Appendix 16 - Carbon Footprint Assessment

1.0 Background

An initial carbon footprint exercise has been carried out to compare the emissions impacts of the various scheme options. This has been confined to a comparison of the transfer pipelines as the WwTP itself will be essentially similar for all nine site options and is based on pumped flow for a set distance from the Blanchardstown catchment (Route 9C) with the remainder of the route via gravity. An alternative is to provide a deep tunnel in place of the pumped section. It will be necessary to pump flow from North Dublin for all options. It is not expected that the relative comparison for the pipelines associated with each of the site options would change should this carbon footprint exercise be carried out on the tunnelling option.

It should be noted that this is not an exercise in presenting a precise and accurate embodied[1] and operational CO_2 footprint, due to limited data availability at this stage. Rather, it is presented to allow comparison using a common currency (CO_2) of the currently available options, applying necessary assumptions and approximations equally to the different options. The following section outlines the approach, data requirements and key assumptions made.

These include emissions of CO_2 related to:

1. Construction
    a. Embodied carbon associated with material production
    b. Emissions from plant associated with tunnelling / open cut pipe laying
2. Operation
    a. Energy associated with pumping requirements (over an assumed 40 year life).

In the course of this exercise an initial carbon footprint was calculated for the nine site options presented within the Alternative Sites Assessment (ASA) matrix (these being: Annsbrook; Baldurgan; Clonshagh; Cookstown; Cloghran; Newtowncorduff; Rathartan; Saucerstown; and Tyrrelstown Little)

A breakdown of the main components of each option was sourced from information provided by the technical team in relation to the outline preliminary design of the required pipelines. The relevant data inputs are the length of open-cut pipeline, length of tunnelled pipeline, length of marine pipeline, the power demand for pumping and estimates of the time that the systems would be in pump operation based on growth projections.

2.0 Materials

Sewage pipe diameters generally range from 1,600mm to 2,500mm and are typically constructed from concrete, glass-reinforced plastic (GRP)[2] or ductile iron with an internal epoxy coating.

[1] Embodied carbon here defined as the CO_2 released from material extraction, transport, manufacturing, and related activities.
[2] Assume 35% fibreglass and 65% HDPE resin by weight.

Embodied carbon emissions factors for materials were sourced from the Inventory of Carbon & Energy (ICE) database[3]:

- Concrete – 0.1 $kgCO_2/kg$
- Fibreglass – 1.54 $kgCO_2/kg$
- HDPE resin – 1.57 $kgCO_2/kg$
- Ductile iron – 1.91 $kgCO_2/kg$
- Epoxy (epoxide resin) – 5.7 $kgCO_2/kg$

For the purpose of this assessment, it has been assumed that all categories of pipeline are constructed from concrete, and of uniform diameter (2500mm). Such assumptions can be challenged at detailed options stage.

3.0 Transport

The emissions associated with transport of materials have not been included at this stage. For example, based on other recent projects, concrete pipes are available that are manufactured in Ireland, GRP pipes are manufactured in Norway and ductile iron pipes in this diameter range are manufactured in China. Other material origins and related transport solutions may be identified at design and build stage. Obviously the choice of material will have implications on the total embodied carbon emissions; however since the same pipe material has been assumed across all options, the omission of transport emissions will not significantly affect the comparison of options relative to each other.

4.0 Construction

To account for emissions from plant associated with open-cut versus tunnel pipe laying, emissions factors were sourced from the UKWIR guidance on carbon accounting in the water industry[4]. For pipe diameters >1200mm, on-site plant and labour emissions for open cut pipe laying range from 410 to 1098 $kgCO_2$/ m depending on the depth and whether laying under fields or roads[5].

For the purpose of this assessment a factor of 609 $kgCO_2/m$ has been applied for open cut pipeline. This reflects the upper bound range of the factors for open-cut installation in fields.

There are currently no equivalent published emissions factors available for tunnelled pipeline construction; therefore for the purpose of this assessment it is assumed that it is twice as energy intensive than open cut construction, corresponding to an emissions factor of 1218 $kgCO_2/m$.

[3] University of Bath (2011) Inventory of Carbon & Energy (ICE) Version 2.0.
[4] UKWIR (2008) Carbon Accounting in the UK Water Industry: Guidelines for Dealing with 'Embodied Carbon' and Whole Life Carbon Accounting (08/CL/01/6).
[5] See Tables 3A.23 and 3A.24 in Appendix 3A of UKWIR (2008).

5.0 Operational Energy

Energy demand related to pumping needs is an approximate undiversified load informed by the requirements of industry benchmark equipment to enable the transport of wastewater of predicted volumes over the presumed distances.

Approximate annual energy consumption has been estimated by multiplying the load by the average time pumping is required from first construction through to 2060. From Blanchardstown and North Dublin, the time required in pumping mode increases over time (as wastewater load increases in line with assumptions regarding population growth). However, for this high level options assessment, an average time required for pumping has been assumed for the northern (10%, or 876 hours a year) and southern (30%, or 2,628 hours a year) sections.

The carbon footprint of this energy use is calculated by using the latest available grid emissions factor published by Sustainable Energy Ireland[6]. This is then considered to hold across 40 years, to give a crude approximation of lifetime operational emissions. Whilst not precise this method is equally applied across all options to give an indicative figure. For a more detailed assessment, energy use over the lifetime of the project, and the forecast grid electricity emissions factors over the same period should both be considered.

6.0 Footprint Summary

The results of the assessment are presented in Table 1 below. Based on the assumptions described above, total carbon emissions associated with the construction and lifetime operation of the scheme options range from 386,000 – 548,000 tonnes of CO_2. The option with the smallest embodied carbon footprint is Clonshagh, with the second smallest being Cloghran. The option with the smallest operational footprint is Saucerstown, with the second smallest being Clonshagh.

Table 1 also shows that the energy requirements for pumping contribute the majority (approximately 89% averaged over all of the options) of the emissions over the assumed 40 year lifetime. Choice of options should therefore be informed by an informed view of the balance between construction and lifetime operational impacts.

[6] Source: (http://www.seai.ie/Publications/Statistics_Publications/Emission_Factors/)

Embodied and Operational Carbon Calculator - Greater Dublin Drainage Alternative Sites Assessment

	SELECT OPTIONS BELOW
Select inland pipe material (type)	concrete
Select INLAND average pipe size (mm)	2,500
Select outfall pipe material (type)	concrete
Select OUTFALL pipe size (mm)	2,500
Total system annual operating hours	8,760
Total system asset lifetime (years)	40

PUMPED OPTIONS	Annsbrook	Balurgan	Clonshagh	Cookstown	Cloghran	Newtown-corduff	Rathartan	Saucerstown	Tyrrelstown Little
Total length of open cut (m)	30,950	28,950	19,600	28,950	18,800	29,450	27,550	26,820	32,650
Total length of tunnel (m)	14,400	16,400	5,000	16,450	9,500	15,900	16,850	18,530	12,750
Total length of marine (m)	2,500	2,500	6,000	2,500	6,000	2,500	2,500	2,500	2,500
Power requirement from 9C to WwTP site (kW)	7,000	6,700	5,450	6,600	6,250	6,750	7,200	5,050	7,950
Hours of operation per year	2,628	2,628	2,628	2,628	2,628	2,628	2,628	2,628	2,628
Annual energy consumption - 9C (kWh)	18,396,000	17,607,600	14,322,600	17,344,800	16,425,000	17,739,000	18,921,600	13,271,400	20,892,600
Power requirement from North Dublin to WwTP (kW)	3,000	3,000	2,400	3,000	2,300	2,550	2,600	2,050	2,550
Hours of operation per year	876	876	876	876	876	876	876	876	876
Annual energy consumption - North Dublin (kWh)	2,628,000	2,628,000	2,102,400	2,628,000	2,014,800	2,233,800	2,277,600	1,795,800	2,233,800
TOTAL ANNUAL ENERGY CONSUMPTION	*21,024,000*	*20,235,600*	*16,425,000*	*19,972,800*	*18,439,800*	*19,972,800*	*21,199,200*	*15,067,200*	*23,126,400*
Annual CO2 at 2009 Emissions Factor (tonnes)	*11,199*	*10,780*	***8,750***	*10,640*	***9,823***	*10,640*	*11,293*	***8,026***	*12,319*
Carbon Impacts - tonnes CO2									
Total Embodied Carbon - INLAND PIPES	15,729	15,729	8,532	15,746	9,815	15,729	15,399	15,729	15,746
Total Embodied Carbon - OUTFALL PIPES	867	867	2,081	867	2,081	867	867	867	867
Total Embodied Carbon - Open Cut	18,849	17,631	11,936	17,631	11,449	17,935	16,778	16,333	19,884
Total Embodied Carbon - Tunnelling (and Outfall)	20,584	23,020	13,398	23,081	18,879	22,411	23,568	25,615	18,575
Total embodied Carbon	**56,029**	**57,247**	**35,947**	**57,325**	**42,225**	**56,942**	**56,613**	**58,544**	**55,072**
Total Lifetime Operational Carbon	**447,979**	**431,180**	**349,984**	**425,580**	**392,915**	**425,580**	**451,713**	**321,052**	**492,777**
Total Carbon (tonnes CO2)	**504,008**	**488,427**	**385,931**	**482,905**	**435,140**	**482,523**	**508,325**	**379,596**	**547,849**
proportion of lifetime emissions from operation	89%	88%	91%	88%	90%	88%	89%	85%	90%

Table 1: High Level Options Embodied and Operational Carbon Assessment