APPENDIX A5 (Bundle 1)

[redacted]

From: Aberson, Marja
Sent: 07 March 2019 20:37
To: McGlynn, Stephanie
Cc: Kiernan, Sarah; Wilson, Rachel
Subject: RE: GDD - Shellfish Summary
Attachments: Lit review - e coli.docx

Hi Sarah and Stephanie,

I've billed today 6.25hrs.
I am leaving by 3pm tomorrow, when do you need this completed by?

Attached is a draft dumping of info found to date, not written formally, with comments and notes to self.

Focussed on those species listed in Table 9.17 of EIAR, but also included the great scallop and blue mussel.

Document includes so far:

1) Summary of data sources used
2) Potential limitations /considerations identified from exploring literature
3) Presented a summary table of sensitivity assessment of all potential pressures of the proposed pipeline
4) Summary text from each literature source (short notes currently)

Unfortunately not much literature on razor clams, as to be expected most on mussels.

The 2x CEFAS reports were the most useful (seek to find a predictor of E Coli in flesh based on concentration in water)

Unfortunately using the CEFAS reports (without consideration of any natural changes in environmental conditions or biological variation we may find at the site), the expected concentration of *E coli* in tissues may exceed guideline levels if using the predicted worse-case for the WWTP under Flow to Full Treatment conditions.

That being said, is it likely the plume will reach this fishery designated sites, and at that maximum with no dilution?

Main points so far are:

- there likely is a relationship between concentration of E coli in water and E coli in tissues (this seems to contradict paragraph 366 (in EIAR) *there is no direct relationship between concentration of coliforms in overlying water and the concentration of coliforms in shellfish flesh....'*)

- literature does however agree that there will be wide variation in uptake (inter/intra species variation and environmental factors of importance)

- literature agrees that 'natural' wide temporal variability of conc. Of E coli in water column

- Microscosm experiments found increase in concentration in flesh to that in water to be very high (e.g. factor of 330 for cockles, but 12 for oysters).
- CEFAS reports seek to find a predictor of contamination in flesh using concentration found in water. This must be a relatively recent objective (reports written 2011-2014).

Apologies I've not been able to find a neat answer of yet. I think the main defence may be distance from pipeline, and that if a failure happened there would be immediate shut down. Although the effects of 'chronic' lower levels of contamination during normal operation may be put forward as a potential issue.

Many thanks
Marja.

Dr Marja Aberson | Jacobs | Senior Marine Ecologist | Environment, Maritime & Resilience | [redacted] | www.jacobs.com

From: McGlynn, Stephanie
Sent: 07 March 2019 15:01
To: Aberson, Marja <Marja.Aberson@jacobs.com>
Cc: Kiernan, Sarah <Sarah.Kiernan@jacobs.com>
Subject: RE: GDD - Shellfish Summary

Hi Marja,

The flow to full treatment is the maximum capacity of the proposed facility (population equivalent of 500,000). The design value for this, as per the EIAR is 281,250 m3/day and 3.26 m3/sec.

Kind regards,

Stephanie

From: Aberson, Marja
Sent: 07 March 2019 14:40
To: McGlynn, Stephanie <Stephanie.McGlynn@jacobs.com>
Cc: Kiernan, Sarah <Sarah.Kiernan@jacobs.com>
Subject: RE: GDD - Shellfish Summary

I do have a (stupid) question

I understand *'Average daily flow'* term in the text

But what is mean by *'Flow to Full Treatment scenarios'*?
Many thanks

Marja.

Dr Marja Aberson | Jacobs | Senior Marine Ecologist | Environment, Maritime & Resilience | [redacted] | www.jacobs.com

From: McGlynn, Stephanie
Sent: 07 March 2019 14:16
To: Aberson, Marja <Marja.Aberson@jacobs.com>
Cc: Kiernan, Sarah <Sarah.Kiernan@jacobs.com>
Subject: RE: GDD - Shellfish Summary

That's no problem at all Marja.

Thanks for your support on this.

Kind regards,

Stephanie

From: Aberson, Marja
Sent: 07 March 2019 14:11
To: McGlynn, Stephanie <Stephanie.McGlynn@jacobs.com>
Cc: Kiernan, Sarah <Sarah.Kiernan@jacobs.com>
Subject: RE: GDD - Shellfish Summary

HI Stephanie,

Many thanks for this.
I 'll probably get something preliminary to you by end of tomorrow if ok? Apologies as time split between office and lab at the moment and just getting head into topic.

Thanks

Marja.

Dr Marja Aberson | Jacobs | Senior Marine Ecologist | Environment, Maritime & Resilience | +[redacted] | www.jacobs.com

From: McGlynn, Stephanie
Sent: 07 March 2019 14:07
To: Aberson, Marja <Marja.Aberson@jacobs.com>
Cc: Kiernan, Sarah <Sarah.Kiernan@jacobs.com>
Subject: FW: GDD - Shellfish Summary

Hi Marja,

FCC are a local authority in which the Greater Dublin Drainage Project will be located.

FCC have come back to us with the following query in relation to the Clarifications Response Report (as attached):

In para.370 the Report states "***For Flow to Full Treatment scenario, the maximum predicted coliform concentra concentrations were less than 147 cfu/100ml with the average coliform concentration over the course of the s value on flooding tides and zero concentration on ebbing tides. This provides equal time for uptake/accumul on the shellfish water quality as a result of the proposed discharge.***" JD asked what would be the implication fo Shellfish classification – Class A?

The legislative requirements state that:

1.6 Legislative Standards

Table 1 Criteria for the classification of bivalve mollusc harvesting areas under Regulation (EC) No 854/2004, Regulation (EC) 853/2004 and Regulation (EC) 2073/2005.

Classification	Standard per 100g of LBM flesh and intravalvular fluid	Treatment required
A	<230 *E. coli* per100g of flesh and intravalvular liquid[1]	None
B	LBMs must not exceed the limits of a five-tube, three dilution Most Probable Number (MPN) test of 4,600 *E. coli* per 100 g of flesh and intravalvular liquid.[2]	Purification, relaying in class A area or cooking by an approved method
C	LBMs must not exceed the limits of a five-tube, three dilution MPN test of 46,000 *E. coli* per 100 g of flesh and intravalvular liquid.	Relaying for a long period or cooking by an approved method
Prohibited	>46,000 *E. coli* per 100g of flesh and intravalvular fluid[3]	Harvesting not permitted

Notes: [1] By cross-reference from Regulation (EC) No 854/2004, via Regulation (EC) No 853/2004, to Regulation (EC) 2073/2005.

Samples of live bivalve molluscs from these areas must not exceed, in 80 % of samples collected during the review period, 230 *E. coli* per 100 g of flesh and intravalvular liquid. The remaining 20 % of samples must not exceed 700 *E. coli* per 100 g of flesh and intravalvular liquid, as amended by Regulation (EC) No 2285/2015.

[2] By way of derogation from Regulation (EC) No 854/2004, the competent authority may continue to classify as being of Class B areas for which the relevant limits of 4,600 E. coli per 100g are not exceeded in 90% of samples.

[3]This level is by default as it is above the highest limit set in legislation.

Another emerging question is how the level of coliforms in the water column can be related to the uptake and level in shellfish flesh and intervalvular liquid. The Shellfish Regulations currently state that the acceptable level of coliforms in the flesh/ intervalvular liquid must be equal to or less than 300 faecal coliforms per 100ml.

The environmental documents for the Project are available online at https://www.gddapplication.ie/environmental-documents/ in case you need to look at anything else.

Please let me know if you require any further information.

Kind regards,

Stephanie

From: Kiernan, Sarah
Sent: 07 March 2019 13:24
To: McGlynn, Stephanie <Stephanie.McGlynn@jacobs.com>
Subject: FW: GDD - Shellfish Summary

Sarah Kiernan BSc. MSc. MCIWEM C.WEM CEnv | Jacobs | Technical Director - Environment | Environment, Maritime & Resilience | [redacted] www.jacobs.com

From: Aberson, Marja
Sent: 07 March 2019 11:46

To: Kiernan, Sarah <Sarah.Kiernan@jacobs.com>
Subject: RE: GDD - Shellfish Summary

HI
NO problem.

Thanks

Marja.

Dr Marja Aberson | Jacobs | Senior Marine Ecologist | Environment, Maritime & Resilience | [redacted] | www.jacobs.com

From: Kiernan, Sarah
Sent: 07 March 2019 11:40
To: Aberson, Marja <Marja.Aberson@jacobs.com>
Subject: RE: GDD - Shellfish Summary

Hi Marja,

I suppose its two parts, it's the literature review but once that's compete we will need you to have a call with the relevant member of the EIA team (i.e the marine water quality SME (Irish subbie Marcon) and Marine ecologist (Ian Wilson of Benthic Solutions UK) just to talk through the review and the findings. But yes we shouldn't need it written down formally to be introduced as evidence, its for the teams use in case we are questioned by the fishing groups in the issue.

why!

Thanks,
Sarah

Sarah Kiernan BSc. MSc. MCIWEM C.WEM CEnv | Jacobs | Technical Director - Environment | Environment, Maritime & Resilience | [redacted] | www.jacobs.com

From: Aberson, Marja
Sent: 07 March 2019 09:55
To: Kiernan, Sarah <Sarah.Kiernan@jacobs.com>
Subject: RE: GDD - Shellfish Summary

Hi

Thanks Sarah, that's great.

I'll spend a few hours and ping across what I've found to date today, if you think we need more info, or written differently then I 'll amend accordingly.

I assume this is more for your reference should Jacobs be questioned on this potential issue, you can reply orally, rather than have it written down formally?

Many thanks

Marja.

Dr Marja Aberson | Jacobs | Senior Marine Ecologist | Environment, Maritime & Resilience | [redacted] | www.jacobs.com

From: Kiernan, Sarah
Sent: 07 March 2019 09:44
To: Aberson, Marja <Marja.Aberson@jacobs.com>
Cc: Wilson, Rachel <Rachel.Wilson@jacobs.com>
Subject: RE: GDD - Shellfish Summary

Hi Marja,

Thank you. Yes please do commence the review. As I'm sure Rachel mentioned, our Oral Hearing (like Public Enquiry) is due to commence on the 20th March so we are under pressure to look into this issue of ecoli and the shellfish.

The job number is 32012902, there is only one task open so please book to that. Let me know if you have any issue booking to the code.

Kind Regards,
Sarah

Sarah Kiernan BSc. MSc. MCIWEM C.WEM CEnv | Jacobs | Technical Director - Environment | Environment, Maritime & Resilience | [redacted] | www.jacobs.com

From: Aberson, Marja
Sent: 07 March 2019 09:39
To: Kiernan, Sarah <Sarah.Kiernan@jacobs.com>
Cc: Wilson, Rachel <Rachel.Wilson@jacobs.com>
Subject: RE: GDD - Shellfish Summary

Hi Sarah

Rachel (Wilson) has discussed with me information that may be required to support the existing modelling data of *E. coli* concentrations in the water, following a total failure at the proposed WWTP with regards to the shellfisheries in the area.

I have read the document sent through by yourself yesterday.

I think we may be able to source from both the peer reviewed and white literature more detail about bioaccumulation and clearance (e.g. depuration rates) of those key fishery species cited in the document. Certainly for bivalves there is likely to be an abundance of research done.

I can call later today if that is convenient, or if you're happy I can start a quick trawl of the literature available now and prep a short summary text for you based on this?

Many thanks

Marja.

Ps. Apologies for any late replies, as will be in and out of our lab for much of the day.

Dr Marja Aberson | Jacobs | Senior Marine Ecologist | Environment, Maritime & Resilience | [redacted] | www.jacobs.com

From: Wilson, Rachel
Sent: 06 March 2019 18:11

To: Aberson, Marja <Marja.Aberson@jacobs.com>
Subject: FW: GDD - Shellfish Summary

Marja,

As discussed, this is the information from Sarah. If you could have a look at the documents and then we can have a chat to look at whether we can support.

Thanks
Rachel

Rachel Wilson | Jacobs | Technical Director | Environment, Maritime & Resilience | [redacted] | www.jacobs.com

From: Kiernan, Sarah
Sent: 06 March 2019 18:08
To: Wilson, Rachel <Rachel.Wilson@jacobs.com>
Subject: GDD - Shellfish Summary

Hi Rachel,

We've complied the relevant sections of the EIAR and other documents that deal with Shellfish, to try and give a reasonable summery of the ' history' for Maya. The attached includes text from;

- Ecology baseline for Shellfish as per EIAR
- Ecology impacts during Operation as per EIAR
- Marine Water Quality impact during Operation as per EIAR
- Marine Ecology impact as discussed in Clarifications Response Report
- Marine Water Quality impact during standard operations as discussed in Clarifications Response Report
- Marine Water Quality impact during total failure at WwTP as modelled this week

As discussed, the area we are hoping to discuss and understand further is how the shellfish (Razorclam, crab and lobster primarily) deal with E coli present in the water.

While we can say what the levels of E coli will be in the water under normal operating conditions of the WWTP and under catastrophic failure, we would like to understand the correlation between this and how E coli is retained/flushed out of the shellfish.

We are likely to face questioning on the commercial impacts various fisheries/fishermen.

Thanks for your help,
Sarah

Sarah Kiernan BSc. MSc. MCIWEM C.WEM CEnv | Jacobs | Technical Director - Environment | Environment, Maritime & Resilience | [redacted] | www.jacobs.com

JACOBS

Contents

1. Introduction and Aim

Commented [AM1]: Irrelevant for this, just part of template – not needed

To understand the potential effects of ..... during a ..... . on the commercially targeted species in Northern Fingal (as summarised in Table 9.17 of the EIAR).

Fisheries in the survey area encompass the Brown (edible) crab (*Cancer pagurus*), velvet swimming crab (*Necora puber*), European lobster (*Homarus gammarus*)., whelk (*Buccinum undatum*), razor clam (*Ensis* sp.) and shrimp (*Palaemon serratus*). .....

2. Methods

Commented [AM2]: Short summary list

2.1 Data Sources

- CEFAS Project Reports (2011 - 2013)
- Peer reviewed literature (1984 – 2017)
- On-line sources (Marine Life Information Network: Biology and Sensitivity Key Information Reviews)

2.2 Limitations and considerations

Commented [AM3]: Brain dump of limitation of data available in how to assess species in question at study area

- Incomplete sensitivity reviews available for all species of interest.
- Bias towards key species such as *M. edulis* over other species e.g. *Ensis* sp.
- Likely high variation in uptake rates and assimilation/depuration between different species.
- Difficulty in prediction of those mobile species (e.g. *C. pagurus* and *H. gammarus*).
- Consider the proximity to these fishery designated areas to proposed pipeline to assess potential risk of contamination

3. Sensitivity Review

Table 3 1 summarises the sensitivity of key commercial species harvested in the area, in response to potential pressures of the proposed outfall. The review is sourced from the MarLIN sensitivity assessment, which is currently being superseded by the MarESA approach to assessment for species and biotopes. Although *Pecten maximus* and *Mytilus edulis* are not listed as a targeted species in Northern Fingal (Table 9.17, EIAR) they are listed as a principal shellfish species in the area (Table 9.16, EIAR).

Commented [AM4]: According to website, should have been done by 2016/17.

Have extracted their data form the website and only 16 species have been listed; none included ones of importance here.
However, mussel habitats sensitivity info is available and maybe worth adding.

Table 3 1: Sensitivity of commercially shellfish species as reviewed under the MarLIN sensitivity assessment process.

Common name	Scientific name	Pressure	Pressure Type	Intolerance	Recoverability	Sensitivity	Evidence/ Confidence	Source
Brown crab	***Cancer pagurus***	Physical	Smothering	Low	Very high	Very low	High	Neal and Wilson (2008)
			Increase in suspended sediment	Low	High	Low	Very low	
			Increase in turbidity	Tolerant	Not relevant	Not sensitive	Very low	
		Chemical	Changes in nutrient level	Tolerant	Not relevant	Not sensitive	Very low	
			Changes in oxygenation	Tolerant	Very high	Not sensitive	High	
		Biological	Introduction of microbial pathogens/parasites	Intermediate	Moderate	Moderate	High	
Velvet swimming crab	***Necora puber***	**No data available**						Wilson (2008a)
European lobster	***Homarus gammarus***	**No data available**						Wilson (2008b)
Shrimp	***Palaemon serratus***	**No data available**						Neal (2008)
Whelk	***Buccinum undatum***	**No data available**						Ager (2008)
Great scallop	***Pecten maximus***	Physical	Smothering	Low	High	Moderate	Moderate	Marshall and Wilson (2008)
			Increase in suspended sediment	Low	High	Low	Low	
			Increase in turbidity	Tolerant	Not relevant	Not sensitive	Not relevant	
		Chemical	Changes in nutrient level	Intermediate	High	Low	Moderate	
			Changes in oxygenation	Low	High	Very low	Low	
		Biological	Introduction of microbial pathogens/parasites	**No data available**				
Razor clam	***Ensis* sp.**	Physical	Smothering	Tolerant	Not relevant	Not sensitive	High	Hill (2006)
			Increase in suspended sediment	Low	High	Low	High	
			Increase in turbidity	Low	High	Low	Moderate	
		Chemical	Changes in nutrient levels	Intermediate	High	Low	Low	
			Changes in oxygenation	Intermediate	High	Low	Moderate	
		Biological	Introduction of microbial pathogens/parasites	**No data available**				

Common name	Scientific name	Pressure	Pressure Type	Intolerance	Recoverability	Sensitivity	Evidence/ Confidence	Source
Blue mussel	***Mytilus edulis***	Physical	Smothering	Intermediate	High	Low	Low	Tyler-Walters (2008)
			Increase in suspended sediment	Low	Intermediate	Not sensitive	High	
			Increase in turbidity	Tolerant	Not relevant	Not sensitive	Not relevant	
		Chemical	Changes in nutrient levels	Intermediate	High	Low	Low	
			Changes in oxygenation	Low	Very high	Very low	High	
		Biological	Introduction of microbial pathogens/parasites	Intermediate	High	Low	High	

4. Risk of bioaccumulation

notes to self

- Pipeline lies outside of the designated shellfish waters for Malahide, but will pass through recognised active production areas.
- Majority of fishing occurs of Dalkey island which lies ~ 10km south of proposed pipeline.
- No set values for coliforms in watercolumn. Guideline levels are at 300 cfu/100ml in flesh and intervalvular liquid.
- The Malahide razor clam fishery has an 'A' classification. Requiring samples of live molluscs not exceed 230 E. coli per 100g.
- Revised model examined effects of discharge of coliforms at a concentration of 300,000 colony forming units (cfu)/100ml for both proposed average daily flow and flow to full treatment scenarios
- Results - Average daily = max near seabed 143 cfu/100ml, for 80% of time predicted < 62 cfu/100ml, average over course of simulation = 33 cfu/100ml
- Results - Flow to Full treatment = max near seabed was 327 cfu/100ml, but for 80% of time predicted concentration <147 cfu/100ml. Average over course of simulation = 78 cfu/100ml.
- Tested total process failure scenario (3,000,000 cfu/100ml over 3 days). Model showed a period of significant increase in coliforms, the levels did gradually return to 'baseline' conditions over matter of days.

Commented [AM5]: may ask, what happens if this occurs during a harvesting period (harvesting is different for different species).

Summary of literature:

1. Walker 2017 VARIATION IN E.COLI In TISSUES:

The distribution of E.coli among shellfish in any one bed will usually be variable between locations in that bed and over time, dependant on a range of factors, such as growth and respiration of the individual organism, the residence time, bioaccumulation kinetics and decay and dispersal of E. coli in the environment.In Uk, E.coli levels in bivalves at a particular monitoring point can vary by 2-3 orders of magnitude or more in the space of just a few hours.

Commented [AM6]: Support defence of not replying on a single point measurement of contamination in tissues (and thus water also I'll assume too)

Also, variation between the sampling occasions and also in average level of contamination from year to year, driven by multiple factors (contaminant input, variable weather patterns etc). Results accumulated over time demonstrate broadly whether the bed can be categorised accordingly. As such long term data provides best overall indication of the sanitary status of a given harvesting area, and is the rationale behind the classification system used across the EU. As the contamination levels increase as does the variability. So does the range of E. coli results returned.

2) Mesquita *et al.* (2011): US OF ECOLI COUNTS TO DETECT ENTERIS VIRUSES

Commented [AM7]: Tears apart argument for reliance on E coli counts as an indicator of contamination
No to be used here, not relevant

Norovirus (NV), Hepatitus A virus (HAV) and enterovirus (EV) are enteric viruses. Bivalves grown in arees of urban sewage polluted waters tend to bioaccumulate environmentally stable enteric viruses. Enteric viruses can survive for long periods in water column especially if associated with particulate matter and sediment.

Standards rely exclusively of e coli no. Several studies show that bacteria are not reliable indicators of viral contamination of shellfish and as such of limited predicted value. This because viruses are more robust than bacteria(and therefore resist better to inactivation in aquatic environment and more resilient to removal by depuration.

Results – viral contamination found in 9 species of shellfish studied and found throughout the year from 8/10 sites independent of their harvesting classification system. Found in 'A class' NoV, HAV and EV are RNA viruses and known that RNA molecule is very unstable, raising question if free unprotected RNA would remain intact in the environment incl. sewage and the digestive tract. Data confirms previous study that lack of association between the actual bacteriological assessment classification system (based only on E. coli) and the presence of human enteric pathogenic viruses. May explain presence of human pathogenic viruses inshellfish that were considered safe based on E.coli legal limit.

3) Faghri *et al* (1984) CONTAMINATION OF CRABS (COLD WATER)

Risk of crabs in vicinity/migrating past outfall can be contaminated and bioaccumulate bacteria from the water column in their gill tissues. Question is - Whether the bacteria associated with crabs contaminate the muscle tissues. the portion of the crab that is eaten. Direct scanning electronic microscopic observations and the viable enumeration procedures indicate that most bacteria are associate with the surface tissues of the gills and shells . Haemolymph and muscle, although not sterile , normally had low populations of bacteria (but these increase post mortam!). Later studies (!!) indicate that the rock crab have an extensive cellular defense system that limits the bacterial contamination of muscle tissue. **IF crabs damaged, injured can become contaminated with bacteria.**

4) Campos et al (2011) CEFAS REPORT relationship between E. coli levels in shellfish verses water.

Species: Pacific oysters, native oysters and mussels. Linear regression model done for each of 3 species and for 'pooled 'species, aim of finding specific WQ threshold E coli values that would ensure similar protection for shellfish beds given by the shellfish flesh guidelines standard 300 faceal per 100g.

Model predicts that this would be achieved at a geometric mean of 10 and 90th percentile of 55 E coli per 100ml water (at 75% compliance with guidelines

Sig. difference in compliance rates between mussels and pacific oysters. Aims to make standard (water column standard verses shell fish flesh standard) for shell fish protected areas under the WFD.(Did not distinguish between *Myt edulis* and *Myt galloprovincalis*.)

602 paired samples from 40 water and 40 flesh monitoring point. Data does not contain info as to how close in space and time the water samples were collected in relation to shell fish samples Review of published literature done to understand potential causes and influences on FIO contamination of shellfish flesh and overlying waters.

Simple linear regression (aka ordinary least squares) models were computed to investigate co-variance between Ecoli levels in flesh and in water. Variable 'ecoli in flesh' is considered the response. Contamination results from filter feeding mechanism of shellfish and accumulation of bacteria present in the seawater (ie the mechanism of contamination integrates contamination available during seawater flows over the preceding hours of the tidal cycle. It is assumed that Ecoli does not multiply with in the shellfish, but may be retained or washed out.

Logistic regression used when response variable is observed only as a binary characteristic: yes/not etc. in this cae comply/fail (1/0)

Models test the relationship between the threshold levels used for the purpose of classifying harvesting areas and the levels of E coli in seawater. No co variates other than monitoring point and time, the data are grouped at that level, and the fitted value is the proportion of samples that come under the threshold for classification. Predicted response in the probability of a sample passing the test at each E coli level in seawater.

Assumptions – measures of e coli and faecal coliforms considered equivalent

Results-

Mussels more contaminated than oysters

Regression of $\log_{10}$ transformed E coli levels in flesh verses seawater shows that a very significant proportion of E coli results lie above the line of equality **(more in flesh proportionately than in water)** This is expected as the mechanism of E coli in shellfish often determines high levels of ecoli in the shellfish flesh than in water. Correlation coefficient (r = 0.59) indicative of level of agreement between variables. NO sign or curvature in relationship. Overall, tendency for E coli levels in shell fish to increase with E coli levels in seawater and the wide spread of values around the line are evident. The regression accounts for 35% of variation in water values, suggesting other factors would explain the variance between variables. A moderate R is typical of data obtained under natural environmental conditions, ie. Relationship between

Commented [AM8]: Good ref to refer to for crabs (e.g. most contamination is in gills than muscle tissue).

Though once you kill it, the immune defence goes and may become contaminated with bacteria in the gills.

Commented [AM9]: Most useful ref found to date.

But find correlation between conc. In water with con. In tissues.

This appears to contradict what is written in EIAR

'para 366 -There is no direct relationship between the concentration of coliforms in overlying water and the concentrate of coliforms in shellfish flesh, as both the uptake/accumulation and clearance/removal of coliforms by filter feedings shell fish is a dynamic process affected by many variables.....).

FIO in shellfish and waters is influenced by various factors. (e.g. physiological mechanisms influencing bacterial accumulation in shell fish and envi factors determining FIO survival and transport in the marine environment

For mussels, E coli levels in water explain a higher proportion of the variation in E coli levels in that species than that in the model for the three species combined. (mussels represent 52% of the total no. of samples). In contrast E coli in pacific oysters and native explain relatively less proportion of the variation of e coli in seawater. And the difference between E coli levels in mussels and in Pacific oysters is highly significant, whereas between native and pacific is marginal.

Pooled species model for compliance with SWD G for all species and for each species, versus geometric mean of E coli in seawater.

Pooled species model (mussel and native oyster) reults across range of E coli values in water.

Pacific oyster achieve higher compliance rates at each water quality than mussels and native oysters. (models fit better for individual species than the 'pooled species model' Pacific oysters higher compliance rates (>90%) when the 90th percentile of E coli in seawater is considered.

5) Kershaw et al, 2013 CEFAS REPORT: chronic microbial pollution on shellfish (cockles, mussels and pacific oysters

Commented [AM10]: Still got to read full report

Lifted from exec summary:

- Microcosm experiments
- Aim to ID water concentration of E coli that results in shellfish flesh values ~ 300 cfu/100ml following SWD 'guideline'
- Simulated 'chronic' pollution in lab, to 6x different conc. Of *E. coli*. (1 - 339 cfu/100ml)
- Linear regression – 52% to 60% of variance of Ecoli in tissues are explained by variation of E.coli levels in water.
- On exposure to sewage, rapid accumulation of E coli occurred to a maximum 'equilibrium' state, following end of dosing, a relatively rapid clearance phase.
- Maximum levels accumulated during exposure, shown to be proportional to level of water contamination.(& with cockles accumulated bacteria to higher level than mussels and oysters) Factors ranged from 330 (cockes) down to 12 (oysters).
- Experiment repeated in the field & incorporated DIVAST modelling, to predict real-time conc. Of E.coli.
- Inter-species ordering of E coli accumulation same as in microcosm. But both modelled and measured *E. coli* in water sampled during preceding tidal incursion impacting upon the shellfish bags were not significantly correlated with measured levels in flesh! Also 'natural' temporal variability in E coli conc. Over a diurnal cycle, even under dry weather conditions. (over 2 $\log_{10}$ orders).
- Assumption most inshore water will show such variability in 'normal' conditions = low levels of microbiological pollution. Such as those below the the faecal coliform standard cannot be characterised as constant faecal indicator concentrations. Need to consider the 'chronic' water quality condition and use the observed accumulation factors to derive an associated flesh concentration from any given water concentration.

Commented [AM11]: This would elevate the levels of E coli predicted in the water above the bed layer to be much higher in the organism.

5. References

Ager, O.E.D. 2008. *Buccinum undatum* Common whelk. In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 07-03-2019]. Available from: https://www.marlin.ac.uk/species/detail/1560

Campos, C.J.A., Reese, A., Kershaw, S., Lee, R.J., 2011. Relationship between the microbial quality of shellfish flesh and seawater in UK harvesting area. CEFAS Project: WT1001 Factors affecting the microbial quality of shellfish. Report submitted to DEFRA, 39 pp.

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Document Title

Association of the United Kingdc
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Wilson, E. 2008b. *Homarus gan*
Information Network: Biology an
Association of the United Kingdc
https://www.marlin.ac.uk/specie:

[redacted]

From: Aberson, Marja
Sent: 08 March 2019 14:38
To: Kiernan, Sarah
Subject: RE: CEFAS report
Attachments: wt0923-impact-of-chronic-microbial-pollution-on-shellfish-2013-final.pdf; CEFAS_2011_-water-flesh-relationships-final-report.pdf

Hi Sarah

attached

For your reference please find attached the 2x CEFAS report I sourced yesterday.

I didn't want to finish off cleaning up my notes from yesterday till I heard back from yourself /Stephanie as didn't want to bill any more hours.
I've been in the lab instead.

Let me know if you'd like me to write a few summary paragraphs next week.

Although the CEFAS work had indicated a (in some cases large) proportional increase in E.coli in tissues relative to concentration in water, assumptions had been made and some work was based on microcosm experiments and no in situe work in the field.

Many thanks

Marja.

Dr Marja Aberson | Jacobs | Senior Marine Ecologist | Environment, Maritime & Resilience | [redacted]

[redacted]

From: Aberson, Marja
Sent: 12 March 2019 16:52
To: Kiernan, Sarah
Cc: McGlynn, Stephanie
Subject: RE: GDD - Ecoli levels in discharge

Thank you, that's really useful.

Especially if even outside of the bathing seasons (I assume winter) the levels <200,000 and not modelled as 300,000 which is when the main harvesting period is for the razor clams at Malahide (e.g table 9.17).
Am getting there with the lit review (it is just a memo). In the final section I am trying to directly pad/support out the responses set out by the applicant to any concerns raised so a quick prompt if needed.

A lot of 'chronic' effects are investigated (by CEFAS) looking at exposure exceeding 5 days and with no variation in water concentration of *E. coli* in that time; which in a open coastal environment we'd expect so we can use that to negate any concerns.

pond like area - Kish bank
no tidal flush like Irish Sea.

Apologies this is taking longer than I had hoped, it is a lot of literature to digest and then summarise in discrete paragraphs.

Thanks

Marja.

Dr Marja Aberson | Jacobs | Senior Marine Ecologist | Environment, Maritime & Resilience | +[redacted] | www.jacobs.com

From: Kiernan, Sarah
Sent: 12 March 2019 16:40
To: Aberson, Marja <Marja.Aberson@jacobs.com>
Cc: McGlynn, Stephanie <Stephanie.McGlynn@jacobs.com>
Subject: FW: GDD - Ecoli levels in discharge

Hi Marja,

Please see below contest for your lit review advice.

Kind Regards,
Sarah

Sarah Kiernan BSc. MSc. MCIWEM C.WEM CEnv | Jacobs | Technical Director - Environment | Environment, Maritime & Resilience | [redacted] | www.jacobs.com

From: O'Keeffe, Ciaran
Sent: 12 March 2019 16:38
To: 'Cathriona.Cahill@rpsgroup.com' <Cathriona.Cahill@rpsgroup.com>
Cc: 'ian@benthicsolutions.com' <ian@benthicsolutions.com>; 'james.mccrory@rpsgroup.com' <james.mccrory@rpsgroup.com>; 'alan@marcon.ie' <alan@marcon.ie>; Kiernan, Sarah <Sarah.Kiernan@jacobs.com>; McGlynn, Stephanie <Stephanie.McGlynn@jacobs.com>
Subject: GDD - Ecoli levels in discharge

Cathriona,

Following our meeting with Senior Counsel last week we have received data from Ringsend for 2018 providing the levels of ecoli in the discharge outside the bathing season (i.e. no UV treatment). These levels vary considerably, with very few data points exceeding 200,000 cfu/100ml with an average discharge of c. 79,000 cfu/100ml. The model run of a continuous 300,000 cfu/100ml is therefore considered very conservative and we are satisfied that there will be negligible impact on the shellfish from normal operation of the WwTP.

Risk of Failure of the WwTP.

We have reviewed the potential failure mechanisms of the WwTP. The embedded design mitigation measures ensures that a total failure of the plant is so minimal as to be non-existent. In the unlikely event that all power should fail, raw sewage cannot reach the marine environment, as the WwTP inlet pumps would not be working and therefore sewage would not be able to pass through the plant. The Abbotstown and Ballymun pumping stations would in turn not pass forward flows to the WwTP and storage in the catchment would be mobilised. A prolonged power outage at the plant would eventually cause sewage flooding in the catchment and discharges to the local watercourses. Therefore ignore the previous 3,000,000 cfu/100ml ecoli discharge. We are satisfied that such a discharge would not occur.

Discharge to Tolka re Bland. tanks; where is storage? Insp. failed to address this.

The plant has been designed to facilitate planned maintenance, i.e. taking individual process units offline and distributing flows to other units, and still maintain the proposed treatment standards. As a result of this planned maintenance the risk of partial failures is minimised. However, in the event of such an event, the flows would be distributed to other process units with no impact on the treatment standards.

The recent plume in Ringsend, caused in the main by significant non sewage suspended solids over loading on the treatment plant also coincided with a failure of the aeration system in one of the SBR tanks. The tank in question had to be taken off line resulting in a decrease in treatment capacity and the flows on that tank could not ne distributed to the already overloaded other tanks. Ecoli levels in the discharge during this event were measured at 233,300 cfu/100ml. Therefore the failure run of 300,000 cfu/100ml over a continuous three day period as previously reported is representative of such a partial failure of the WwTP and we are satisfied that there is negligible impact as a result.

Regards

Ciarán

3m cfu/100ml ecoli discharge as modelled flows around Howth end + back along Portmarnock

modelling ~~attached~~ of process failure attached

3 million Scenario. attachment to the record 6. Summary of model output. Philip OE

A scenario to assess the impacts of discharging untreated effluent over a three day period, simulating a process failure at the proposed WwTP was undertaken. The flows and loads defined to the model are detailed in the table below.

The model commenced the simulation on 18/04/2015 at 00:00hrs with the proposed GDD Project discharging at average daily flow rate of 1.63 m^3/s with a coliform concentration of 300,000 mpn/100ml.

The process failure was simulated to occur on 26/042015 at 12:00hrs resulting in immediate increase in coliform concentrations to 3,000,000 mpn/100ml in the discharge flow until 29/04/2019 at 12:00hrs when coliforms concentrations reverted back to the normal discharge level of 300,000 mpn/100ml.

Table 1: WwTP Flows and loads defined to Numerical Model

WwTP	Flow rate (m^3/s)	Coliforms (mpn/100ml)
Barnageeragh	0.09	1,000
Portrane	0.06	1,000
Malahide	0.05	1,500
Swords	0.16	100,000
Shanganagh	0.36	100,000
Ringsend (future average)	6.95	300,000
Proposed GDD Project (average)	1.63	300,000 (from 18/04 00:00 to 26/04 12:00) 3,000,000 (from 26/04 12:00 to 29/04 12:00) 300,000 (from 29/04 12:00 to 06/05 00:00)

The extents of the coliform effluent plume at mid flood, high tide, mid ebb and low water on the final day of the process failure (29/04/2015) are presented below in Figure 1 to Figure 4. The concentrations are coloured in accordance with the contouring intervals adopted previously in the EIAR report.

The attached video (Video_ProcessFailure_MaxColiforms.avi) shows the evolution of the coliform plume over time from 26/04 through the period of the simulated process failure(26/04-29/04) and continuing until 03/05. Whilst the process failure does obviously result in period of significant increase in coliform levels throughout the coastal waters of north county Dublin, the receiving waters are shown to gradually return to conditions preceding the process failure over a matter of days.

Video modelling is for 3,000,000. PE

Questions:
- multiport OR Single diffuser USED IN MODEL?
- was wave action included in model(s) simulations?
- why not model each day? Why final day
- What happens if process failure in Ringsend + GDDP? which includes All SWO CSO overflow/discharges.

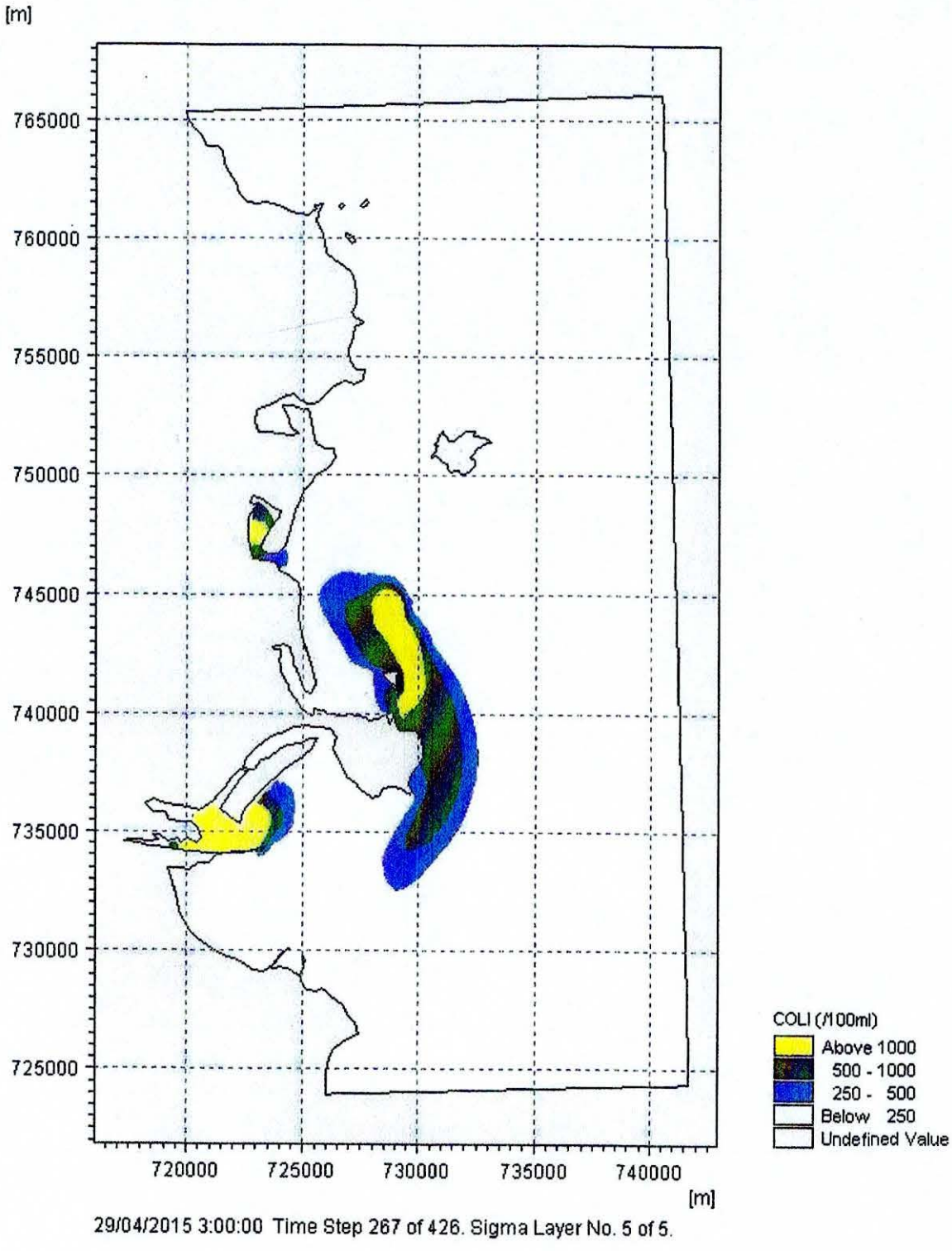

Figure 1: Coliform concentrations during mid flood on final day of process failure scenario.

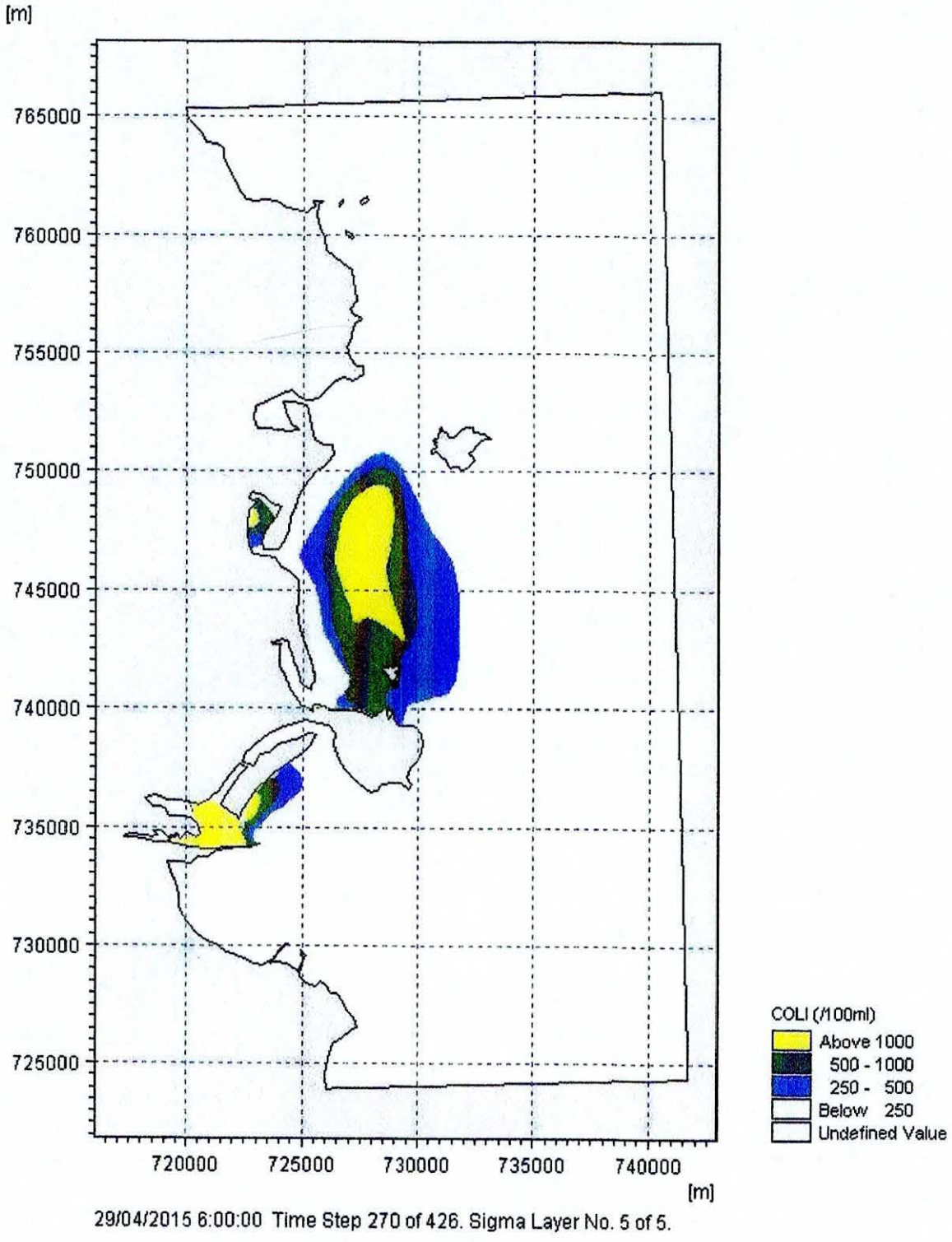

Figure 2: Coliform concentrations during high water on final day of process failure scenario.

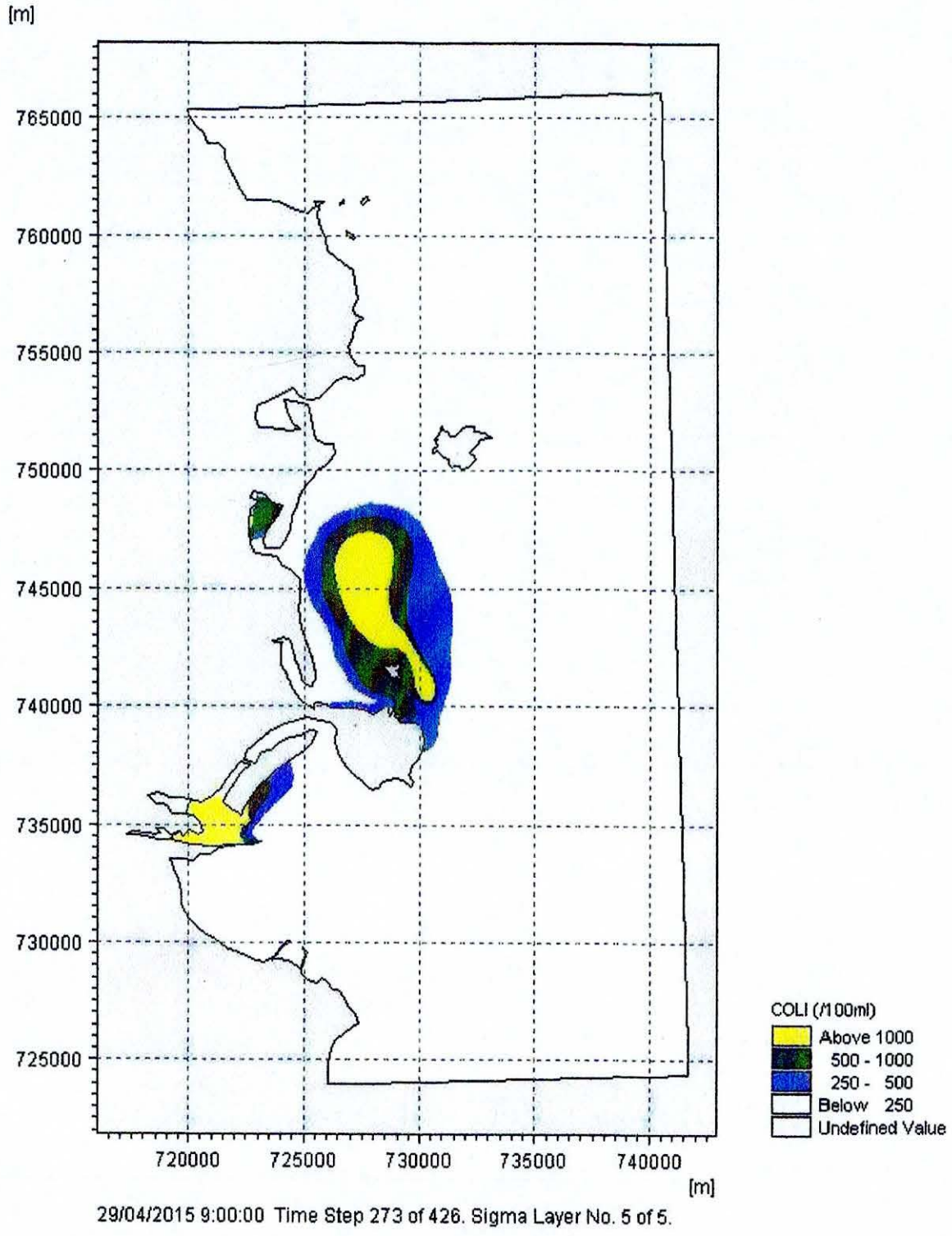

Figure 3: Coliform concentrations during mid ebb on final day of process failure scenario.

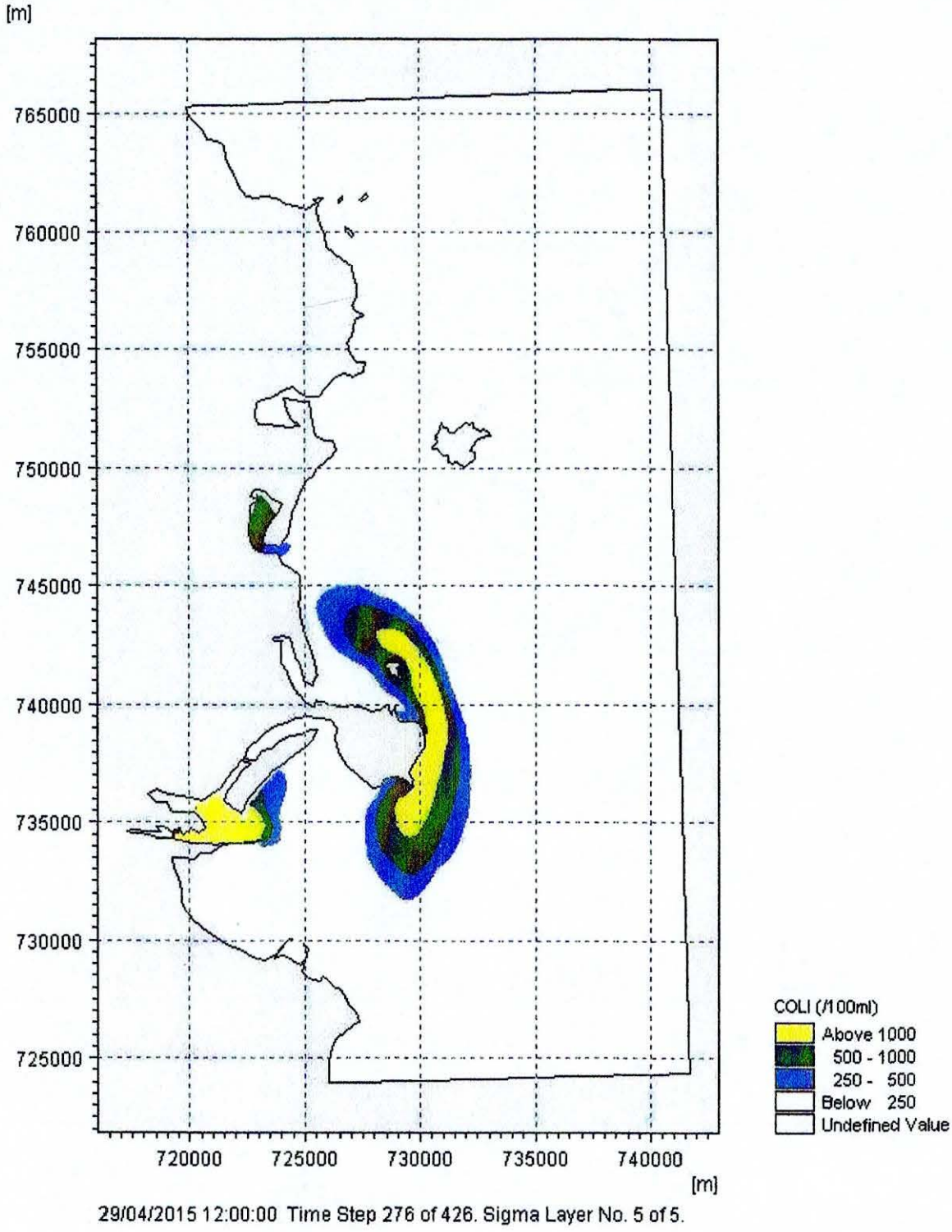

Figure 4: Coliform concentrations during low water on final day of process failure scenario.

[redacted]

From: Aberson, Marja
Sent: 14 March 2019 13:35
To: O'Keeffe, Ciaran; 'dwhite@water.ie'
Cc: Kiernan, Sarah; McGlynn, Stephanie; 'ian.wilson@benthicsolutions.com'
Subject: RE: Marine ecology review of the Ecoli and Fisheries review from Jacobs and the 300k model
Attachments: CEFAS_ WT0923-impact-of-chronic-microbial-pollution-on-shellfish-2013-final.pdf

HI

FYI- here is the extract from :

Cefas, 2013. Impact of chronic microbial pollution on shellfish. *Project WT093.* Cefas/CREH report to DEFRA. 88 pp (report also attached).

Highlighted for both tables is the values for cockles (assumed worse case) and the 'all species', standard values for the SWD standard of 300 and the Class A of 230

Note – in table 5.3 of the memo i mistakenly lifted of the values for all three species for 75% target annual compliance for Class A and not 80%

[redacted]

Table 5 - Indicative water standards required to achieve shellfish flesh standard of 300 *E. coli* MPN/100g)

Species	No samples annual	Target annual compliance rate (%)	Compliance required in individual samples (%)	Geomean required in flesh (MPN/100g)	Estimated geomean *E. coli* in seawater (cfu/100ml)	Estimated 90%ile *E. coli* in seawater (cfu/100ml)
Mussels	4	95	99	28	2.2	8
	4	90	97	45	3.4	13
	4	80	95	57	4.3	16
	4	75	76	149	10	38
	12	90	95	57	4.3	16
	12	80	87	97	7	26
	12	75	76	149	10	38
Pacific oysters	4	95	99	14	2.1	16
	4	90	97	26	3.6	27
	4	80	95	36	4.8	36
	4	75	76	122	14	108
	12	90	95	36	4.8	36
	12	80	87	71	9	66
	12	75	78	112	13	100
Cockles	4	95	99	8	0.03	0.3
	4	90	97	16	0.05	0.5
	4	80	95	23	0.07	0.7
	4	75	76	102	0.28	2.8
	12	90	95	23	0.07	0.7
	12	80	87	53	0.16	1.5
	12	75	78	93	0.26	2.5
All species	4	95	99	2.8	0.39	5.6
	4	90	97	7.1	0.66	9.5
	4	80	95	11	0.88	13
	4	75	76	74	2.7	38
	12	95	99	2.8	0.39	5.6
	12	90	95	11	0.88	13
	12	80	87	32	1.6	23
	12	75	78	74	2.7	38

Table 6 - Indicative water standards required to achieve shellfish flesh standard of 230 *E. coli* MPN/100g

Species	No. samples /annum	Target annual compliance rate (%)	Compliance required in individual samples (%)	Geomean required in flesh (MPN/100g)	Estimated geomean *E. coli* in seawater (cfu/100ml)	Estimated 90%ile *E. coli* in seawater (cfu/100ml)
Mussels	4	95	99	21	1.7	6
	4	90	97	34	2.7	10
	4	80	95	44	3.4	12
	4	75	76	114	8	30
	12	90	95	44	3.4	12
	12	80	87	75	5.5	20
	12	75	76	114	8	30
Pacific oysters	4	95	99	11	1.7	12
	4	90	97	20	2.9	21
	4	80	95	28	3.8	28
	4	75	76	94	11	85
	12	90	95	28	3.8	28
	12	80	87	55	7	52
	12	75	78	86	11	79
Cockles	4	95	99	5.8	0.02	0.2
	4	90	97	12	0.04	0.4
	4	80	95	18	0.06	0.6
	4	75	76	79	0.22	2.2
	12	90	95	18	0.06	0.6
	12	80	87	41	0.12	1.2
	12	75	78	71	0.2	2.0
All species	4	95	99	2.2	0.33	4.8
	4	90	97	5.4	0.57	8
	4	80	95	8.7	0.75	11
	4	75	76	57	2.3	33
	12	95	99	2.2	0.33	4.8
	12	90	95	8.7	0.75	11
	12	80	87	25	1.4	20
	12	75	78	50	2.1	30

Dr Marja Aberson | Jacobs | Senior Marine Ecologist | Environment, Maritime & Resilience | [redacted] |
Marja.Aberson@jacobs.com | www.jacobs.com

From: O'Keeffe, Ciaran
Sent: 14 March 2019 12:08
To: 'dwhite@water.ie' <dwhite@water.ie>; Aberson, Marja <Marja.Aberson@jacobs.com>
Subject: FW: Marine ecology review of the Ecoli and Fisheries review from Jacobs and the 300k model

fyi

From: Cathriona Cahill <Cathriona.Cahill@rpsgroup.com>
Sent: 14 March 2019 11:33
To: O'Keeffe, Ciaran <Ciaran.OKeeffe@jacobs.com>
Cc: McGlynn, Stephanie <Stephanie.McGlynn@jacobs.com>; Ian Wilson <ian.wilson@benthicsolutions.com>
Subject: [EXTERNAL] Fwd: Marine ecology review of the Ecoli and Fisheries review from Jacobs and the 300k model

Hi Ciaran
Ian has set out some notes below on his review of the memo
Chat at 12

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From: Ian Wilson <ian.wilson@benthicsolutions.com>
Sent: Thursday, March 14, 2019 11:03:57 AM
To: Cathriona Cahill
Cc: James McCrory; Simon Zisman
Subject: Marine ecology review of the Ecoli and Fisheries review from Jacobs and the 300k model

Cathriona,

Thanks for the document. This makes for an interesting read and is very useful as a general literature review of the situation. However, this has highlighted a few potential points.

- The proposal for revised *E.coli* discharge is 300k/100ml, would appears to be very conservative and may create unnecessary impacts.
- The revised model was pulled out of the response document (already sent in the submissions). This uses the 250cfu/100ml as the bottom contour so is very insensitive to low level contours that may exist over the shellfish waters as a whole.
- The review was not specific for *Ensis*, but from an ecological point of view, the impact to this species from a chronic coliform is more likely to reflect that of the cockle than the mussel. This means that this species will be quite sensitive to continual import inputs.
- The details in the shellfish study indicates that there is a direct linear relationship between water quality and shellfish uptake of coliforms. Uptake is rapid within 1 hour of exposure and plateaus at 17 hours. Flesh counts reduce almost as quickly on flushing events so an equilibrium based on a tidal cycle and constant input could be expected.
- The key area of concern would be maintaining a Class A status for this species at these rates. A comparison from the 300k model and the uptake factor described for other species would suggest that this is unlikely to be maintained, although we have no current level of flesh or water quality for this area.
- Comparison with levels given in the submission for Velvet strand varies from 4 to 18 cfu this might be similar to what would be expected at the seabed in the Malahide SW. If we assumed an average of these rates at around 11cfu (based on a tidal flushing), then this would arguably only meet Class B for Mussels, with *Ensis* likely to be significantly more sensitive than this.

Overall, the question of meeting water quality requirement of <250cfu/100ml for the Shellfish waters is likely based on the model, but a chronic release based on the 300,000cfu/100ml is also likely to degrade the waters where Class A is unlikely to be achieved. Therefore, if a specific question is raised as to the expected Class qualification to shellfish as a result of this outfall within the Shellfish waters, it would be impossible to argue against a degradation

of quality based on the recent model used and the uptake data that is currently available for this species. We need to be sure of IW and Jacobs position on this if this is raised in the OH. Note that this is a socio-economic and not an ecological issue.

Regards

Ian Wilson
Benthic Solutions Limited
[redacted]
ian@benthicsolutions.co.uk
www.benthicsolutions.co.uk

Registered in England Company Registration Number: 5115407
Registered Office: Copseford, Hartwell Road, Wroxham, Norfolk NR12 8TL

From: Cathriona Cahill <Cathriona.Cahill@rpsgroup.com>
Sent: 13 March 2019 18:38
To: Ian Wilson <ian.wilson@benthicsolutions.com>
Cc: James McCrory <James.McCrory@rpsgroup.com>; Simon Zisman <Simon.Zisman@rpsgroup.com>
Subject: Fwd: Marine

Hi Ian
See attached.
I will give you a call to discuss in the morning

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From: McGlynn, Stephanie <Stephanie.McGlynn@jacobs.com>
Sent: Wednesday, March 13, 2019 6:30:34 PM
To: Cathriona Cahill
Cc: Kiernan, Sarah
Subject: RE: Marine

Hi Cathriona,

Please see attached preliminary memo re. shellfish from our expert.

Could you please revert as soon as possible with any comments and we will aim to arrange a call with the shellfish experts and relevant specialists tomorrow.

Kind regards,

Stephanie

From: Cathriona Cahill <Cathriona.Cahill@rpsgroup.com>
Sent: 13 March 2019 15:29
To: McGlynn, Stephanie <Stephanie.McGlynn@jacobs.com>; Kiernan, Sarah <Sarah.Kiernan@jacobs.com>

Cc: O'Keeffe, Ciaran <Ciaran.OKeeffe@jacobs.com>
Subject: [EXTERNAL] Marine

Hi Girls
Apologies for the delay.

Just to note that Ian has proposed to include Figure 1 which addresses the failure event at the outfall pipeline. (please note this is new information)
However, I am unsure now if this should be included based on Ciarán's email last night regarding the change in the failure event.
Also see comment re: shellfish.

Let me know if you need to discuss.

Cathriona Cahill
Associate Environment
RPS | Consulting UK & Ireland
West Pier Business Campus
Dun Laoghaire, Co. Dublin A96 N6T7, Ireland
[redacted]
E cathriona.cahill@rpsgroup.com
rpsgroup.com

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RPS Group Plc web link: http://www.rpsgroup.com

[redacted]

From: Aberson, Marja
Sent: 13 March 2019 16:32
To: Kiernan, Sarah
Subject: RE: DRAFT memo
Attachments: Memo_GDD E coli.docx

Hi Sarah

Please find attached a draft version of memo. IT has not been through CRAV so may not be fit for external distribution.

Please accept my apologies for the long delay, I think I would have happily spent all week on it, not so helpful.

Am working latish today (7ish) and tomorrow so available if needed.

Thanks

Marja.

Dr Marja Aberson | Jacobs | Senior Marine Ecologist | Environment, Maritime & Resilience | [redacted]

JACOBS

Memorandum

Kenneth Dibben House
Enterprise Road, Southampton Science Park
Chilworth, Southampton SO16 7NS
United Kingdom
T +44 (0)23 8011 1250
F +44 (0)23 8011 1251

Subject	**Literature review *E. coli***	**Project Name**	Dublin Drainage Project
Attention	<Name>		
From	Marja Aberson		
Date	13 March 2019		
Copies to	<Name>		

1. Aim

This short literature review of accumulation of the bacteria *Escherichia coli* in shellfish, encompasses the following:

Section 2: Summary of data and literature sources used.

Section 3: Potential limitations and important considerations identified.

Section 4: A high-level summary of the sensitivity of targeted commercial shellfish to potential pressures from the proposed discharge during operation (of the marine section).

Section 5: Background summary information of factors affecting concentrations of *E. coli* in the environment, in shellfish, and current understanding of the relationship between these parameters.

Section 6: Additional text to supplement 'The Applicant's response to consultees concerns of potential impact on shellfish waters and shellfish from the proposed discharge (of the marine section), as documented in Jacobs (2019).

2. Methods

Peer and non-peer reviewed literature has been sourced, and these have included the following:

- Cefas Project Reports to DEFRA (2006 --2013).
- Cefas Shellfish Water Quality Investigation Reports (2012)
- Scientific peer-reviewed literature (1984-2018).
- Marine Life Information Network (MarLin): Biology and Sensitivity Key Information Reviews. [Accessed On-Line March 2019]. The reviews are cited from the MarLIN sensitivity assessment process, which is currently being superseded by the MarESA approach to assessment for species and biotopes.

Much of the information summarised in this document, is cited from reports submitted by Cefas to DEFRA as part of the Projects WT1001 (*'Factors affecting the microbial quality of shellfish'*) and WT0923 (*'Impact of chronic microbial pollution on shellfish'*). These technical reports themselves provided a comprehensive overview of scientific literature, and report upon results of experimental work that investigate the relationship between concentrations of *E. coli* in ambient waters and in the tissues of shellfish.

3. Limitations and considerations

- **The MarLin sensitivity review data is not available for all commercial shellfish species of interest, and with low level of associated evidence and/confidence in assessments made.**
- **Significant bias in studies of commercial shellfish species (e.g. *Mytilus edulis*) over others (*e.g. Ensis* sp.).**
- **Likely high inter-species variation in accumulation and depuration rates.**
- **Difficulty in assessment of mobile species (e.g. *Cancer pagurus* and *H. gammarus*) due to life history and lack of data.**
- **Assessments of rate of uptake and clearance are often undertaken under a microcosm laboratory condition where expected variations in environmental conditions will not be incorporated.**

4. Sensitivity Review

Table 4 1 summarises the sensitivity review of key commercial species harvested in the area, in response to all key potential pressures of the proposed discharge. Although *Pecten maximus* and *Mytilus edulis* are not listed as a targeted species in Northern Fingal (Table 9.17, EIAR) they are listed as a principal shellfish species in the area (Table 9.16, EIAR).

Potential pressures may encompass physical (smothering, increased sediment deposition and turbidity), chemical (changes in nutrient and oxygenation levels), and biological (increase in pathogens). No sensitivity review data was available for the following commercial species of interest: *Necora. puber, Homarus gammarus, Palaemon serratus* and *Buccinum undatum.*

Except *M. edulis*, all species are assessed to have a low level of intolerance and high recoverability to any potential physical disturbances, and with all species (except *P. maximus*) being of low sensitivity to such pressures overall. All species are assessed to have low level of sensitivity to chemical pressures overall, but with the bivalves *P. maximus, Ensis* sp. and *M. edulis* exhibiting an intermediate level of intolerance to one or both potential chemical pressures listed in Table 4 1. Responses to an increase in microbial pathogens/parasites had only been assessed in *Cancer pagurus* and *M. edulis*; with both species assessed as being of low sensitivity.

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Memorandum

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Table 4 1: Sensitivity of commercial shellfish species, as reviewed under the Marlin sensitivity assessment process.

Common name	Scientific name	Pressure	Pressure Type	Intolerance	Recoverability	Sensitivity	Evidence/ Confidence	Source
Brown crab	***Cancer pagurus***	Physical	Smothering	Low	Very high	Very low	High	Neal and Wilson (2008)
			Increase in suspended sediment	Low	High	Low	Very low	
			Increase in turbidity	Tolerant	Not relevant	Not sensitive	Very low	
		Chemical	Changes in nutrient level	Tolerant	Not relevant	Not sensitive	Very low	
			Changes in oxygenation	Tolerant	Very high	Not sensitive	High	
		Biological	Introduction of microbial pathogens/parasites	Intermediate	Moderate	Moderate	High	
Velvet swimming crab	***Necora puber***	**No data available**						Wilson (2008a)
European lobster	***Homarus gammarus***	**No data available**						Wilson (2008b)
Shrimp	***Palaemon serratus***	**No data available**						Neal (2008)
Whelk	***Buccinum undatum***	**No data available**						Ager (2008)
Great scallop	***Pecten maximus***	Physical	Smothering	Low	High	Moderate	Moderate	Marshall and Wilson (2008)
			Increase in suspended sediment	Low	High	Low	Low	
			Increase in turbidity	Tolerant	Not relevant	Not sensitive	Not relevant	
		Chemical	Changes in nutrient level	Intermediate	High	Low	Moderate	
			Changes in oxygenation	Low	High	Very low	Low	
		Biological	Introduction of microbial pathogens/parasites	**No data available**				
Razor clam	***Ensis* sp.**	Physical	Smothering	Tolerant	Not relevant	Not sensitive	High	Hill (2006)
			Increase in suspended sediment	Low	High	Low	High	
			Increase in turbidity	Low	High	Low	Moderate	
		Chemical	Changes in nutrient levels	Intermediate	High	Low	Low	
			Changes in oxygenation	Intermediate	High	Low	Moderate	

		Biological	Introduction of microbial pathogens/parasites	**No data available**				
Blue mussel	***Mytilus edulis***	Physical	Smothering	Intermediate	High	Low	Low	Tyler-Walters (2008)
			Increase in suspended sediment	Low	Intermediate	Not sensitive	High	
			Increase in turbidity	Tolerant	Not relevant	Not sensitive	Not relevant	
		Chemical	Changes in nutrient levels	Intermediate	High	Low	Low	
			Changes in oxygenation	Low	Very high	Very low	High	
		Biological	Introduction of microbial pathogens/parasites	Intermediate	High	Low	High	

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5. Accumulation of *E. coli* in commercial shellfish

5.1 *E. coli* concentrations in seawater

The degree of *E. coli* contamination of a receiving water body by a Waste Water Treatment Works (WwTW) will be primarily influenced by the level operational activity of the plant itself, but in addition to this the potential risk of accidental release from sewage overflows or plant failure. Heavy rainfall and increased fluvial inputs may also increase the loading and subsequent *E. coli* contamination of a receiving water body (Craig *et al.,* 2008; Cefas, 2012a; Cefas, 2012b).

The concentration of the bacteria *E. coli* within crude sewage itself will not exhibit a clear normal distribution pattern (curve) with often skewed abundances as bacteria often occurs in clumps. Following dilution with the receiving waters, the distribution curve of bacteria will be expected to flatten across its range of concentrations, thereby also increasing its variation in levels (Cefas, 2013). The fate and transport of faecal bacterial once released into ambient waters will be influenced by a number of complex and interacting processes where concentrations may be further affected by temperature, salinity, tidal conditions, current velocities and geomorphological features of the water body itself. Discharges into shallow tidal inlets with constricted entrances may create complex tidal currents and flow patterns restricting the potential mixing and dilution of any contaminants in the water column (e.g. Portsmouth Harbour, UK (Cefas, 2012a)). Discharges into an open coastal system subject to strong tidal currents may promote rapid diffusion and dilution of faecal bacteria levels in the plume. Hydrodynamic modelling of the narrow, Dart Estuary (Devon, UK) were simulated across five days in January for a sewage overflow of untreated sewage discharge of 200 m^3 (Garcia *et al.,* 2018). It was computed that overall, the largest area of *E. coli* contamination (>10 cfu/100ml) occurred during periods of neap tides and low river discharges, but also with a maximum value obtained during neap tide and high river discharges; these both representing the worse-case scenarios.

The exponential decay (die-off) rates of *E. coli* in the environment will be a function of natural factors including temperate, salinity and irradiation (Garcia *et al.,* 2018). A review by Craig *et al.,* (2004) concludes that in general, within the water column, there is a positive relationship with rates of decay and temperature and sunlight. However, an increase in turbidity of the water may restrict any solar penetration through the water column. An *in-situ* study by Craig *et al,* (2004), further showed that *E. coli* can persist in coastal sediments even after any rapid decline of levels in the overlying water. Within contaminated sediments, particle size has also been shown to be important factor with an increase in *E. coli* decay rates in those sediments comprised of larger particles and containing low organic carbon. It may be that increased nutrient availability in those finer sediment may provide an important food source for bacteria.

5.2 *E. coli* concentrations in shellfish (review by Cefas, 2012c)

Accumulation of *E. coli* bacteria in bivalves will occur during filter-feeding (process of water pumping and filtration). This process can be limited by the physical properties of the filter pump and concentration of food in the water. Filter feeding has been shown to be autonomous and not regulated at the organism level with processes kept open and operating at a constant rate during optimal conditions. The efficiency of accumulation can naturally vary with external environmental conditions such as concentration and composition of particulates, temperature, current speed, and in part viscosity of the water.

Pumping rates are shown to increase with increasing temperature and also with a decrease in viscosity; of which is in itself temperature dependant. Effects of changes in salinity have not been

shown to be as important as temperature but with a general pattern of delayed valve opening with a decrease in salinity. Euryhaline bivalves can tolerate and thus feed in lower saline conditions (e.g. *M. edulis*) than others (e.g. *Ostrea edulis* and *Ensis* sp.). Species-specific responses to different environmental conditions thus may overall, naturally result in different rates of accumulation.

There has been shown to be wide inter-specific differences in relative levels of accumulation and so contamination in different bivalves. For example, levels of *E. coli* in *M. edulis* and *Cerastoderma edule* have been shown to be approximately 1<2, to 3 times higher than *Magallana gigas* (previously called *Crassostrea gigas*), respectively. Variations in accumulation may be attributable to physiological differences but also due to methods of growth (e.g. in bags on bed verses grown directly on bed itself). Even among shellfish of the same species in any one bed, the distribution of *E. coli* in tissues can be variable both spatially and over time, with levels between monitoring points varying by 2-3 orders of magnitude within just a few hours (Walker *et al.*, 2017; Cefas, 2011).

5.3 Uptake of *E. coli* in shellfish in response to concentrations in seawater

It can be difficult to directly quantify the relationship between *E. coli* concentrations in the water to the uptake and accumulation in the flesh of shellfish. However, recently funded DEFRA projects undertaken by Cefas in the UK sought to: explore the relationship between microbial quality of shellfish flesh and seawater, investigate the dynamics of uptake and clearance of *E. coli* in shellfish subject to chronic contamination, identify water concentrations of *E. coli* which would be compliant with the Shellfish Water Directive (SWD) "guideline" standard (G) of 300 cfu/100g (in 75% of samples), and make recommendations regarding an *E. coli* standard (water column standard verses shellfish flesh) for shellfish protected areas (Cefas, 2011;Cefas, 2012b; Cefas, 2013).

5.3.1 Relationship between concentrations in seawater and shellfish

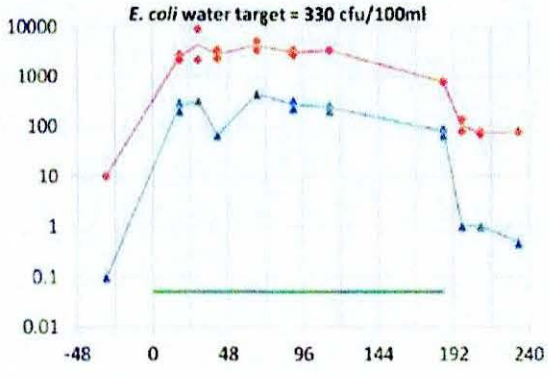
The relationship between *E. coli* counts in sampled seawater and shellfish flesh of three species (*O. edulis, M. gigas* and *Mytilus* spp. (*M. edulis* and *Mytilus galloprovencialis* data not separated)), sampled between 1991-1994 within six different production areas in the UK was analysed (Cefas, 2011). The level of contamination between the three bivalves, as expected was variable with *M. edulis* being more contaminated overall and for all species a greater geometric mean concentration calculated in the tissues than in the seawater. For all data pooled (all three species, n=602) a positive linear relationship between increasing *E. coli* levels in the seawater and in the shellfish was apparent, however, with a wide spread of values around the computed regression line. This wide range in measured values around the predicted values is an expected artefact of data obtained under natural environmental conditions.

Microcosm tank experiments monitored the uptake of *E. coli* in the tissues of the bivalves *M. edulis, M. gigas* and *C. edule* exposed to chronic exposure (continuous dosing for 5 days) to a range of water quality levels (1 cfu/100ml – 330 cfu/100ml) (Cefas, 2013). Across all concentrations, a rapid uptake of *E. coli* was shown for all species to a maximum 'equilibrium' (plateau) state (within 17 hours) and on cessation of dosing, a rapid clearance was also exhibited.Previous studies have shown that there is a threshold for *E. coli* concentrations in the water, above which bivalves are unable to accumulate more bacteria, however this maximum 'equilibrium' state will vary between both individuals and species (Cefas, 2011).

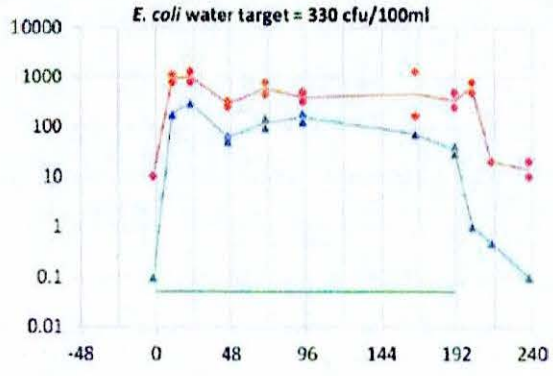
Figure 5.1 shows the time-series data for each species in the microcosm tanks under the maximum target *E. coli* seawater conditions (330 cfu/100ml). Changes in concentrations in the shellfish appear to mirror changes in the ambient seawater for all species during the 10-day experiment. Where only a low percentage (35% overall) of the variation in concentrations of shellfish tissue was explained by concentrations in the water from analysis of historic monitoring data (Cefas, 2011), under these microcosm conditions, this was found to be much higher at 55 – 60%. The overall factorial increase

between seawater and shellfish *E. coli* concentrations (as calculated across all tank concentrations) ranged from 11.7 for *M. gigas,* 15.2 for *M. edulis,* and 330 for *C. edule* with a wider range of accumulation rates found overall for *C. edule* at each seawater tank concentrations. Although flesh concentrations increased linearly with concentrations of the tank seawater, there was no direct association with an increase in seawater concentration of the microcosms and resulting accumulation factor.

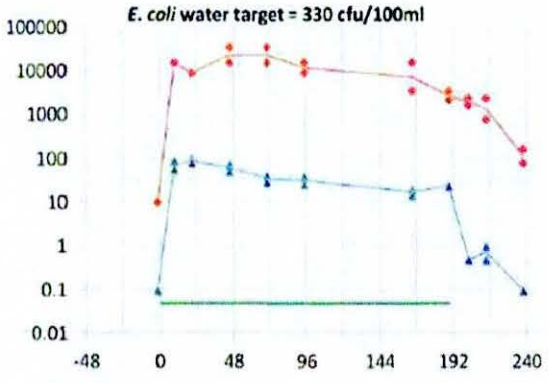
The rate of accumulation in tissues in the study was overall proportionate to the changes in water quality, the rate of clearance following the end of dosing was not as much (Figure 5.1). Bacteria can be rapidly cleared from shellfish when exposed to clean waters, with an initial phase of greatest clearance lasting <10hrs then followed by a less evident phase of 10-30 hrs. Within 24 hours of exposure to un-contaminated waters, clearance rates of approximately 100 times the initial concentrations have been observed in mussels and oysters (Cefas, 2011).



a) ***Mytilus edulis***



b) Magallana gigas



c) ***Cerastoderma edule***

Figure 5.1: Time series of levels of *E. coli* in tank water and tissues of a) *M. edulis,* b) *M. gigas* and c) *C. edule* for the target tank water concentration of 330 cfu/100ml. X-axis is hours relative to start of sewage dosing with Green line = period of sewage dosing. Red line = flesh concentrations and Blue line = tank water concentrations (Cefas, 2013).

Investigations of *E. coli* accumulation in *M. edulis*, *C. edule* and *M. gigas* was also undertaken in Mumbles Bay, UK across 10- day exposure period in September 2011, by attaching specimen bags to the intertidal zone at the site (Cefas, 2013). The relative ordering in inter-species *E. coli* accumulation remained valid with other studies and the microcosm experiment (e.g. greatest uptake in *C. edule*). However, no clear statistically significant difference between mean *E. coli* concentrations between the three species sampled from these environmental investigations was reported; only in comparison with *E. coli* seawater concentrations. Variation recorded in both water and flesh concentration is expected and will reflect variations in the environmental waters.

Direct measurements of water quality in the study area did not significantly correlate with *E. coli* shellfish concentrations. Therefore, a hydrodynamic two-dimensional water quality model (DIVAST) predicted *E. coli* concentrations for Swansea Bay was also done to provide near-real-time prediction of *E. coli* concentrations for where the shellfish bags had been positioned. The results of the model could not find a statistically significant correlation between water quality and the laid shellfish in this study. Diurnal and tidal patterns in concentrations have been found to be important, indicating a ubiquitous and high 'natural' variability in *E. coli* concentrations with differences exceeding 2 $\log_{10}$ orders diurnally even under dry conditions (review by Cefas, 2013). Such short term variability in bacterial concentrations may now be considered the 'normal' condition

5.3.2 Predicting compliance using *E. coli* seawater concentrations

Using the historic data collected in 1991-1994, models were computed for the three shellfish species *O. gigas, M. gigas* and *Mytilus* spp., to predict compliance with the SWD G value of 300 cfu/100g against a range of *E. coli* water quality concentrations (Cefas, 2011). The greatest proportion of samples compliant was shown to be for the Pacific oyster *M. gigas*. Assessing all three species together, indicated that a geometric mean threshold of 9.6 cfu/100ml and a 90th percentile of 55 cfu/100ml in seawater would be equivalent to the current SWD G standard.

The indicative thresholds for *E. coli* water concentrations for each species to meet the SWD G based on this study is listed in Table 5 1, and for 90% compliance with thresholds for Class B (<4,600 cfu/100g) is listed in Table 5 2. However, in terms of compliance with Class A threshold (<230 cfu/100m) none of the samples in this study met the criteria.

Later studies by Cefas (2013) also calculated indicative water quality standard values, to meet both the SWG G and Class A thresholds for concentration of *E. coli* in shellfish. Estimations were semi-quantitative (pass/fail), based either on samples taken quarterly, or monthly per annuum looking at overall distribution of readings to derive parameters. It is assumed that samples are taken equally spaced through the year and are independent; excluding any risk-based or biased sampled. Table 5 1 and Table 5 3 lists the indicative standards estimated for meeting the SWD G and Class A thresholds based on monthly sampling per annum. The indicative *E. coli* seawater concentrations for individual species are more conservative when compared to values calculated based on monitoring data (Cefas, 2011).

As the thresholds determined in the Cefas (2011) study were based on historic data (1991-1994), it has been recommended that these are validated with more up to date samples from production areas to draw more accurate comparisons and be comparable with the microcosm experiments of project WT0923 (Cefas, 2013).

Table 5 1: Indicative concentrations of *E. coli* in seawater (geometric mean and 90th percentile) to achieve 75%* compliance with SWD G (300 fcu/100g) in shellfish. *Cefas (2013) data predicted for 75% target annual compliance rate.

Species	Study Type	Geometric mean Seawater cfu/100ml	90th percentile seawater cfu/100ml	Sample size	Reference
Mytilus spp.	Natural sampling	8.9	102	313 individuals (pooled sites)	Cefas (2011)
Mytilus edulis	Microcosm	10	38	predicted from 12 samples taken per annum	Cefas (2013)
Magallana gigas	Natural sampling	41	492	111 individuals (pooled sites)	Cefas (2011)
Magallana gigas	Microcosm	13	100	predicted from 12 samples taken per annum	Cefas (2013)
Ostrea. edulis	Natural sampling	8.3	64	178 individuals (pooled sites)	Cefas (2011)
Cerastoderma. edule	Microcosm	0.26	2.5	predicted from 12 samples taken per annum	Cefas (2013)

Table 5 2: Indicative concentrations of *E. coli* in seawater (geometric mean) to achieve target annual 90% compliance with SWD standard for harvesting Classification B (<4,600 cfu/100g) in shellfish (Cefas, 2011).

Species	Study	Geometric mean seawater cfu/100ml	Number of samples
Mytilus spp.	Natural sampling	33	313 individuals (pooled sites)
O. edulis	Natural sampling	177	178 individuals (pooled sites)
M. gigas	Natural sampling	4,200	111 individuals (pooled sites)

Table 5 3: Indicative concentrations of *E. coli* in seawater (geometric mean and 90th percentile) to achieve annual 80% compliance with SWD standard for harvesting Classification A (<230 cfu/100g) in shellfish (Cefas, 2013).

Species	Study	Geometric mean seawater cfu/100ml	90th percentile seawater cfu/100ml	Number of samples/annum
M. edulis	Microcosm	8	30	12
C. edule	Microcosm	0.2	2.0	12
M. gigas	Microcosm	11	79	12

6. The Greater Dublin Drainage Project (GDD)

The below section lists responses from the 'Applicant' to consultee submissions following the lodging of the Planning Application; responses are regarding the impact of Proposed Project on shellfish and shellfish waters during operation. The responses are sourced and numbered, as cited in the *Greater Dublin Drainage Report: Response to Submissions* (Jacobs, 2019).

Succeeding each statement response(s) is further information that aims to support/ or expand upon these given statements.

6.1.1 Concerns regarding impact of Proposed Project on designated shellfish waters

457. In summary the plumes arising.....from the discharge of treated wastewater from the proposed outfall pipeline route (marine section) fall outside the designated shellfish waters. Furthermore, the modelled data for the discharge during the Operational Phase indicates that the impact plume has a limited spatial impact and will disperse significantly into the prevailing oceanography at the site. This fact coupled with the discharge parameters will ensure there will be no impact to shellfish waters.

Response remains valid.
Comparisons with monitoring studies of the dispersal and fate of *E. coli* in water bodies in the UK where they are more restrictive in tidal flow and exposure, would support conclusions that the outcome of the model for the GDD project has a plume with a restricted impact on any surrounding areas, such as the designated shellfish waters at Malahide.

6.1.2 Concerns regarding impact of Proposed Project on shellfish

364. Schedule 2 of S.I. No. 268/2006 does not set values for the coliform concentrations in the water column. Schedule 4 of S.I. No. 268/2006 sets a guide value for coliform concentrations equal to or less than 300 faecal coliforms per 100 millilitres in the shellfish flesh and intervalvular liquid but does not set values for coliform concentrations in the water column.

Response remains valid.
There is at present no agreed upon *E. coli* seawater concentration guideline value in which to monitor against. Recent studies have shown that for compliance with the current SWD G, there can be a wide range in predicted *E. coli* water concentrations calculated, that primarily depend on the targeted species in question and methods of assessment (e.g. microcosms vs. environmental studies). As such these studies have not support the application of a single guideline value for water quality standard, where more than one species is harvested.

Such studies done to date have focussed on only a few commercial species, primarily the blue mussel *Mytilus edulis,* the Pacific oyster *Magallana gigas (*previously known as *Crassostrea gigas)* and the common cockle *Cerastoderma edule.* There is no data available for those commercial bivalve species known to be harvested within the study area (razor clam *Ensis* sp), whelks (*Buccinum undatum*) and large mobile crustaceans (*Homarus gammarus* and *Cancer pagurus*).

366. There is no direct relationship between the concentration of coliforms in overlying water and the concentration of coliforms in shellfish flesh as both the uptake/accumulation and clearance/removal of coliforms by filter-feeding shellfish is a dynamic process affected by many variables (e.g. temperature, food availability, salinity, shellfish age, season, reproductive state, health of the shellfish and the impacts of toxins and other contaminants.

Statement may require further validation if questioned further on.
Although there is still a high level of variance in the data that remains unexplained when paired values of concentrations of *E. coli* in seawater verses shellfish are analysed; there is still a clear linear relationship between these two measured parameters. However, differences in the strength of this relationship has been shown to vary between species and between artificial microcosm conditions to *in situ* studies in the field, where natural fluxes in environmental conditions may mask any patterned responses or reduce any predicted effects.

It will be important to acknowledge that following exposure that there will be likely rapid increase (within 1 hour) in uptake and assimilation of *E. coli* in tissues of bivalves, with 'equilibrium' reached within 17 hours (in these tested cases), and clearance following end of exposure. Microcosm studies done to date have looked at chronic exposure, with aim of continuous contamination over a period of 5 days. In this data set, declines and subsequent increases in tissue concentration occurred during this dosing period when there had been a short-term fault in equipment, reducing the flow of diluted sewage into the test tanks. The patterned decline with decline in water concentration bears evidence that under natural conditions when these fluxes occur it will instantly result in a reduction in tissues of shellfish, and as likely to occur regularly and over longer periods this will naturally allow clearance to occur (e.g. during tidal periods). However, it also highlights the rapid physiological response by bivalves to uptake, which may occur following heavy rainfall for example which may for the short term increase uptake in tissue of resident shellfish.

Variations in uptake and maximum concentrations at 'equilibrium' state between species has been shown, with an agreed ranking of greater concentration accumulated in cockles compared to mussels and oysters. The literature suggests that there is a maximum accumulation level a species can reach, independent of any further increase concentrations in the ambient waters. The duration of exposure will be of importance, for allowing full clearance from the tissues. It is unlikely that bivalve shellfish of the study area will be subject to prolonged exposure periods comparable with these experimental studies (e.g. 5-10 days) and

367. The potential impacts on the Malahide shellfishery were examined using a revised modelling simulation examining the discharge of coliforms at a concentration of 300,000 cfu/100ml for both the proposed Average Daily Flow and Flow to Full Treatment scenarios.

370. For Flow to Full Treatment scenario, the maximum predicted coliform concentration in the water near the seabed was 327 cfu/100ml. For 80% of the time the predicted concentrations were less than 147 cfu/100ml with the average coliform concentration over the course of the simulation predicted to be 78 cfu/100ml. The coliform concentrations fluctuate between a maximum value on flooding tides and zero concentrations on ebbing tides. This provides equal time for uptake/accumulation and subsequent clearance/removal of any coliforms by shellfish. No impact is predicted on the shellfish water quality as a result of the proposed discharge.

Response may require to be updated
The modelled simulation at 300,000 cfu/100ml for normal operation of the proposed WwTP may be considered to be conservative (C. O'Keeffe *pers. comm.* 12 March 2019). 2018 discharge data from Ringsend WwTP have reported variable levels, with very few data points exceeding 200,000 cfu/100ml, and with an overall average discharge of 79,000 cfu/100ml. The maximum modelled coliform in the water near the seabed of 327 cfu/100ml, will therefore, likely be considerably less than this, as will the concentrations for 80% of a given period, and the overall average.

There will be variation in rate of uptake and rate of clearance between species, as shown in previous studies. This will also be expected to vary across seasons. During winter periods (low temperature and solar irradiation), the natural decay of *E. coli* in the water column may be slower than in the summer months, possibly also further impacted by increased rainfall and fluvial inputs during this

period. The lowered values currently sourced for the Ringsend WwTP were taken outside of the bathing season (e.g. the winter months with no UV treatment) and excluding an overflow or plant failure event, may indicate a worst-case chronic exposure scenario for the receiving water body and one that is not as conservative as the modelled scenarios.

Local shellfisheries harvest throughout the year but with specific collection periods for some species. Harvesting of the razor clam *Ensis* sp. (predominantly *Ensis siliqua)* occurs over the winter months in the area. The Malahide production area (site name: DN-ME) has a shellfish harvesting classification of A, and as per the status of the last sample analysed (taken 5 February 2019), remains as 'Open'. Monthly monitoring data for biotoxins over the last 12 months (January 2018 – February 2019) reported on only one occasion (14 June 2018) a failure (status changed to 'Closed pending') but an additional sample taken that month, had a reported status then of 'Open' (Marine Institute, 2019).

Unfortunately, studies to date of *E. coli* accumulation in *Ensis* spp. have not been undertaken, with focus on other commercially important bivalves. Substances within sediments are known to have longer residence time than water-borne contaminants. As bottom dwelling infaunal species, there is the higher risk that they will be exposed to any contaminants within the sediment compared to bivalves that grow above the seabed. *Ensis* spp. tend to inhabit coarser sediments, but with spatial distribution in different sediments between this con-specifics. Such sediments will likely contain a lower organic content and thus support a relatively lower resident population of bacteria than finer sediments.

It will be imprudent to estimate a potential accumulation factor in the tissues of razor clams at Malahide as current work has shown a wide range of uptake rates and maximum concentrations between bivalve species, and with spatio-temporal differences also expected. The distance of the Malahide production area from the point-source (outfall pipe), and consideration of the predicted plume in the far field zones, and the current data from an existing WwTP in Dublin Bay, reduces the level of assessed risk of contamination to shellfish. It will be important to acknowledge potential increased risks to harvesting post heavy rainfall events and the expected natural tidal and seasonality in water column *E. coli* concentrations when harvesting.

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8. Glossary

Definitions sourced and adapted from: Cefas (2012c),

Accumulation:	Uptake and storage of FIOs within the cells of the living shellfish species.
Accumulation factor:	Measure of the intensity of the accumulation of FIOs in bivalve shellfish. This measure is given by the ration between the concentration of FIOs in shellfish relative to the concentration of FIOs in the overlying water.
Bivalve filter pump:	Group or bands of lateral cilia on filaments arranged in parallel within the mantle cavity of the bivalve.
Chronic exposure:	Contact of shellfish with *E. coli* in the overlying waters that occurs over a long time (e.g. > 5 days).
Clearance:	Process by which shellfish eliminate FIOs (e.g. from filter-feeding in bivalve species).
Microcosm:	Artificial simplified ecosystem up under often laboratory conditions to predict responses to a variation in environmental conditions.

[redacted]

From: Olwyn James <ojames@water.ie>
Sent: 14 March 2019 14:42
To: Gerry O'Donoghue; Brian Deegan
Subject: RE: GDD - Ecoli levels in discharge - Shellfish expert memo

Thanks Gerry.

I will forward to Brian Deegan too.

Olwyn James
Project Planning Manager
Asset Delivery

Irish Water
Colville House| Talbot St.| Dublin 1
[redacted]
Please consider the environment before printing this e-mail

From: Gerry O'Donoghue
Sent: 14 March 2019 13:10
To: Olwyn James
Subject: Fwd: GDD - Ecoli levels in discharge - Shellfish expert memo

Olwyn,
FYI.
Gerry

From: "O'Keeffe, Ciaran" <Ciaran.OKeeffe@jacobs.com>
Sent: Thursday 14 March 2019 11:13
To: Dara White <dwhite@water.ie>
CC: Geoff OSullivan <Geoff.OSullivan@ervia.ie>,Gerry O'Donoghue <godonoghue@water.ie>
Subject: GDD - Ecoli levels in discharge - Shellfish expert memo

Dara, Geoff,

Tried calling you re above. We received a memo from our inhouse shellfish specialist last night, see attached. In my opinion it is not as strong as I would have hoped for and it leaves some doubt that requires a discussion.

Regards

Ciarán

Jacobs Engineering Ireland Limited
Merrion House, Merrion Road, Dublin 4, Ireland
Registered in Ireland under number 111945

Thank you for your attention.

Go raibh maith agat as d'aird a thabhairt.

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Thank you for your attention.

Go raibh maith agat as d'aird a thabhairt.

[redacted]

From: Aberson, Marja
Sent: 14 March 2019 14:47
To: O'Keeffe, Ciaran; 'dwhite@water.ie'
Cc: Kiernan, Sarah; McGlynn, Stephanie; 'ian.wilson@benthicsolutions.com'
Subject: RE: Malahide - shellfish monitoring

Also – please click on link for latest sample results (early Feb 19) for Malahide as analysed by the Marine Institute https://webapps.marine.ie/HABs/AreaStatus/AreaStatusSummary?locationId=44&locationNameCode=Malahide%20%20(DN-ME)&locationType=Onshore&isFinfish=false#/biotoxin

Production Area	Sample Site	Sample Date	Species	Tissue	SampleCode	ASP mg/kg	AZP ug/g	DSP ug/g	PSP ug STXdiH equival
Carrigaholt	CE-CT-CT	04/02/2019	Crassostrea gigas	Whole	BTX1906051	n.d.(a)	0.02(a)	<LOD(a)	
Ardgroom	CK-AM-AM	04/02/2019	Mytilus edulis	Whole	BTX1906042	n.d.(a)	<LOD(a)	<LOD(a)	
Gouleenacoush	CK-GH-GH	04/02/2019	Mytilus edulis	Whole	BTX1906041	n.d.(a)	<LOD(a)	<LOD(a)	
Lough Foyle	DL-LF-MF	04/02/2019	Crassostrea gigas	Whole	BTX1906047	n.d.(a)	0.02(a)	<LOD(a)	
Lough Foyle	DL-LF-QP	04/02/2019	Mytilus edulis	Whole	BTX1906046	n.d.(a)	0.02(a)	<LOD(a)	
Lough Foyle	DL-LF-QP	04/02/2019	Ostrea edulis	Whole	BTX1906048	n.d.(a)	0.02(a)	<LOD(a)	
Kilmakilloge	KY-KE-KE	04/02/2019	Mytilus edulis	Whole	BTX1906039	n.d.(a)	<LOD(a)	<LOD(a)	
Carlingford	LH-CL-MY	04/02/2019	Mytilus edulis	Whole	BTX1906045	n.d.(a)	<LOD(a)	<LOD(a)	
Clew Bay North	MO-CN-IL	04/02/2019	Mytilus edulis	Whole	BTX1906044		<LOD(a)	<LOD(a)	
Bannow Bay	WX-BB-BB	04/02/2019	Crassostrea gigas	Whole	BTX1906050	n.d.(a)	<LOD(a)	<LOD(a)	
Bannow Bay	WX-BB-BB	04/02/2019	Mytilus edulis	Whole	BTX1906049	n.d.(a)	<LOD(a)	<LOD(a)	
Donegal Harbour	DL-DH-MS	05/02/2019	Mytilus edulis	Whole	BTX1906043	n.d.(a)	0.02(a)	<LOD(a)	
Malahide	DN-ME-ME	05/02/2019	Ensis siliqua	Whole	BTX1906054		<LOD(a)	<LOD(a)	
Gormanstown	MH-GN-GN	05/02/2019	Ensis siliqua	Whole	BTX1906055		<LOD(a)	<LOD(a)	
Achill South	MO-AS-CN	05/02/2019	Crassostrea gigas	Whole	BTX1906052	n.d.(a)	0.08(a)	<LOD(a)	
Waterford Harbour	WD-WH-WN	05/02/2019	Crassostrea gigas	Whole	BTX1906053	n.d.(a)	<LOD(a)	<LOD(a)	
Wexford Harbour	WX-WH-WH	05/02/2019	Mytilus edulis	Whole	BTX1906040		<LOD(a)	<LOD(a)	

LOD = Limit of Detection, LOQ = Limit of Quantification, ULQ = Upper Limit of Quantification, N.D. = Not Detected

Malahide	DN-ME-ME	05/02/2019	Ensis siliqua	Whole	BTX1906054		<LOD(a)	<LOD(a)		<LOD(a)	<LOD(a)	Op

Thanks
Marja.

Dr Marja Aberson | Jacobs | Senior Marine Ecologist | Environment, Maritime & Resilience | [redacted] | www.jacobs.com

From: Aberson, Marja
Sent: 14 March 2019 13:35
To: O'Keeffe, Ciaran <Ciaran.OKeeffe@jacobs.com>; 'dwhite@water.ie' <dwhite@water.ie>
Cc: Kiernan, Sarah <Sarah.Kiernan@jacobs.com>; McGlynn, Stephanie <Stephanie.McGlynn@jacobs.com>;

'ian.wilson@benthicsolutions.com' <ian.wilson@benthicsolutions.com>
Subject: RE: Marine ecology review of the Ecoli and Fisheries review from Jacobs and the 300k model

HI

FYI- here is the extract from :

Cefas, 2013. Impact of chronic microbial pollution on shellfish. *Project WT093.* Cefas/CREH report to DEFRA. 88 pp (report also attached).

Highlighted for both tables is the values for cockles (assumed worse case) and the 'all species', standard values for the SWD standard of 300 and the Class A of 230

Note – in table 5.3 of the memo i mistakenly lifted of the values for all three species for 75% target annual compliance for Class A and not 80%

Table 5 - Indicative water standards required to achieve shellfish flesh standard of 300 *E. coli* MPN/100g)

Species	No samples annual	Target annual compliance rate (%)	Compliance required in individual samples (%)	Geomean required in flesh (MPN/100g)	Estimated geomean *E. coli* in seawater (cfu/100ml)	Estimated 90%ile *E. coli* in seawater (cfu/100ml)
Mussels	4	95	99	28	2.2	8
	4	90	97	45	3.4	13
	4	80	95	57	4.3	16
	4	75	76	149	10	38
	12	90	95	57	4.3	16
	12	80	87	97	7	26
	12	75	76	149	10	38
Pacific oysters	4	95	99	14	2.1	16
	4	90	97	26	3.6	27
	4	80	95	36	4.8	36
	4	75	76	122	14	108
	12	90	95	36	4.8	36
	12	80	87	71	9	66
	12	75	78	112	13	100
Cockles	4	95	99	8	0.03	0.3
	4	90	97	16	0.05	0.5
	4	80	95	23	0.07	0.7
	4	75	76	102	0.28	2.8
	12	90	95	23	0.07	0.7
	12	80	87	53	0.16	1.5
	12	75	78	93	0.26	2.5
All species	4	95	99	2.8	0.39	5.6
	4	90	97	7.1	0.66	9.5
	4	80	95	11	0.88	13
	4	75	76	74	2.7	38
	12	95	99	2.8	0.39	5.6
	12	90	95	11	0.88	13
	12	80	87	32	1.6	23
	12	75	78	74	2.7	38

Table 6 - Indicative water standards required to achieve shellfish flesh standard of 230 *E. coli* MPN/100g

Species	No. samples /annum	Target annual compliance rate (%)	Compliance required in individual samples (%)	Geomean required in flesh (MPN/100g)	Estimated geomean *E. coli* in seawater (cfu/100ml)	Estimated 90%ile *E. coli* in seawater (cfu/100ml)
Mussels	4	95	99	21	1.7	6
	4	90	97	34	2.7	10
	4	80	95	44	3.4	12
	4	75	76	114	8	30
	12	90	95	44	3.4	12
	12	80	87	75	5.5	20
	12	75	76	114	8	30
Pacific oysters	4	95	99	11	1.7	12
	4	90	97	20	2.9	21
	4	80	95	28	3.8	28
	4	75	76	94	11	85
	12	90	95	28	3.8	28
	12	80	87	55	7	52
	12	75	78	86	11	79
Cockles	4	95	99	5.8	0.02	0.2
	4	90	97	12	0.04	0.4
	4	80	95	18	0.06	0.6
	4	75	76	79	0.22	2.2
	12	90	95	18	0.06	0.6
	12	80	87	41	0.12	1.2
	12	75	78	71	0.2	2.0
All species	4	95	99	2.2	0.33	4.8
	4	90	97	5.4	0.57	8
	4	80	95	8.7	0.75	11
	4	75	76	57	2.3	33
	12	95	99	2.2	0.33	4.8
	12	90	95	8.7	0.75	11
	12	80	87	25	1.4	20
	12	75	78	50	2.1	30

Dr Marja Aberson | Jacobs | Senior Marine Ecologist | Environment, Maritime & Resilience | +[redacted] | www.jacobs.com

From: O'Keeffe, Ciaran
Sent: 14 March 2019 12:08
To: 'dwhite@water.ie' <dwhite@water.ie>; Aberson, Marja <Marja.Aberson@jacobs.com>
Subject: FW: Marine ecology review of the Ecoli and Fisheries review from Jacobs and the 300k model

fyi

From: Cathriona Cahill <Cathriona.Cahill@rpsgroup.com>
Sent: 14 March 2019 11:33
To: O'Keeffe, Ciaran <Ciaran.OKeeffe@jacobs.com>
Cc: McGlynn, Stephanie <Stephanie.McGlynn@jacobs.com>; Ian Wilson <ian.wilson@benthicsolutions.com>
Subject: [EXTERNAL] Fwd: Marine ecology review of the Ecoli and Fisheries review from Jacobs and the 300k model

Hi Ciaran
Ian has set out some notes below on his review of the memo
Chat at 12

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From: Ian Wilson <ian.wilson@benthicsolutions.com>
Sent: Thursday, March 14, 2019 11:03:57 AM
To: Cathriona Cahill
Cc: James McCrory; Simon Zisman
Subject: Marine ecology review of the Ecoli and Fisheries review from Jacobs and the 300k model

Cathriona,

Thanks for the document. This makes for an interesting read and is very useful as a general literature review of the situation. However, this has highlighted a few potential points.

- The proposal for revised *E.coli* discharge is 300k/100ml, would appears to be very conservative and may create unnecessary impacts.
- The revised model was pulled out of the response document (already sent in the submissions). This uses the 250cfu/100ml as the bottom contour so is very insensitive to low level contours that may exist over the shellfish waters as a whole.
- The review was not specific for *Ensis*, but from an ecological point of view, the impact to this species from a chronic coliform is more likely to reflect that of the cockle than the mussel. This means that this species will be quite sensitive to continual import inputs.
- The details in the shellfish study indicates that there is a direct linear relationship between water quality and shellfish uptake of coliforms. Uptake is rapid within 1 hour of exposure and plateaus at 17 hours. Flesh counts reduce almost as quickly on flushing events so an equilibrium based on a tidal cycle and constant input could be expected. Constant discharge - Can flush occur ?
- The key area of concern would be maintaining a Class A status for this species at these rates. A comparison from the 300k model and the uptake factor described for other species would suggest that this is unlikely to be maintained, although we have no current level of flesh or water quality for this area.
- Comparison with levels given in the submission for Velvet strand varies from 4 to 18 cfu this might be similar to what would be expected at the seabed in the Malahide SW. If we assumed an average of these rates at around 11cfu (based on a tidal flushing), then this would arguably only meet Class B for Mussels, with *Ensis* likely to be significantly more sensitive than this.

Overall, the question of meeting water quality requirement of <250cfu/100ml for the Shellfish waters is likely based on the model, but a chronic release based on the 300,000cfu/100ml is also likely to degrade the waters where Class A is unlikely to be achieved. Therefore, if a specific question is raised as to the expected Class qualification to shellfish as a result of this outfall within the Shellfish waters, it would be impossible to argue against a degradation

of quality based on the recent model used and the uptake data that is currently available for this species. We need to be sure of IW and Jacobs position on this if this is raised in the OH. Note that this is a socio-economic and not an ecological issue.

Regards

Ian Wilson
Benthic Solutions Limited
[redacted]
ian@benthicsolutions.co.uk
www.benthicsolutions.co.uk

Registered in England Company Registration Number: 5115407
Registered Office: Copseford, Hartwell Road, Wroxham, Norfolk NR12 8TL

From: Cathriona Cahill <Cathriona.Cahill@rpsgroup.com>
Sent: 13 March 2019 18:38
To: Ian Wilson <ian.wilson@benthicsolutions.com>
Cc: James McCrory <James.McCrory@rpsgroup.com>; Simon Zisman <Simon.Zisman@rpsgroup.com>
Subject: Fwd: Marine

Hi Ian
See attached.
I will give you a call to discuss in the morning

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From: McGlynn, Stephanie <Stephanie.McGlynn@jacobs.com>
Sent: Wednesday, March 13, 2019 6:30:34 PM
To: Cathriona Cahill
Cc: Kiernan, Sarah
Subject: RE: Marine

Hi Cathriona,

Please see attached preliminary memo re. shellfish from our expert.

Could you please revert as soon as possible with any comments and we will aim to arrange a call with the shellfish experts and relevant specialists tomorrow.

Kind regards,

Stephanie

From: Cathriona Cahill <Cathriona.Cahill@rpsgroup.com>
Sent: 13 March 2019 15:29
To: McGlynn, Stephanie <Stephanie.McGlynn@jacobs.com>; Kiernan, Sarah <Sarah.Kiernan@jacobs.com>

Cc: O'Keeffe, Ciaran <Ciaran.OKeeffe@jacobs.com>
Subject: [EXTERNAL] Marine

Hi Girls
Apologies for the delay.

Just to note that Ian has proposed to include Figure 1 which addresses the failure event at the outfall pipeline. (please note this is new information)
However, I am unsure now if this should be included based on Ciarán's email last night regarding the change in the failure event.
Also see comment re: shellfish.

Let me know if you need to discuss.

Cathriona Cahill
Associate Environment
RPS | Consulting UK & Ireland
West Pier Business Campus
Dun Laoghaire, Co. Dublin A96 N6T7, Ireland
[redacted]
rpsgroup.com

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RPS Group Plc web link: http://www.rpsgroup.com

[redacted]

From: Aberson, Marja
Sent: 14 March 2019 20:05
To: O'Keeffe, Ciaran; 'dwhite@water.ie'
Cc: Kiernan, Sarah; McGlynn, Stephanie; 'ian.wilson@benthicsolutions.com'
Subject: RE: Further lit review - focussed on Ensis sp. accumulagtion

Dear all,

After another search please note the brief statements below. Slightly relevant info have highlighted in yellow.

SHELLFISH MONITORING IN RIO

1) SOURCE: Food safety authority of Ireland
https://www.fsai.ie/enforcement_audit/monitoring/shellfish.html

- Sea-Fisheries Protection Agency (SFPA) and the marine institute (MI) do monthly tests for biotoxins (ASP, AZP, DSP, PSP) – includes test on razor clams.
- Results – 'open with 2x samples taken 48 hrs apart'
  'closed' – positive biotoxin samples
  ' closed pending (1st sample +ve, awaiting results of 2nd'
- Data available on MI website for Malahide. Current status for Malahide is Open as determined by biotoxins.
- Shellfish production area also defined and classified using microbiological data from SFPA
- Following 'full assessment of risk'.
- Results from this not used to open or close production areas on a week to week basis, Ongoing monitoring establishes if risk has changed.
  Accessed SFPA website = No *E. coli* concentration data available for any of the listed production sites (note – off all ROI production areas ~ 3 only harvest Ensis sp. https://www.sfpa.ie/What-we-do/Shellfish/Classified-Areas

2) SOURCE: Irish Water Annual Environmental Reports (2012-2016
(seems as though they haven't considered risk to shellfish last few years at Malahide?)

a) Agglomeration Malahide
(2016)

2.3 Ambient Monitoring Summary

Table 2.3 Ambient Monitoring Report Summary Table

Ambient Monitoring Point from WWDL (or as agreed with EPA)	Irish Grid Reference	EPA Feature Coding Tool code	Bathing Water	Drinking Water	FWPM	Shellfish	Current WFD Status
BM210-Causeway Cascade	322582E, 246924N	CW09001007BM2001	No	No	No	No	Moderate (Coastal Wa 2010 - 2015)
BM220-Malahide Marina	322731E, 246527N	CW09001007BM2002	No	No	No	No	Moderate (Coastal Wa 2010 - 2015)
BM230-Malahide Navigation Channel	323482E, 246290N	CW09001007BM2003	No	No	No	No	Moderate (Coastal Wa 2010 - 2015)
Balcarrick Beach, Donabate	325151E, 249004N	N/A	Yes	No	No	No	Good (Coastal Water (- 2015)
Malahide Beach	324034E, 246133N	N/A	Yes	No	No	No	Good (Coastal Water (- 2015)

b) Agglomeration Malahide (2015)

Table 2.3 - Ambient Monitoring Report Summary

Ambient Monitoring Point from WWDL (or as agreed with EPA)	Irish Grid Reference	EPA Feature Coding Tool code	Receiving Waters Designation (Y/N)				WFD Status	Does assessment of the ambient monitoring results indicate that the discharge is impacting on water quality?
			Bathing Water	Drinking Water	FWPM	Shellfish		
BM210-Causeway Cascade	322582E, 246924N	CW090010 07BM2001	N	N	N	N	Moderate (WFD Status 2010-2012)	No
BM220-Malahide Marina	322731E, 246527N	CW090010 07BM2002	N	N	N	N	Moderate (WFD Status 2010-2012)	No
BM230-Malahide Navigation Channel	323482E, 246290N	CW090010 07BM2003	N	N	N	N	Moderate (WFD Status 2010-2012)	No
BM230-Malahide Marina	322731E, 246527N	CW090010 07BM2002	N	N	N	N	Moderate (WFD Status 2010-2012)	No
Balcarrick Beach, Donabate	325151E, 249004N	N/A	Y	N	N	N	10 out of 13 samples taken during 2015 Bathing season achieved "Excellent" Status.	No
Malahide Beach	324034E, 246133N	N/A	Y	N	N	N	This beach has been de-listed and will not receive a Bathing Water Status	No

The results for the ambient and bathing water monitoring are included in Appendix 7.2

c) Agglomeration Malahide (2012)

SFPA indicates only a single sample of razor clam specific to Malahide was taken in 2012 (in table results for 2010-2012 also included)

2.5(c)i Sea Fisheries Protection Authority Results Table 2010/2011/2012 Malahide Shellfish Area

Sample Position	Sample Date	Result No	Sample Type	Lab	E.Coli Shell per gram	E. Coli/100g Shellfish Flesh and intervalvular fluid
N/A	18-Jan-10	24407	RAZ	MI	2.3	230
N/A	2-Feb-10	24485	RAZ	MI	1.7	170
N/A	2-Mar-10	24647	RAZ	MI	0.2	20
N/A	22-Jul-10	25313	RAZ	MI	0.7	70
N/A	9-Aug-10	25384	RAZ	MI	0.5	50
N/A	26-Oct-10	25741	RAZ	MI	0.2	20
N/A	22-Feb-11	26287	RAZ	MI	2.3	230
N/A	16-Apr-12	28062	RAZ	MI	0.2	20

2.5(g) Interpretation of Ambient Monitoring Results against Designation as Shellfish Waters

The data presented above was collated by the Sea Fisheries Protection Authority (SFPA) and was used by them to determine the classification of Malahide Shellfish waters.

Malahide Shellfish area is classified "B" for Razor Clams. In order to meet the criteria for Class "A", there must be fewer that 230 E.coli per 100grams found in the flesh and intervalvular fluid of shellfish tested. It can be seen in the table above (2.5(c)i) that, on just two occasions, shellfish harvested in Malahide shellfish waters were found to have 230 E.coli per 100 grams flesh and intervalvular fluid while on all other occasions the said shellfish fully complied with Class "A" criteria. Therefore, Malahide Shellfish area has only missed Class "A" by the narrowest of margins.

S.I. No. 268/2006-European Communities (Quality of Shellfish Waters) Regulations 2006, were consulted, but there was no definitive standard for E. coli, applicable to shellfish flesh and intervalvular fluid.

Having considered the abovementioned regulations, the test results provided by the SFPA and the assessment carried out pursuant to Condition 5.6 of WWDL No. D0021-01 (included below in this report) it is concluded that the discharge from the Malahide agglomeration is not affecting the Malahide Designated Shellfish Waters.

d) Agglomeration Ringsend (2017)

2.3. Ambient Monitoring Summary

Ambient Monitoring Point from WWDL (or as agreed with EPA)	*Irish Grid Reference*	EPA Feature Coding Tool code	Receiving Waters Designation (Yes)				WFD Status	Does assessment of the ambient monitoring results indica impacting on water quality?
			Bathing Water	Drinking Water	FWPM	Shellfish		
Upstream monitoring point	Liffey U/S Islandbridge	Unknown	No	No	No	No	Moderate	n/a The River Liffey U/S Islandbridge is freshwater and canno receiving waters.
Downstream monitoring point	Liffey Estuary Upper	Unknown	No	No	No	No	Moderate	Yes Impacts in the near field and the plume of the sewage disc *Results"* section below. Liffey Estuary tidal
Downstream monitoring point	Liffey Estuary Lower	Unknown	Yes	No	No	No	Moderate	Yes Impacts in the near field and the plume of the sewage disc *Results"* section below. Liffey Estuary tidal
Downstream monitoring point	Tolka Estuary	Unknown	No	No	No	No	Moderate	Yes Impacts of the sewage discharge plume and the Tolka River inflow – see *"Significance of Results"* se Tolka Estuary tidal
Downstream monitoring point	Dublin Bay	Unknown	No	No	No	No	Good	No See *"Significance of Results"* section below.
Downstream monitoring point	Bathing Waters Dollymount Bathing Zone Sandymount Merrion	Unknown	Yes	No	No	No	(2017 EPA) Good Poor Poor	 Ectocarpus noted on many dates. *Significance of Results"* s Investigations Ongoing

SCIENTIFIC LITERATURE

1) Howard *et al.* (1998) Preminary trials to assess the variability in purifying the razor fish (*E. siliqua*) by depuration using UV steralisation

- New (<1998) Ensis fishery opened in Scotland
- Some classified a B so need to depurate catch
- Ensis can be caught by hand, by divers and by dredge
- Experiment 1: Ensis put into tanks, exposed to E. coli for 4 hrs (at 80/**ml(?)**), then UV treated
- Results Exp1: ALL DIED as someone accidently put on water heater!
  Did show, Ensis readily contaminated, E. coli levels, range from 7,500 – 35,000 cfu/100g tissue
- Experiment 2: Ensis put into tanks @ different orientations, exposed to E.coli (3.4/**ml(?)**) for 4 hrs , then UV treated for 42hrs
- Results Exp 2: Also, Ensis readily contaminated, but not as high, to concentrations 110-1,700 cfu/100g tissue
  All successfully depurated at end of cycle (E. coli conc. No detected < 90 cfu/100g tissue
- Experiment 3: Ensis put into tanks to test being in bundles at different orientatins, exposed to E. coli for 4 hours, then UV treated for 42 hrs
- Results Exp 3: Ensis tissues 750-11,000 cfu/100g
  At end of depuration 4 samples passed Class A (40-90 cfu/100g)
  At endof deputation 2 sampels failed Class A (310 and 500 cfu/100g)(these had been laid flat)
- Concl: Ensis successfully held in depuration cycle of 42 hrs
  e. coli clearence in Ensis achievable providing correct conditions
  Animals subjected to stress, capture and transport, this may inc. concentrations.
  Harvesting techniques should be designed to reduce damage to animal (and handling (e.g. in budles<10, laide vertically in trays in depuration tanks)

2) Lopez *et al.* (2005). Depuration of the razor clams *Ensis arcuatus* and *Ensis siliqua.* (ABSTRACT SOURCED ONLY)

- Aim to evaluate specific method for depuration of razor clams.
- Results: Importance of damaged specimens and bundle size and orientation in cages.
  IN all cases, 21 hours are needed in order to rach legal limits for consumption.

3) Lee and Murray (date?)Chapter 6 – Components of microbiological monitoring programmes

- In England and Wales, a general tendance been shown for the degree of contaminatio to be in the order (from highes to lowest)

1) *Mytilus edulis, Ostrea edulis, Ruditapes philippinarum*
2) *Magallena (Crassostrea) edulis*
3) Other clams, including razor clams (*Ensis* spp), scallops (*Pecten maximus*)

GOVERNMENT (CEFAS/EU) REPORTS

1) **Cefas, 2014. Critical review of current evidence for potential use of indicator species to classify UK shellfish production areas.**

- Aim – assess current evidence see if it supports concept of using single indicator species to represent multiple spcies
- Exec summary: *Mytilus* may be used as an indicator in many situations, (represent C. *gigas, O. edulis, Tapes* spp).
  Support use of *C. edule* to represent *Mytilus* where monitoring of *C. edule* is practical
  Indicator approach cannot at this stage be recommended for represenation for *C. edule, Ensis* spp ...as either contradictory or no supporting data from the literature is available.
- Italian offshore production areas – Accumulation higher rates in *Ensis* than the venus clam.
- Benefits of an indicator species approach e.g new sites with one species (e.g. Ensis) that require specialist equipment to sample and where an indicator speies (perhaps deployed in bafs) from a readily accessible location) could be used instead. But there is insufficoent data to recommend such an approach for *Ensis.*
- It would be of interest to udtake similar work for other commercially important species like *Ensis..* (in England + wales , a difficult species for local authoritis to sample and so a direct comparison with *Mytilus* and *C. edule* would give most practical benefit.

2) **EU Working group on microbiological monitoring of bivalve mollusc harvest areas (2005)**

- In England and Wales, a general tendance been shown for the degree of contamination to be in the order (from highes to lowest)

4) *Mytilus edulis, Ostrea edulis, Ruditapes philippinarum*
5) *Magallena (Crassostrea) edulis*
6) Other clams, including razor clams (*Ensis* spp), scallops (*Pecten maximus*)
   (SAME STATEMENT AS CITED IN LEE AND MURRAY REF ABOVE)

3) **Cefas (2006.) development of suitable dredge for exploitation of razorfish in the wash**

- Under EU shellfish growing waters direction – obtaining a water classification for any potential future razorshell fishery requies collection ot samples of razorshell over specific minimum time, ~ 6 mo, or 10 samples over 3 mo. Form each site possible..
- Classification of beds in the wash – initial results 40 and 70 cfu/100g (< 230 Class A.

4) **Cefas (2017) EU general laboratory protocals**

- Sub-samples required for homogenisation step for Ensis : 10-12 speciemens

5) **Cefas + FSA (2018) Protocol for collection of shellfish under the microbiological classificaiton monitoring programme (EU Reg 854/2004)**

- Sample sizes for ensis: 12-18
- Sample freq. for classified sites
  - done randomly (weather.tidal state)
  - For classified beds (e.g. Malahide): Maintenance sampling undertaken montly basis, if problem occurs, then frequency may have to be increased.
  - For commercial inactive beds (6 mo. Or more): reduced frequency monitoring
  - For uncharacteristic high results – increase frequency to fortnightly (*ad hoc* investigative samples)

SPANISH MONITORING OF SHELLFISH BEDS

1) **EC (2011) Evaluate food safety control systems in place governing production and placing on market of bivalve molluscs in Spain**

- 2 main areas: Andalusia and Galicia (has the largest no. of production areas), both areas product 98% of total spanish shellfish production..
- For Galicia: Sampling freq. is montly, in most every 2 mo. For stable beds
  Geometric mean of last 3 years Xg <13 (class A)
  Geometric mean of last 3 years 40 < Xg > 210 (Class B)
  Geometric mean of last 3 years 750 < Xg > 2,250 (Class C)
  If a + ve results, frequency is increased and investigation (Alert Plan) carried out
  Temporary closure of production area. Alert plan see if issue with sampling, or meterological impacts
- Galicia' scontrol systems is in compliance with EU (andalusia sig. non-compliance)

NOTE: Spain use the laboratory INTECMAR for their monitoring. Couldn't find any historic data or anything of use on their site, even after translated into english!

Couldn't find anything for monitoring E. coli in Ensis. In spanish reports/literature.

Dr Marja Aberson | Jacobs | Senior Marine Ecologist | Environment, Maritime & Resilience | [redacted]
[redacted] | www.jacobs.com

From: Aberson, Marja
Sent: 14 March 2019 13:35
To: O'Keeffe, Ciaran <Ciaran.OKeeffe@jacobs.com>; 'dwhite@water.ie' <dwhite@water.ie>
Cc: Kiernan, Sarah <Sarah.Kiernan@jacobs.com>; McGlynn, Stephanie <Stephanie.McGlynn@jacobs.com>; 'ian.wilson@benthicsolutions.com' <ian.wilson@benthicsolutions.com>
Subject: RE: Marine ecology review of the Ecoli and Fisheries review from Jacobs and the 300k model

HI

FYI- here is the extract from :

Cefas, 2013. Impact of chronic microbial pollution on shellfish. *Project WT093.* Cefas/CREH report to DEFRA. 88 pp (report also attached).

Highlighted for both tables is the values for cockles (assumed worse case) and the 'all species', standard values for the SWD standard of 300 and the Class A of 230

Note – in table 5.3 of the memo i mistakenly lifted of the values for all three species for 75% target annual compliance for Class A and not 80%

Table 5 - Indicative water standards required to achieve shellfish flesh standard of 300 *E. coli* MPN/100g)

Species	No samples annual	Target annual compliance rate (%)	Compliance required in individual samples (%)	Geomean required in flesh (MPN/100g)	Estimated geomean *E. coli* in seawater (cfu/100ml)	Estimated 90%ile *E. coli* in seawater (cfu/100ml)
Mussels	4	95	99	28	2.2	8
	4	90	97	45	3.4	13
	4	80	95	57	4.3	16
	4	75	76	149	10	38
	12	90	95	57	4.3	16
	12	80	87	97	7	26
	12	75	76	149	10	38
Pacific oysters	4	95	99	14	2.1	16
	4	90	97	26	3.6	27
	4	80	95	36	4.8	36
	4	75	76	122	14	108
	12	90	95	36	4.8	36
	12	80	87	71	9	66
	12	75	78	112	13	100
Cockles	4	95	99	8	0.03	0.3
	4	90	97	16	0.05	0.5
	4	80	95	23	0.07	0.7
	4	75	76	102	0.28	2.8
	12	90	95	23	0.07	0.7
	12	80	87	53	0.16	1.5
	12	75	78	93	0.26	2.5
All species	4	95	99	2.8	0.39	5.6
	4	90	97	7.1	0.66	9.5
	4	80	95	11	0.88	13
	4	75	76	74	2.7	38
	12	95	99	2.8	0.39	5.6
	12	90	95	11	0.88	13
	12	80	87	32	1.6	23
	12	75	78	74	2.7	38

Table 6 - Indicative water standards required to achieve shellfish flesh standard of 230 *E. coli* MPN/100g

Species	No. samples /annum	Target annual compliance rate (%)	Compliance required in individual samples (%)	Geomean required in flesh (MPN/100g)	Estimated geomean *E. coli* in seawater (cfu/100ml)	Estimated 90%ile *E. coli* in seawater (cfu/100ml)
Mussels	4	95	99	21	1.7	6
	4	90	97	34	2.7	10
	4	80	95	44	3.4	12
	4	75	76	114	8	30
	12	90	95	44	3.4	12
	12	80	87	75	5.5	20
	12	75	76	114	8	30
Pacific oysters	4	95	99	11	1.7	12
	4	90	97	20	2.9	21
	4	80	95	28	3.8	28
	4	75	76	94	11	85
	12	90	95	28	3.8	28
	12	80	87	55	7	52
	12	75	78	86	11	79
Cockles	4	95	99	5.8	0.02	0.2
	4	90	97	12	0.04	0.4
	4	80	95	18	0.06	0.6
	4	75	76	79	0.22	2.2
	12	90	95	18	0.06	0.6
	12	80	87	41	0.12	1.2
	12	75	78	71	0.2	2.0
All species	4	95	99	2.2	0.33	4.8
	4	90	97	5.4	0.57	8
	4	80	95	8.7	0.75	11
	4	75	76	57	2.3	33
	12	95	99	2.2	0.33	4.8
	12	90	95	8.7	0.75	11
	12	80	87	25	1.4	20
	12	75	78	50	2.1	30

Dr Marja Aberson | Jacobs | Senior Marine Ecologist | Environment, Maritime & Resilience | [redacted] | www.jacobs.com

From: O'Keeffe, Ciaran
Sent: 14 March 2019 12:08
To: 'dwhite@water.ie' <dwhite@water.ie>; Aberson, Marja <Marja.Aberson@jacobs.com>
Subject: FW: Marine ecology review of the Ecoli and Fisheries review from Jacobs and the 300k model

fyi

From: Cathriona Cahill <Cathriona.Cahill@rpsgroup.com>
Sent: 14 March 2019 11:33
To: O'Keeffe, Ciaran <Ciaran.OKeeffe@jacobs.com>
Cc: McGlynn, Stephanie <Stephanie.McGlynn@jacobs.com>; Ian Wilson <ian.wilson@benthicsolutions.com>
Subject: [EXTERNAL] Fwd: Marine ecology review of the Ecoli and Fisheries review from Jacobs and the 300k model

Hi Ciaran
Ian has set out some notes below on his review of the memo
Chat at 12

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From: Ian Wilson <ian.wilson@benthicsolutions.com>
Sent: Thursday, March 14, 2019 11:03:57 AM
To: Cathriona Cahill
Cc: James McCrory; Simon Zisman
Subject: Marine ecology review of the Ecoli and Fisheries review from Jacobs and the 300k model

Cathriona,

Thanks for the document. This makes for an interesting read and is very useful as a general literature review of the situation. However, this has highlighted a few potential points.

- The proposal for revised *E.coli* discharge is 300k/100ml, would appears to be very conservative and may create unnecessary impacts.
- The revised model was pulled out of the response document (already sent in the submissions). This uses the 250cfu/100ml as the bottom contour so is very insensitive to low level contours that may exist over the shellfish waters as a whole.
- The review was not specific for *Ensis*, but from an ecological point of view, the impact to this species from a chronic coliform is more likely to reflect that of the cockle than the mussel. This means that this species will be quite sensitive to continual import inputs.
- The details in the shellfish study indicates that there is a direct linear relationship between water quality and shellfish uptake of coliforms. Uptake is rapid within 1 hour of exposure and plateaus at 17 hours. Flesh counts reduce almost as quickly on flushing events so an equilibrium based on a tidal cycle and constant input could be expected.
- The key area of concern would be maintaining a Class A status for this species at these rates. A comparison from the 300k model and the uptake factor described for other species would suggest that this is unlikely to be maintained, although we have no current level of flesh or water quality for this area.
- Comparison with levels given in the submission for Velvet strand varies from 4 to 18 cfu this might be similar to what would be expected at the seabed in the Malahide SW. If we assumed an average of these rates at around 11cfu (based on a tidal flushing), then this would arguably only meet Class B for Mussels, with *Ensis* likely to be significantly more sensitive than this.

Overall, the question of meeting water quality requirement of <250cfu/100ml for the Shellfish waters is likely based on the model, but a chronic release based on the 300,000cfu/100ml is also likely to degrade the waters where Class A is unlikely to be achieved. Therefore, if a specific question is raised as to the expected Class qualification to shellfish as a result of this outfall within the Shellfish waters, it would be impossible to argue against a degradation

of quality based on the recent model used and the uptake data that is currently available for this species. We need to be sure of IW and Jacobs position on this if this is raised in the OH. Note that this is a socio-economic and not an ecological issue.

Regards

Ian Wilson

[redacted]
ian@benthicsolutions.co.uk
www.benthicsolutions.co.uk

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From: Cathriona Cahill <Cathriona.Cahill@rpsgroup.com>
Sent: 13 March 2019 18:38
To: Ian Wilson <ian.wilson@benthicsolutions.com>
Cc: James McCrory <James.McCrory@rpsgroup.com>; Simon Zisman <Simon.Zisman@rpsgroup.com>
Subject: Fwd: Marine

Hi Ian
See attached.
I will give you a call to discuss in the morning

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From: McGlynn, Stephanie <Stephanie.McGlynn@jacobs.com>
Sent: Wednesday, March 13, 2019 6:30:34 PM
To: Cathriona Cahill
Cc: Kiernan, Sarah
Subject: RE: Marine

Hi Cathriona,

Please see attached preliminary memo re. shellfish from our expert.

Could you please revert as soon as possible with any comments and we will aim to arrange a call with the shellfish experts and relevant specialists tomorrow.

Kind regards,

Stephanie

From: Cathriona Cahill <Cathriona.Cahill@rpsgroup.com>
Sent: 13 March 2019 15:29
To: McGlynn, Stephanie <Stephanie.McGlynn@jacobs.com>; Kiernan, Sarah <Sarah.Kiernan@jacobs.com>

Cc: O'Keeffe, Ciaran <Ciaran.OKeeffe@jacobs.com>
Subject: [EXTERNAL] Marine

Hi Girls
Apologies for the delay.

Just to note that Ian has proposed to include Figure 1 which addresses the failure event at the outfall pipeline. (please note this is new information)
However, I am unsure now if this should be included based on Ciarán's email last night regarding the change in the failure event.
Also see comment re: shellfish.

13/3/19.

Let me know if you need to discuss.

Cathriona Cahill
Associate Environment
RPS | Consulting UK & Ireland
West Pier Business Campus
Dun Laoghaire, Co. Dublin A96 N6T7, Ireland
[redacted]
rpsgroup.com

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RPS Group Plc web link: http://www.rpsgroup.com

[redacted]

From: O'Keeffe, Ciaran <Ciaran.OKeeffe@jacobs.com>
Sent: 15 March 2019 14:25
To: Dara White
Subject: Confidential - Ecoli levels in discharge
Attachments: 20190315_Statistical Analysis of predicted Ecoli concentrations_ver2.docx

Importance: High

Dara,

As discussed

From: Alan Berry <alan@marcon.ie>
Sent: 15 March 2019 11:19
To: O'Keeffe, Ciaran <Ciaran.OKeeffe@jacobs.com>
Cc: McGlynn, Stephanie <Stephanie.McGlynn@jacobs.com>
Subject: [EXTERNAL] Re: FW: Shellfish expert [ALG-MAIN.FID2334887]
Importance: High

Ciaran,

Updated version of document, containing additional comparison against Oysters and Mussels.

Alan Berry
Managing Director
MarCon Computations International

[redacted]
W: http://www.marcon.ie

On 2019-03-15 10:34, Alan Berry wrote:

> Ciaran,
>
> Find attached.
>
> Not good.
>
> Alan Berry
>
> Managing Director
> MarCon Computations International

[redacted]
W: http://www.marcon.ie

MarCon Computations International is a registered business name of Global Earth and Ocean Modelling Solutions Limited.
Company registration details for Global Earth and Ocean Modelling Solutions Limited:
Registered Number: 425721
Registered Office: Cahergal, Tuam, Co. Galway.

On 2019-03-14 08:25, O'Keeffe, Ciaran wrote:

Alan,

See email below from ALG which is raising two questions that FCC are concerned about. We have a meeting with FCC this afternoon to discuss these concerns. In light of the memo from our shellfish expert that Sarah circulated yesterday do we have a problem with our assessment? Could you give me a call to discuss please.

Regards

Ciarán

From: Alison Fanagan <afanagan@algoodbody.com>
Sent: 13 March 2019 08:47
To: O'Keeffe, Ciaran <Ciaran.OKeeffe@jacobs.com>
Cc: Noeleen McHenry (nmchenry@water.ie) <nmchenry@water.ie>; Olwyn James <ojames@water.ie>; Kristen Read <kread@algoodbody.com>; Brendan Curran <bcurran@algoodbody.com>; Chris Stynes <cstynes@algoodbody.com>
Subject: [EXTERNAL] RE: Shellfish expert [ALG-MAIN.FID2334887]
Importance: High

[redacted]

[redacted]

[redacted]

[redacted]

Alison Fanagan | Consultant

A&L Goodbody

[redacted]

IFSC, 25-28 North Wall Quay, Dublin 1, D01 H104 | www.algoodbody.com

---

From: O'Keeffe, Ciaran [mailto:Ciaran.OKeeffe@jacobs.com]
Sent: 13 March 2019 08:30
To: Alison Fanagan
Subject: RE: Shellfish expert [ALG-MAIN.FID2334887]

Expecting a memo from her today with phone call to follow.

From: Alison Fanagan <afanagan@algoodbody.com>
Sent: 13 March 2019 08:29
To: O'Keeffe, Ciaran <Ciaran.OKeeffe@jacobs.com>
Subject: [EXTERNAL] Shellfish expert [ALG-MAIN.FID2334887]

maya atherson?

Hi Ciaran

How are you getting on with this expert, is he or she on board yet?

Regards

Alison Fanagan | Consultant

A&L Goodbody

[redacted]

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