that the assessment of the Sutton PS will be complete by September 2017.

Hydraulic Model and Available Data:

Model used:

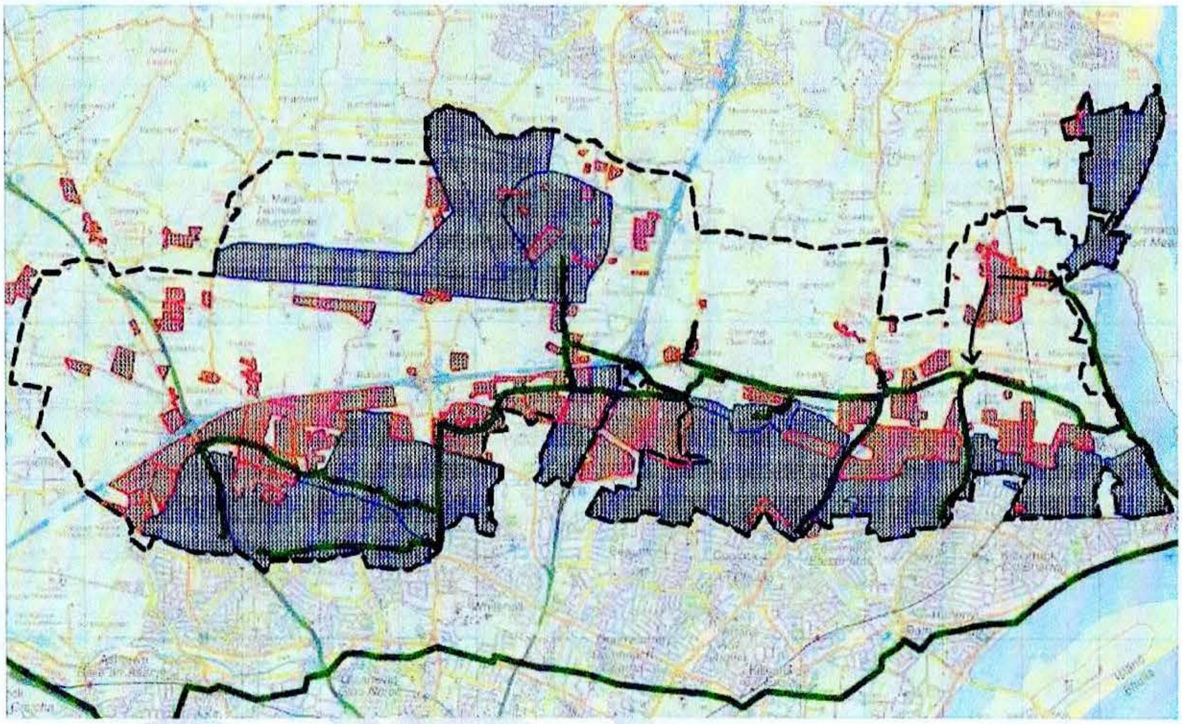
- GDSDS NDDS model (verified 2002)
- GDSDS NFS model (parts verified 2002)
- These models were updated with some as-constructed asset information particularly at Sutton PS & Grange Tank
- Some development since 2002 was added to the model, and the added development includes a 2% gross area misconnection allowance,

The following scenarios were modelled:

- Storms: M5-180 and M20-180
- Pump to Ringsend operational at 2.0, 2.4 & 2.8m3/s
- Pump failure at Sutton PS
- Failure of Howth Overflow (e.g. sewer/tunnel collapse)
- NFS Flow included/NFS diverted out of catchment altogether
- 2.65mOD 1000mm dia by-pass pipe open/closed
- Inlet weir to Grange Tank at 9.6 & 9.1mOD

- Tide levels at 1.7, 2.7mOD

While the original models date from 2002 it was updated in 2009. This is shown in the drawing under. The blue polygons were part of the GDSDS verified model; the red polygons (some of which are now developed) are now included in the model as per zoning at typical development levels with a 2% area allowance for misconnection.



Up to date models will be available from the DAP project (at tender).

We do have operational data from the existing system for the period 2007 to date, at 15 min intervals. Primarily this consists of:

- Pumped flow rate from Sutton to Ringsend
- Inlet flow on NDDS
- Level in both wet wells

The flow meter on the NFS inlet is not operational and so no flow data is available. We have examined the Pumped flow – NDDS inflow, when sump level is below overflow, to get an indication of the proportion of flow contributed by the NFS. This indicates that, on average, the NDDS flow is about 67% of the total flow.

We also have flow data from meters higher in the NFS catchment.

In relation to the data:

- Peak flows recorded from NDDS appear higher than expected and requires validation

- Depth measurements in the Pumping Station are not against the invert of the wet well. Following discussion with the site personnel it has been determined that a -4.25 m adjustment is required to convert the depth reading (local gauge) to m OD (Malin)..

Significance and Risk associated with Pumping Station Levels:

Level, mOD	Consequence	Risk	Mitigation
10m	Invert of main roof slab. Above this would pressurise main roof slab of wet well	Very High	If any circumstances cause this to occur. Structural risk to building, upstream pressurised sewers and associated flooding risk. Mitigation is to ensure overflows operate to prevent excessive surcharge. Modelling is important having regard for surge effects in incoming sewers.
7.5 m+	Floor level of low level sump roof section, and level of sump wall ships door. Previous incident in 2004 due to inadequate sealing in floor hatch; flooding pump dry well. Cause of surcharge was pump failure[1].	Medium - High	Within design parameters with +3.5m surcharging to incoming sewers. Surcharge of wet well roof slab cover commences. Design envisaged this wet well surcharge. Extra bracing applied to wet well sealed covers to reduce risk of leakage. Residual risk of overflow can be mitigated by relatively minor structural mods.
7 m+	Overflow weir to Howth Outfall	Low	Within design parameters with 3m surcharging of incoming sewers. No wet well surcharging.
5 m	Commencement of overflow to storm tanks	Low	Within design parameters with 1m surcharging of incoming sewers. No wet well surcharge.
4 m	Level of lower manholes covers on NDDS	Low	Within design parameters with minimal surcharging of incoming sewers. No wet well surcharging..
2.65m	Level of Bypass Pipe to Overflow	Very low	
-2.85 to 0.95 m	Normal operating level (Pump 1 cutout to Pump 3 cut-in)	Very low	

Operational Data:

[1] Initially installed pumps were very prone to blocking, up to 24 times per day, these were replaced with more effective Hidrostal pumps; these were subsequently replaced by IW in 2016 by Flygt N impeller pumps. Both have demonstrated reliable clog-free operation.

Operational data (see table under) indicates that the maximum level reached over the 10 years of available data is 7.72m OD, just over the sealing hatch in the low section of the sump roof.

The maximum levels in 2012 and 2014 were associated with pump failures rather than particularly high flows. Otherwise the levels are generally associated with high flows.

A recent site visit indicates debris on the lower rail of the walkway in the wet well. This suggests that there was a recent event that caused a surcharge to approximately 8.2m OD. This may be associated with a more recent event not captured in the data files analysed. This will require further investigation, which will include whether any such event was associated with pump failures (as occurred for the 2012 and 2014 peak level events).

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Metric	Unit	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Average Inlet (NDDS only)	l/s	660	716	684	682	701	701	690	726	667	627	632
Max Inlet (NDDS only)	l/s	3026	3485	3987	3286	3987	3291	3538	3577	3240	3323	3386
Average Level 1 Foul Sump	Local Gauge	2.72	2.91	2.94	2.85	2.76	2.99	2.94	3.16	2.78	2.57	2.35
Average Level 2 Foul Sump	Local Gauge	2.61	2.81	2.87	2.78	2.71	2.95	2.92	3.19	2.81	2.59	2.39
Max Level 1 Wet Well/Storm	Local Gauge	9.16	11.29	11.765	8.56	11.97	10.87	10.39	11.11	11.48	11.63	10.52
Max Level 2 Wet Well/Storm	Local Gauge	9.29	11.25	11.71	8.63	11.97	10.92	10.53	11.12	11.43	11.59	10.56
Average Outflow	l/s	917	987	960	911	904	1012	952	1035	972	919	864
Max Outflow	l/s	2525	2518	2462	2321	*3978*[2]	2537	2261	2155	2160	2172	2281
Average Level 1 Foul Sump	mOD	-1.53	-1.34	-1.31	-1.40	-1.49	-1.26	-1.31	-1.09	-1.47	-1.68	-1.90
Average Level 2 Foul Sump	mOD	-1.64	-1.44	-1.38	-1.47	-1.54	-1.30	-1.33	-1.06	-1.44	-1.66	-1.86
Max Level 1 Wet Well/Storm	mOD	4.91	7.04	7.52	4.31	7.72	6.62	6.14	6.86	7.23	7.38	6.27
Max Level 2 Wet Well/Storm	mOD	5.04	7.00	7.46	4.38	7.72	6.67	6.28	6.87	7.18	7.34	6.31
Max Inlet Time Date		06/08/2007 17:30	12/08/2008 01:45	03/11/2009 07:00	22/09/2010 20:00	01/12/2011 04:15	01/05/2012 12:00	26/07/2013 17:30	10/08/2014 05:00	28/12/2015 22:45	11/04/2016 14:30	10/06/2017 03:00
Max Level 1 Time Date		03/06/2007 11:00	09/08/2008 18:45	02/07/2009 05:15	27/12/2010 21:15	24/10/2011 20:15	24/09/2012 19:00	22/03/2013 14:00	11/11/2014 17:30	12/12/2015 12:30	09/01/2016 23:45	27/05/2017 14:30
Max Level 2 Time Date		03/06/2007 11:00	09/08/2008 18:45	02/07/2009 05:15	27/12/2010 21:15	24/10/2011 20:00	24/09/2012 19:00	22/03/2013 14:00	11/11/2014 17:30	12/12/2015 12:30	09/01/2016 23:45	27/05/2017 14:30
Max Outflow Time Date		15/08/2007 09:00	09/08/2008 18:30	02/07/2009 17:15	16/07/2010 02:15	11/10/2011 11:15	28/06/2012 19:30	25/01/2013 23:30	13/11/2014 15:45	03/12/2015 16:15	09/01/2016 22:30	10/06/2017 04:45
Outflow @ Max Level	l/s	2101	2510	2421	2117	2370	796	2146	901	2067	2132	1507
Level @ Max Outflow	mOD	1.65	7.04	5.98	3.09	0.58	1.88	4.934999	6.55	6.985	7.205	4.185
Comment on Level							Pump Failure		Pump Failure			

[2] This is an obvious error in data as the pump capacity is exceeded.

Level @ Maximum Inlet	mOD	2.14	4.05	0.18	3.05	-1.62	3.34	2.94	4.43	3.45	3.36	2.90

Further analysis of the data shows the level of overflow that has occurred from 2007 to date. This data is based on the times that the sump level was greater than 2.65m OD, at which stage the bypass starts to operate.

Year	NO. OF SPILL EVENTS	Total No. of 15min Intervals Over (2.65mOD)	Minutes/ Annum	Hours/ Annum	Days/ Annum	% Time
2016	22	619.00	9,285.00	154.75	6.45	1.77
2015	30	790.00	11,850.00	197.50	8.23	2.25
2014	35	1,325.00	19,875.00	331.25	13.80	3.78
2013	22	608.00	9,120.00	152.00	6.33	1.74
2012	19	844.00	12,660.00	211.00	8.79	2.41
2011	11	495.00	7,425.00	123.75	5.16	1.41
2010	12	472.00	7,080.00	118.00	4.92	1.35
2009	26	793.00	11,895.00	198.25	8.26	2.26
2008	25	827.00	12,405.00	206.75	8.61	2.36
2007	27	456.00	6,840.00	114.00	4.75	1.30
Average	23	722.90	10,843.50	180.73	7.53	2.06

This indicates that overflows, to some extent are occurring approximately 2% of the time (on average), with frequencies between 11 and 35 times per annum.

The data also suggests that the Grange tank has rarely filled in the last 10 years, which opinion is shared by DCC.

The bypass pipe installed at invert 2.65m OD is permanently open. A screen at the higher weir overflow has been removed because of concern of blockage.

Modelled Scenarios:

Initial model runs were based on overflow weir to Grange Tank at 8.8m OD, however it was subsequently confirmed by DCC that this level is 9.5/9.6 mOD. 9.6m OD was used in subsequent models (though level may actually be 9.5 m OD).

Further model runs were carried out to determine the impacts of reducing the weir to 9.1m OD, which we understand to be the original intention. This is also the level of the weir overflow from the Grange Tank to the Mayne River.

Model runs were carried out for various pumping rates, 2, 2.4 and 2.8 m3/s. The results represented under relate specifically to a 2 m3/s pumping rate.

The combinations that were considered were:

- Bypass open or closed
- NFS flow included or removed
- Pumps operating or failed (total)

Further extreme events were also modelled; complete collapse of the Howth Outfall, and a combination of collapse and pump failure, all under 20 year storm conditions.

Grange Weir 9.6mOD

20-year 180 min Event (starting at 7am) (Sutton PS 2.0)

	Scenarios										
	1	2	3	4	5	6	7	8	1(a)	3(a)	5(a)
1000mm OF pipe penstock	Open	Closed	Open	Closed	Open	Closed	Open	Closed	Open	Open	Open
NFS Flow	Included	Included	Diverted	Diverted	Included	Included	Diverted	Diverted	Included	Diverted	Included
Sutton Pumps	Operation	Operation	Operation	Operation	Failure	Failure	Failure	Failure	Operation	Operation	Failure
Howth Outfall	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Collapsed	Collapsed	Collapsed
Max HGL @											
Sutton PS	7.157	7.372	3.367	5.501	9.779	9.822	7.332	7.717	10.422	5.501	14.405
Raheeny Valve House	16.194	16.194	16.194	16.194	16.194	16.194	16.194	16.194	16.194	16.194	17.351
Grange Storm Tank	9.7	9.762	5.451	5.451	9.899	9.908	5.454	5.454	9.951	5.451	10.08
Max. Flow (m3/s)											
NDDS @ Sutton PS	2.485	2.457	2.429	2.387	2.413	2.418	2.564	2.495	2.348	2.386	1.947
Contract 5 @ Sutton PS	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
NFS @ Sutton PS	2.402	2.238	N/A	N/A	1.787	1.394	N/A	N/A	2.227	N/A	-2.059
Sutton Pumps	2	2	2	2	N/A	N/A	N/A	N/A	2	2	N/A
Sutton 1000mm OF Pipe	1.899	N/A	0.5	N/A	1.902	N/A	1.886	N/A	0.163	0.049	0.005
Sutton OF Weir	0.768	2.343	0	0	2.763	2.967	1.894	2.585	0.162	0	0.008
Raheeny OF Weir	0	0	0	0	0	0	0	0	0	0	0
Grange Tanks Inflow Weir	0.459	0.946	0	0	2.369	2.473	0	0	2.792	0	4.804
Grange Tanks OF Weir	0	0	0	0	2.351	2.473	0	0	3.007	0	4.804
Max Vol. (m3)											
Sutton Storm Tanks (total)	Full	Full	0	2258.9	Full	Full	Full	Full	Full	0	Full
Grange Storm Tanks	1769.6	3280.9	0	0	Full	Full	0	0	Full	0	Full

Grange Weir 9.1mOD

20-year 180 min Event (starting at 7am) (Sutton PS 2.0)

	Scenarios							
	1	2	3	4	5	6	7	8
1000mm OF pipe penstock	Open	Closed	Open	Closed	Open	Closed	Open	Closed
NFS Flow	Included	Included	Diverted	Diverted	Included	Included	Diverted	Diverted
Sutton Pumps	Operational	Operational	Operational	Operational	Failure	Failure	Failure	Failure
Max HGL @								
Sutton PS	7.086	7.349	3.367	5.501	9.349	9.364	7.332	7.717
Raheeny Valve House	16.194	16.194	16.194	16.194	16.194	16.194	16.194	16.194
Grange Storm Tank	9.219	9.283	5.451	5.451	9.438	9.451	5.454	5.454
Max. Flow (m3/s)								
NDDS @ Sutton PS	2.479	2.461	2.429	2.387	2.424	2.43	2.564	2.495
Contract 5 @ Sutton PS	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
NFS @ Sutton PS	2.299	2.14	N/A	N/A	1.56	1.244	N/A	N/A
Sutton Pumps	2	2	2	2	N/A	N/A	N/A	N/A
Sutton 1000mm OF Pipe	1.868	N/A	0.5	N/A	1.902	N/A	1.886	N/A
Sutton OF Weir	0.325	2.177	0	0	2.673	2.894	1.894	2.585
Raheeny OF Weir	0	0	0	0	0	0	0	0
Grange Tanks Inflow Weir	0.596	1.135	0	0	2.487	2.467	0	0
Grange Tanks OF Weir	0	0	0	0	2.312	2.428	0	0
Max Vol. (m3)								
Sutton Storm Tanks (total)	Full	Full	0	2258.9	Full	Full	Full	Full
Grange Storm Tanks	2665.6	4607.8	0	0	Full	Full	0	0

The model predicts that under a 20 year storm event (associated with high network usage), and normal operation, the level in the Pumping Station can rise to 7.157m (bypass open, as present). The storm tanks in the PS would be full and the Grange Tank would be almost full.

The readings show that this level was exceeded in 4 of the last 10 years. Most significantly in 2011 when the level reached 7.72m OD. This may be due to the model under-representing the degree of connectivity, foul and storm, due to its age (2002).

As noted on page 8 a recent visit indicated debris up to approximately 8.2m OD. It is not clear if this was associated with a failure event. Further investigation is required.

The outcomes of the modelling exercise are summarised as follows:

Normal Operation – high flow (20 year event):

- Sutton PS can surcharge to c. 7.2m (bypass open, Sutton Pumps 2m3/s).
- Increasing pump rate to 2.4/2.8 (data not included in report) makes little difference with bypass closed (-c. 200mm) but makes a considerable difference with the bypass open (c. 2m).
- Closing bypass raises max level by c. 200mm.
- Lowering overflow weir to Grange tank to 9.1m OD does not significantly alter levels.
- Removing NFS would reduce levels such that overflow to Howth Outfall would not occur, if the bypass is closed.

Failure Mode – Complete Pump failure – high flows:

- Sutton PS surcharges to c. 9.8m (bypass closed or open). At this stage NFS is overflowing to the Grange Tank.
- Above based on Grange Tank inlet weir at 9.6m OD. Lowering the weir to 9.1m OD would reduce surcharge to c.9.35mOD.
- Removing NFS reduces surcharge to 7.3 (bypass open) or 7.7m (bypass closed).

Failure Mode – Collapse on Howth Overflow (complete blockage) – high flows

- Scenario 1(a) indicates a surcharge to c. 10.4m, at which stage the wet well roof would be subject to 400mm WG uplift pressure.
- The reduction from lowering the NFS overflow to the Grange Tank has not been modelled.
- Removing the NFS reduces the maximum level to 5.5 m OD.

In normal operation the diversion of the NFS would reduce surcharge in the Sutton Pumping Station and has the potential to eliminate (other than in emergency situations) overflow to the Howth Outfall.

In the event of pump failure the Pumping station can operate in accordance with design, by overflowing the NFS via the Grange Tank, and catering for the NDDS flow through the overflow.

Diversion would not necessarily eliminate the need for this overflow as the Grange Tank would be associated with the operation of a new PS at Grange.

While a complete collapse of the Howth Outfall has a very low probability[3], it has the potential to cause more significant surcharging to the pumping station. In an emergency situation the inlet penstocks to the Pumping Station may be closed, which would cause backup in the sewer to overflow points. The pressures involved were envisaged in the system design (see under replication from Appendix B).

Table 3			
Maximum system Pressure			
With NDDS & NFS Penstocks Closed at Sutton PS			
Weir Levels (m) OD	Sutton Invert Level (m) OD	Total Head Pressure (m) OD	Maximum Pressure BAR
Between Raheny Weir & NDDS IC Chamber			
17.60	1.73	15.87	1.55
Between Raheny Weir & NDDS Penstock			

[3] NDDS Overflow line: in 1992 (when the overflow line was the working sewer) a CCTV Survey was undertaken and we have the raw defect coding files for this survey. It appears that <u>most</u> of the 1500mm pipe was surveyed between the location of Sutton PS and Howth Harbour. The pipe is recorded as being in very good structural condition and only 2 minor defects were visible. There is some silt, 5 to 10% max, recorded in some sections. Downstream of Howth Harbour the section was tunnelled – we have no record of CCTV here.

17.00	-3.50	21.10	2.06
Between Raheny Weir & NDDS Penstock			
9.10	-3.50	12.60	1.23

In this regard the operability of these penstocks is important. At present there is a reticence to operate these due to risk of failure to open.

However the following need to be addressed:

- Maintenance and reliable operability of these penstocks
- Modelling to assess impacts of full shut down on NDDS. This needs to take account of limited capacity of 600mm overflow at Raheny, and any other connection, in particular the route 14 connection (records indicate this connection is retained as an overflow from an NFS branch).

Records show that NDDS flow can be up to 4 m3/s, though the validity of these results need to be assessed, as this flow exceeds the calculated hydraulic capacity of the pipeline to Sutton from the Raheny Valve House of c. 2.7 m3/s. This indicates potential over-reading of flows by the NDDS flowmeter..

Other summary points from the modelling are:

- Raheny Valve House overflow (closest overflow on NDDS to Sutton PS) is not activated under any scenario (sewer is free flow, never surcharged);

- Tide levels make no difference or very little difference to levels/flows;

- Modelling indicates that when the Sutton PS pumps are operational and the NFS is removed from the catchment there would be a substantial reduction in the frequency of surcharging of the NDDS and Sutton PS itself. The use of Time Series Rainfall runs would give a better indication of the frequency of surcharge event reduction. This will be provided in the model update under the proposed DAP (at tender);

- Modelling evidence suggest that when levels in Sutton PS rise above 7.0mOD spills into the Grange Tank (weir @ 9.6mOD) are also occurring. Further modelling would be required to get a more refined picture of the balance between the water levels at these two locations e.g. to answer which spill is triggered first: the spill to the Nose of Howth or the spill to Grange Tank;

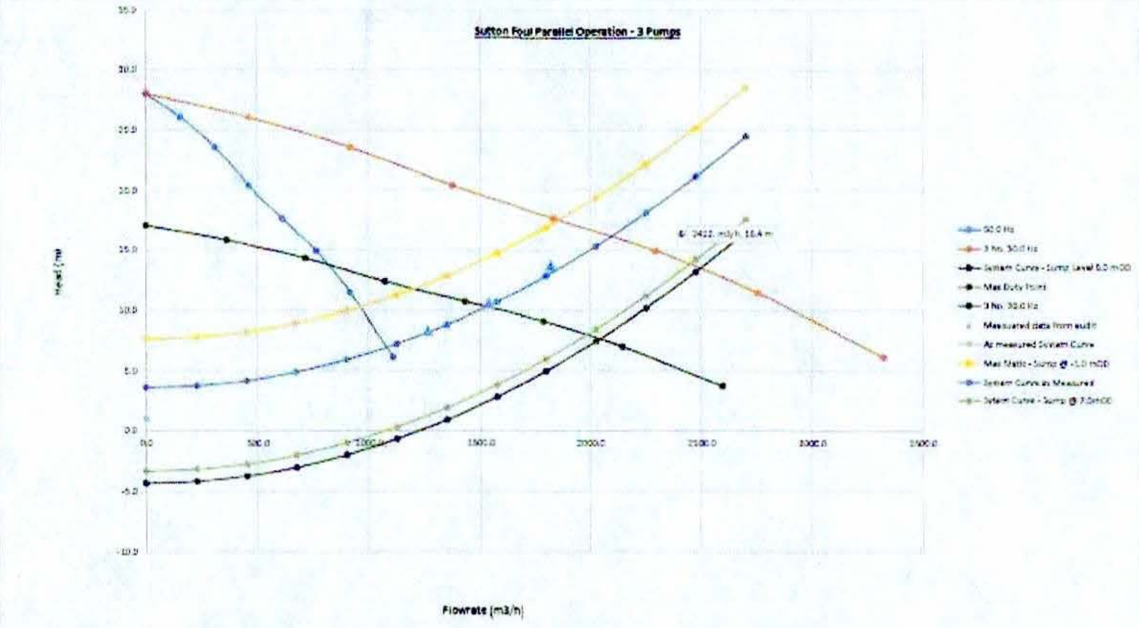
- The by-pass pipe reduces the frequency of levels in Sutton PS rising above 3mOD and reaching the weir level of 7mOD. An assessment of the impact of the by-pass pipe on spill frequency (to Nose of Howth) would require further modelling using Time Series Rainfall.

Pumping Capacity

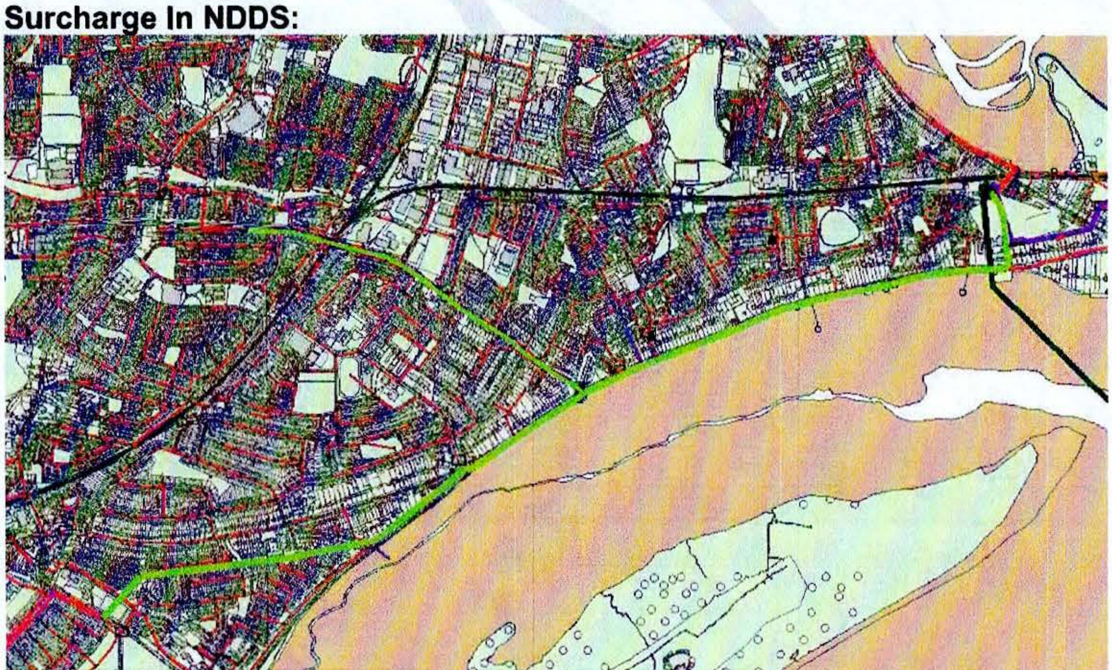
While the newly installed pumps have a specified normal duty point of 2 m3/s (3 pumps out of 4 running) examination of performance and system curves show that 3 pumps, at high sump level (7 to 8 m OD), can deliver approximately 2.5 m3/s.

It is likely that the contractor has set the speed control to limit the maximum pumping rate, but this can be adjusted.

The models referred to above were based on 2 m3/s pump rate.



Surcharge In NDDS:



Extent of NDDS Subject to Surcharging up to 10mOD

(highlighted green, NDDS: 4,240m & 25manholes, Route 14 1,500m & 7 manholes)

Planning Issues

Planning Risks have been assessed by the Ervia Project Team (Major Projects).

Communication Risks: The communication risks associated with omitting the Grange Pumping Station and its twin Rising Mains from GDD Phase 1 are as follows. The omission:

- Undermines the engagement with the communities in the vicinity of the WwTP - the treatment of effluent from the communities in the vicinity of the treatment plant has been a key message in the materials and political engagement and communication to date;
- Presents an opportunity to undermine the need for the project as currently envisaged; and.
- Provides an opportunity to undermine and challenge the site selection process.

Furthermore, and to the contrary, the inclusion of NFS in the GDD project necessitates upgrading the WWTP at Clonshaugh from a 420,000 P.E plant to c. a. 600,000 P.E. plant. To date, all communication associated with a new plant at Clonshaugh has been based on a 420,000 P.E. plant. An increase in plant capacity runs the risk of heightening objections and fuelling the argument that the plant is not serving the immediate locality but is in fact, serving communities from much further afield.

Wayleave Risks: The proposed exclusion of the Grange Pumping station and associated twin rising mains from the scope of the GDD project presents a number of risks from a wayleave acquisition perspective as follows:

- Interactions with landowners to date have been on the basis that all three pipelines (outfall and twin Rising Mains) will be laid at the same time; disturbance associated with construction will be mitigated and minimised; works will be completed as quickly as possible; the 40 metre wide working corridor will be fully reinstated. A period of 18 months will enable lands to be reinstated to its original condition/agricultural production, resulting in a 20 metre permanent wayleave with no requirement to carry out extensive works in the future, save normal maintenance. Any deviation from these plans undermines confidence in Irish Water and will need to be communicated to landowners as soon as possible.

- The pipeline corridor between the WwTP and Grange Pumping Station traverses some of the most productive agricultural land in north County Dublin; the quality of reinstatement of land post construction and the reconditioning / recovery of the lands thereafter is a significant concern for affected landowners. The suggestion that Irish Water will be returning in 10, 20 or even 30 years to re-excavate this land and lay the twin Rising Mains will be unpalatable to landowners. It is highly likely that this will contribute to increased opposition to the project as a whole and consequently instigate a reduction in the number of wayleaves that might be secured on a voluntary basis.

- Exclusion of the twin Rising Mains will not lead to any reduction in wayleave acquisition costs for Phase 1 of the project, with exception of the section comprising solely of the Rising Main spur with no Outfall and the acquisition of the Grange Pumping Station site. Indeed, to the contrary, it is possible that an increase in wayleave costs may occur.

- The likelihood of future development taking place up to the edge of the proposed 20m permanent wayleave, within the medium to long term cannot be ignored. This could mean that any future Rising Main construction activity may not have the benefit of the 40m wide working area of the outfall and future construction works being confined to the 20m permanent wayleave.

- In the event that it was intended to use the GDD 20m wide permanent wayleave for the future installation of the Rising Mains our legal advisors have indicated that it would be prudent to amend the current Deed of Easement to expressly provide for this. The GDD CPO documentation will need to be amended similarly to refer to the future potential for inclusion of additional Rising Main pipelines. Specialist planning advice will need to be sought to understand the planning implications of this.

- If the amendment of the Deed of Easement and CPO documentation is not undertaken, it is likely that a "new" wayleave over the existing wayleave will need to be acquired prior to future construction of the rising main.

- Additional costs will be payable in the future in respect of any losses and disturbance arising from future construction associated with laying the Rising Mains.

Impact on Design capacity for GDD:

At present Asset Strategy has signed off on a 420,000 PE phase 1 for the GDD WWTW. This is based on diversion of the 9C (including Leixlip transfer) and some interception of the NFS (i.e. NFS branches intercepted by the GDD Orbital sewer – which accounts for approximately 14% of the NFS load). The figure is also in line with previously publicised figures.

In the event of a decision to implement full transfer of NFS loads to the GDD, the relative design capacities of the Ringsend and GDD WWTWs would change as follows:

- Ringsend: 2.4m PE to 2.22m PE
- GDD: 0.42m PE to 0.60m PE

The above is an estimate based on incomplete update of data to account for 2016 census. This can be validated by the Consultant (who has updated the data set).

Note that the figures refer to capacity requirements, and exceed projected load due to the addition of 20% headroom. The projected capacity is based on:

- Projection for 25 years (tactical fit-out of the plant may be phased during this period)
- Projected domestic and associated commercial loads
- Present industrial discharge, plus proposed industrial discharge of 150,000 PE transferred from Leixlip
- 20% headroom applied to the domestic/commercial load. This provides resilience and a buffer against normal variations. It also can be assigned to new industry in accordance with prevailing CDS policy; per WSSP this would be on the basis that planning of works is brought forward to restore headroom.

The resulting calculated capacity figures are as follows (to be updated to 2016 census baseline):

Year	NFS Full Transfer to GDD		NFS partial transfer to GDD (orbital interception, excluding Ballymun PS)		Total	Original GDD Report total load projection (incl Industry)
	Ringsend Required Capacity	GDD required capacity	Ringsend Required Capacity	GDD required capacity		

2016	2,102,524	-	2,102,524	-	2,102,524	1,808,046
2017	2,119,486	-	2,119,486	-	2,119,486	1,836,725
2023	2,379,600	-	2,379,600	-	2,379,600	2,029,984
2024	1,879,613	520,630	2,017,789	382,455	2,400,244	2,066,759
2025	1,896,770	524,342	2,036,556	384,556	2,421,113	2,012,879
2030	1,985,412	543,507	2,133,518	395,402	2,528,920	2,121,045
2040	2,135,919	576,778	2,298,206	414,490	2,712,696	2,313,404
2045	2,211,513	593,541	2,380,929	424,126	2,805,055	2,411,332
2046	2,226,891	596,951	2,397,756	426,086	2,823,842	2,431,294
2047	2,242,392	600,389	2,414,719	428,062	2,842,781	2,451,422
2048	2,258,020	603,854	2,431,820	430,054	2,861,874	2,471,717
2049	2,273,774	607,347	2,449,059	432,062	2,881,121	2,492,181
2050	2,289,655	610,869	2,466,438	434,086	2,900,524	2,512,389

Impact of NFS full load diversion on GDD design:

	Current Proposal		Full NFS diversion	
	2016	2048	2016	2048
Domestic & Commercial	152,264	203,903		
Ex. Industry	14,541	14,541		
SIC	150,000	150,000		
NFS	16,668	17,336	+98,959	+138,168
Sub-Total	333,473	385,780	432,432	523,948
Headroom	33,786	44,248	53,578	71,881
Total	**367,259**	**430,028**	**486,010**	**595,829**

The above are provisional figures and will require updating arising from the full update from the 2016 census (only partially reflected above)

Costs:

Estimates of the capital and operational costs differences for the options are as follows:

Capital Costs:

item	Cost increase (decrease)
Increase in GDD WWTW from 430,000 PE to 600,000 PE	€62m
Decrease in Ringsend WWTW cost. Approx 170,000 PE reduction. It is not possible to give an accurate assessment as the design details for Ringsend will only be confirmed when the trial (PPS2) is complete (probably Q2 2018). Working assumption is that a bank of 4 SBR tanks can be upgraded to hybrid rather than full AGS. There would be some costs for sludge transfer that would also come into play.	(€58.5m)
Pumping Station at Grange; model suggests peak flow may be up to 2.4 m3/s, but average flow may be in the order of 0.3-0.4 m3/s. calculations will assume 0.35 m3/s average.: Average flow 0.35 m3/s Peak flow 1.05 m3/s Average power consumption (39m static head, friction 1 – 9.5m, say 2 m average, 70% wire efficiency) = 201 kW average; Calculate only difference from Sutton PS at 16 m TDH Delta energy is 123 kW average; 1,077,480 kWh p.a.	€10.76m
Site and access for Pumping Station (may fall for consideration for phase 1)	€0.26m
Rising main; 5,459m of 900mm dia rising main, and sleeves for future diversion of NDDS (allow 1000mm)	€7.2m
Increased storage at Grange: At present peak NFS flows normally discharge to Sutton PS and can overflow there. The Existing Grange Tank is only to provide emergency storage. If pumped flow to GDD WWTW is to be limited to 3 DWF then additional storage will likely be required at the Grange to prevent excessive overflow to the Mayne River. The alternative of allowing high overflows to continue to Sutton would defeat any objective of reducing risk at Sutton PS[4]. Alternatively flow	€3.3m

[4] In normal operation it may be better to allow flow to continue onto Ringsend, for reduced pumping costs. However the advantage of this overflow is not available at high flows if the object is to prevent excessive surcharge at Sutton PS

rates as high as 2.4 m3/s would have to be pumped to the GDD WWTW, requiring storage their or additional capacity to treat this flow. Assume additional 5,000 m3 storm tank.	
Total Additional Cost	€25.02m

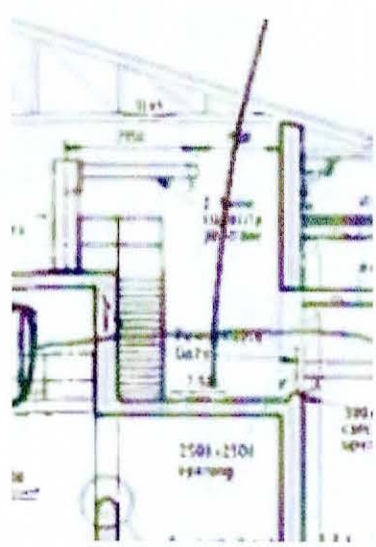
Operational Costs:

item	Cost increase (decrease)
Increase in GDD WWTW operating costs 430,000 PE to 600,000 PE	**€2,126,700**
Decrease in Ringsend WWTW operating costs. Estimate is based on current PE costs. While the upgraded plant will be more efficient, it will also operate to higher standards. Both of these factors are assumed to cancel each other. Reduced by 170,000 PE.	**€1,810,500**
Increase in pumping costs (Grange PS v Sutton): • Energy cost 1,077,480 kWh p.a. @ 20c/kWh • Fixed PS operating costs (estimate 1,000 kW installed power)	 **€215,000 p.a.** **€200,000 p.a**

Risk Mitigation

Flooding and Environmental Risk:

1. Recommission flowmeter for NFS inflow to Sutton PS and provide telemetry at Grange Tank to provide data on levels and spill frequency.
2. Verify performance of NFS/NDDS network under normal and extreme conditions (DAP at tender, and Pumping Station assessment contract in place)
3. Verify condition and risk to Howth Outfall by survey. This should extend from connection at Sutton PS at least to the old Howth Screenhouse. Condition of overflow at that point to be assessed for use in extreme emergency.
4. Measures to be put in place to inspect existing isolation penstocks and ensure operability.
5. Inspection and maintenance regime for penstocks at Grange Tank and Raheeny Valve House.
6. Existing pump control philosophy to be reviewed with the purpose of maximising pump forward capacity at high wet well levels to reduce flood risk.
7. Maintenance regime at Sutton PS to be critically examined and updated where required to ensure reliable availability of all critical plant and equipment (including pumps, generator, electrics and controls, surge control and ventilation equipment). Ensure programmed maintenance regime for all critical Pumping Station plant and equipment, and ready availability of service and spares. Carry out risk assessment to eliminate potential for any one fault to shut down pumping.
8. Establish priority telemetry alarm to control room linked to flow/rainfall data.
9. Review risk associated with surcharge of sump above the lower floor section (see right), and higher. If required make structural or other modifications to reduce risk to lowest levels.



10. Consider bypass reconnection of NDDS line to the NDDS outfall (to allow bypassing of pumping station to overflow in the event of emergency)
11. Inspect sealed manhole covers to ensure theses are correctly fitted and serviceable. (Note: Even if NFS was diverted the isolation of the NDDS by closing the inlet penstock will pressurise the manholes)
12. Reduction of flows by diversion of some of NFS can be used to offset growth increases. At present the Phase 1 Orbital Sewer intercepts some branches feeding the NFS, diverting about 14% of the load (and potential high hydraulic flows from the sub-catchment). Further extension of the rising main from the Ballymun PS to the Orbital Sewer would bring the total NFS flow diverted to close to 30%. This would bring the GDD up to about 450,000 PE. Or diversion of the NFS at the proposed WWTP by gravity would divert a similar percentage. These diversions are more sustainable from an energy perspective and should be considered in any event. Also such diversions may be useful in managing planning/comms risk and merit consideration from that perspective.
13. Integration of measurement and control measures to provide predictive Real Time Control (RTC) with capability to control flow at optimum control points (potentially downstream of Grange Tank).

Planning Risk:

1. Construction of future works at phase 1, e.g. installation of rising mains for future use.
2. Diversion of portion of NFS in vicinity of WWTW, e.g. gravity connection at access road to new WWTW. Such connection would mitigate any complaint that the WWTW was not serving the local area.

Conclusions

1. Full diversion of the NFS to the GDD will reduce flows, level of surcharge under all conditions, and significantly reduce volume and frequency of overflow.
2. Modelling done to support this report indicates surcharge close to the level of the soffit of the main wet well roof slab to the Pumping Station under extreme conditions only (high flow and complete failure of pumping station), and pressurisation of the roof slab under the improbable coincidence of high storm flow and total collapse/blockage of the Howth Outfall.
3. There are technical mitigations to the above risk, principally
    a. Inspection and maintenance of overflow (with consideration of maintenance of Howth Screening Overflow for extreme emergency).
    b. Reductions in inflow to Sutton PS by partial diversion of NFS and lowering of overflow to Grange Tank. These reductions will be countered by increased growth; and the impact depends on the relative growth potential of the diverted portion.
    c. Real Time Control and predictive flow management. For example under very extreme events (high flow and station failure) flow at Grange can be optimised, maximising timely utilisation of storage capacity.
    d. Enhanced Planned Maintenance regime at Sutton PS, to ensure reliable availability of all critical plant and equipment (including pumps, generator, electrics and controls, surge control and ventilation equipment). Ensure programmed maintenance regime for all critical Pumping Station plant and equipment, and ready availability of service and spares.
4. For extreme emergency it is necessary to be able to isolate inlet lines to the Pumping Station. This applies whether or not the NFS is fully diverted. A failsafe and reliable system should be put in place.
5. There are also planning risks associated with the historical development of the GDD scheme and public expectation regarding any proposal to divert, or not, flows from the NFS to the GDD WWTW.. In this regard the partial diversion of the NFS to connect the local drainage to the GDD WWTW would mitigate risk of complaint that it was not servicing the area in which the WWTW was located, while also relieving flows to the Sutton Pumping Station and reducing risks there..
6. A decision on options requires consideration of the best balance of risk and cost in the context of the delivery of the GDD, regional development needs, and the future performance of the Sutton Pumping Station. In this regard it appears that the following measures offer the best balance:
    a. Partial diversion of flow from the NFS to the GDD WWTW, possibly by supplementing the interception of flows by the orbital sewer with the diversion of the NFS to the GDD WWTW at the closest point. This would result in the diversion of approximately 30% of the NFS flow to the GDD. This reduces the

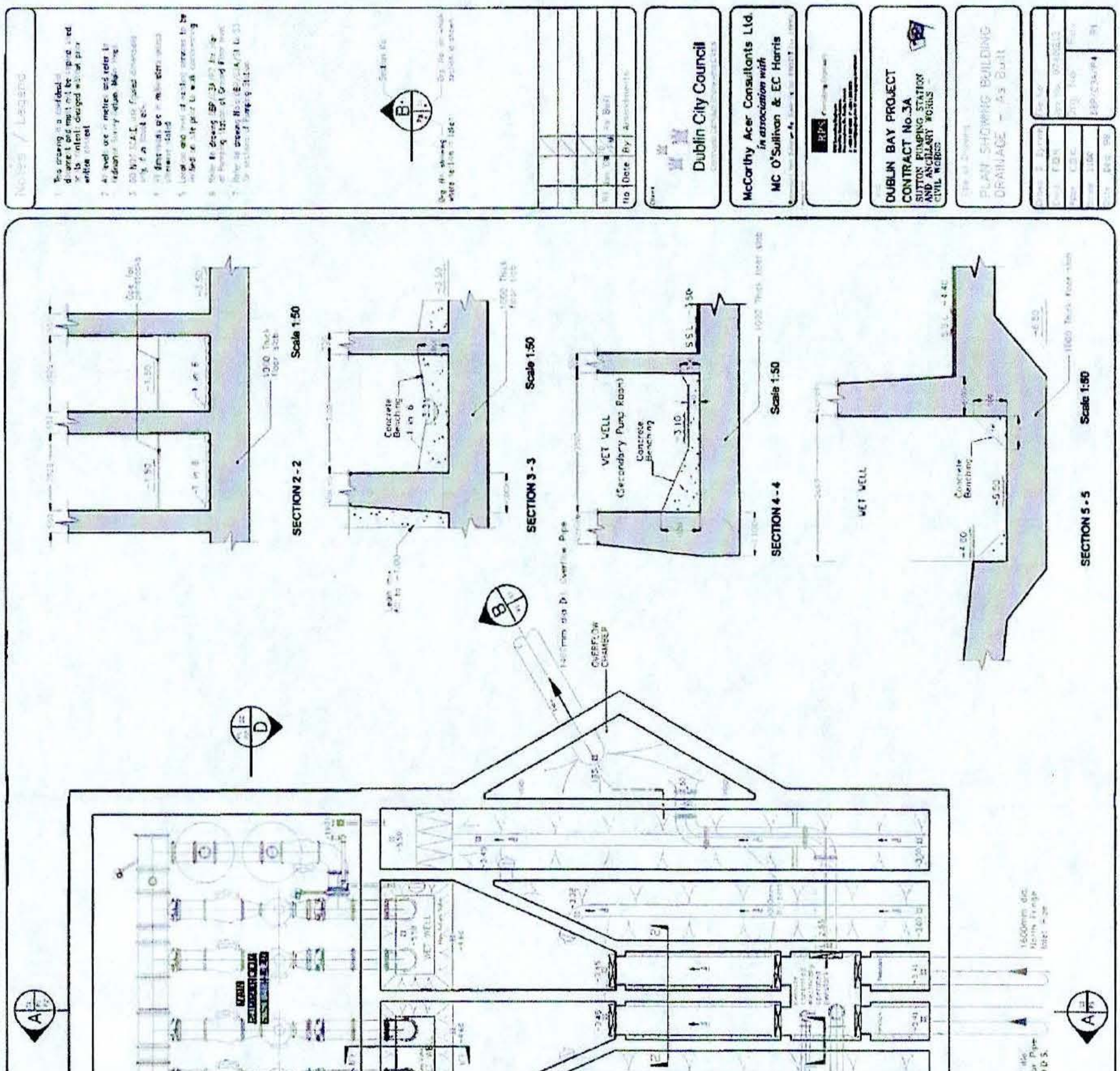
flow to the Sutton Pumping Station and also minimises the energy usage associated with diversion (by having the lowest pumping energy).

b. Further mitigation of risk at Sutton Pumping Station by implementing technical measures, generally as described, to;
    i. Ensure high reliability of operation of all critical components in the PS,
    ii. Ensure reliable operation of inlet isolation
    iii. Ensure and maintain effectiveness of NFS and NDDS systems to operate under surcharged conditions
    iv. Provide control to optimise the pumping rate forward and the network and storage utilisation, to minimise risk and overflows.

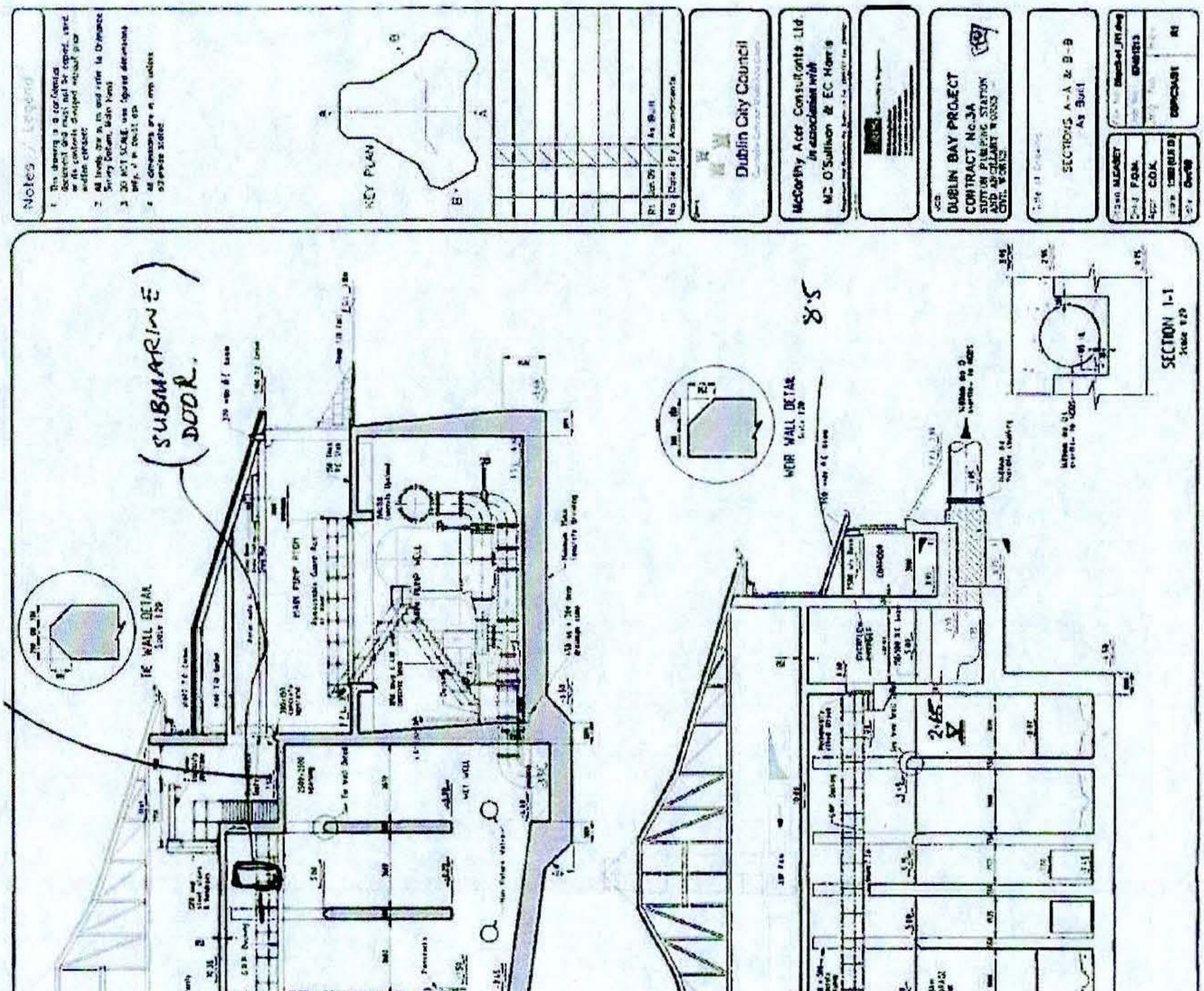
The detail of these measures will be further advised by the current work assessing pumping station performance and risk (due for completion in September) and the Drainage Area Plan for the catchment (currently at tender)

APPENDICES:

Appendix A1: Layout of Sutton Pumping Station



Appendix 2: Sections of Sutton Pumping Station



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Appendix B1: Hydraulic Analysis for original design

SUTTON PUMPING STATION

DWF = 1.6 m^3/s

Inflow (Max) = 5.3 m^3/s → NDDS = 3.2 m^3/s max; NFS = 2.1 m^3/s max

Main Pump Capacity = 2.4 - 2.8 m^3/s (Minimum Flow = 1.4 m^3/s)

Overflow Capacity = 2.49 m^3/s - 2.98 m^3/s (See Table 1)

Outflow Max = 5.29 m^3/s

OPERATION OF SYSTEM UNDER STORM CONDITIONS & PUMP FAILURE

If inflow is below 5.0m OD :
Wet Well sump level will rise

If Wet Well sump rises to over 5.0m OD:
Overflow into storm tanks at Sutton (Storm Capacity 3500m³).

If Wet Well sump rises to over 7.0m OD:
Flow to Outfall
Refer to TABLE 1 for flows to outfall at tides of 1.7m OD and 2.7m OD.

If Wet Well sump rises to 9.1m OD :
The NFS flow (max 2.1 m^3/s) will cease and Grange Storm Tank (Weir 9.1m OD) will start to fill (capacity 5000m³). When the tank reaches capacity storm overflow will occur into Mayne River.

If Wet Well sump rises to 10.0m OD:
NDDS: The maximum flow into Sutton = 2.53 m^3/s (See TABLE 2) and maximum possible flow to Howth outfall = 2.6 - 2.98 m^3/s (See TABLE 1). Any overflow flows onto North Bull Island foreshore.
NFS: Overflow of all NFS flow continues at Grange Storm Tank. Any overflow flows into Mayne River.

TABLE 1

SUTTON P.S. TO HOWTH OUTFALL MAXIMUM FLOWS

(Under Storm Conditions and Spring and Extreme Tides)

CONDITION	SUMP(m OD)	TIDE(m OD)	MAX FLOW m^3/s (K_s = 1.5mm)
STORM & SPRING	7.50	1.70	2.49
STORM & SPRING	10.0	1.70	2.98
STORM & EXTREME	7.50	2.70	2.27
STORM & EXTREME	10.0	2.70	2.80

TABLE 2

RAHENY VALVE HOUSE TO SUTTON P.S. MAXIMUM FLOW (Under Storm Conditions)

RAHENY(m OD)	SUTTON(m OD)	STATIC HEAD(m OD)	MAX FLOW m^3/s (K_s = 1.5mm)
17.60	7.50	10.10	3.20
17.60	10.00	7.60	2.53

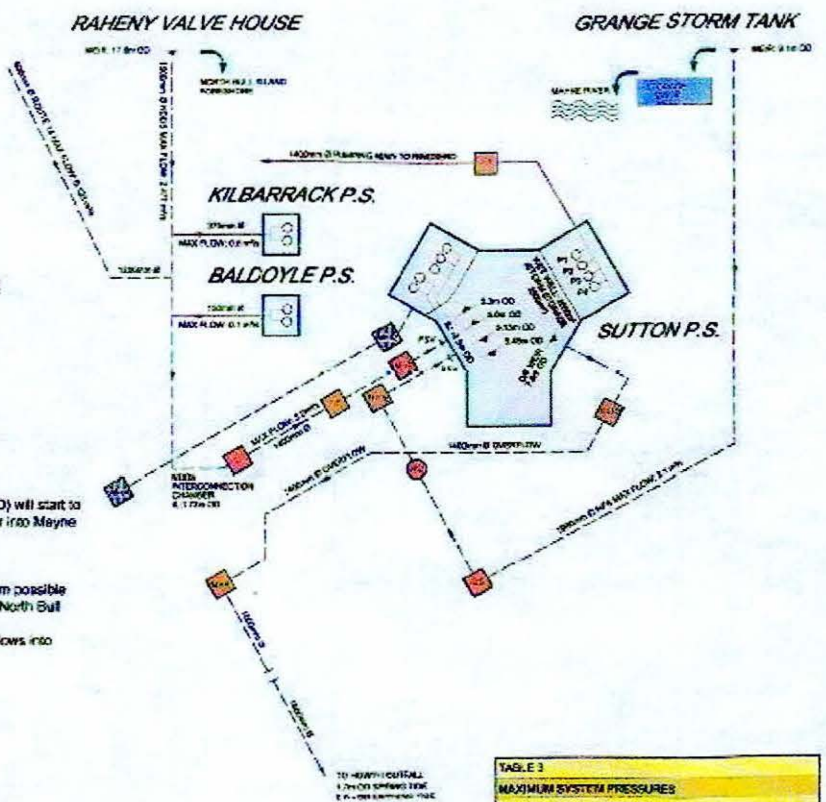


TABLE 3

MAXIMUM SYSTEM PRESSURES

WITH NDDS & NFS PENSTOCKS CLOSED AT SUTTON P.S.

WEIR LEVELS (m) OD	SUTTON INVERT LEVEL (m) OD	TOTAL HEAD PRESSURE (m) OD	MAXIMUM PRESSURE BAR
BETWEEN RAHENY WEIR & NDDS IC CHAMBER			
17.60	1.73	15.87	1.55
BETWEEN RAHENY WEIR & NDDS PENSTOCK			
17.60	-3.50	21.10	2.06
BETWEEN GRANGE WEIR & NFS PENSTOCK			
9.10	-3.50	12.60	1.23

NOTES

LEGEND

Dublin City Council

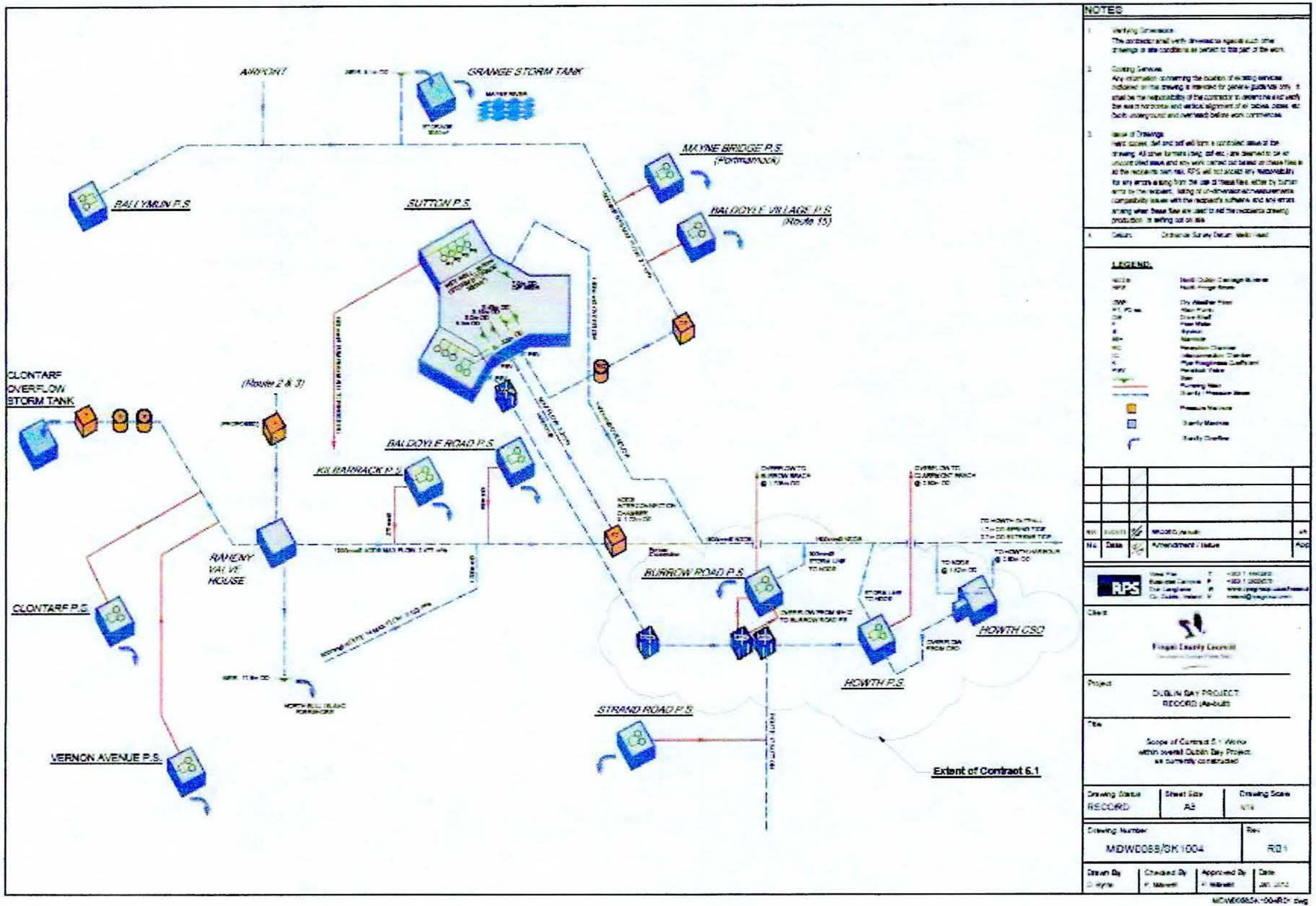
RPS mcos

DUBLIN BAY PROJECT

HYDRAULIC ANALYSIS AT SUTTON PUMPING STATION

D01

Appendix B2: Schematic Representation of catchment



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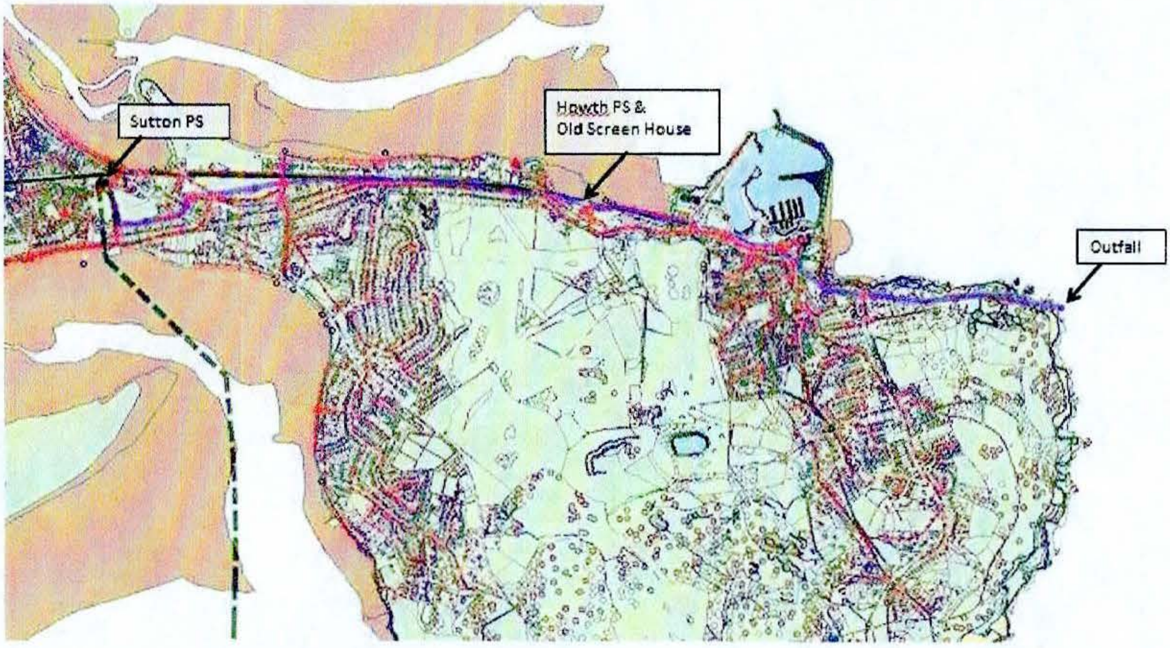
Appendix C: NDDS Overflow / Howth Outfall

NDDS Overflow Pipe (purple)



Potential Overflow Diversion at Screen House if failure pipe pipeline between Howth PS & Nose of Howth