



Feidhmeannacht na Seirbhíse Sláinte
Health Service Executive



Submission on Food Harvest 2020

RE - Food Harvest 2020 Environmental Analysis Report

HSE Consultant in Public Health Medicine Environment and Health Group

11th November 2013

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Submission Summary

Ireland has possibly the highest rate of Verotoxigenic E. coli (VTEC) in the world. The public health priority is to protect the Irish population from potentially devastating infectious diseases. The reservoir of this infectious disease is mainly ruminant animals, so control of this illness must involve the agricultural sector.

Food Harvest 2020 sets out to improve the Irish agricultural economy. Its success depends on being Smart and Green and achieving Growth. However, Ireland's green reputation could be seriously damaged by an outbreak affecting visitors to the country. The perception that Spanish cucumbers may have been the cause of the VTEC outbreak in Germany in 2011 damaged that industry. The commercial damage occurred even though it was quickly determined that the cucumbers were not the source of the outbreak. The Irish tourist industry is vital to the Irish economy. Visitors exposed to a contaminated water supply particularly visiting children are susceptible to infection.

The Irish Food Industry is a growing sector. Contaminated water could also affect the safety of raw food industries, such as production of salad vegetables. A serious food borne illness incident could have very detrimental effects on Ireland's clean, green and healthy reputation.

This submission expands on these and other risks and makes recommendations towards reducing the public health risk associated with Food Harvest 2020.

Introduction

The HSE Consultant in Public Health Medicine Environment & Health Group welcomes Food Harvest 2020 which hopes to contribute significantly to economic recovery in Ireland. Economic sustainability is essential for the health of the Irish population, communities, families and individuals.

Our interest lies in the effect of changes in agriculture on the environment and how this may affect the health of the population of Ireland. Consultants in Public Health Medicine carry the responsibility for the investigation and control of notifiable infectious diseases including "removing conditions favourable to such infection"¹. Therefore we have a particular interest in preventing environmental conditions conducive to the transmission of serious infectious diseases in humans.

We note in the Food Harvest 2020 Environmental Analysis Report that price changes are expected to provide much of the increase in value and therefore this element of change will not directly impact the environment.

This group welcomes the statement in the report that "further improvements to water quality and other environmental characteristics are called for" and notes the importance of Ireland's "green" reputation.

Comments on methodology

Although EPA "Advice Notes on Current Practice in the Preparation of Environmental Impact Statements"² emphasises the importance of assessing human health effects, and this document was referenced in the methodology, public health risks related to agriculture were not addressed directly in the Environmental Analysis Report. We identify this as a significant limitation to this report.

This gap may be related to the emphasis of Food Harvest 2020 and that while the Food Harvest 2020 Committee Members represent a wide group of stakeholders, there is no representative from the human or animal health sectors. It should be noted that public health risks are not always widely known as they may not be reported in the media. This is because an incident involves

¹ Infectious Diseases Regulations 1981, Section 11.

² Advice Notes on Current Practice in the Preparation of Environmental Impact Statements. Available at: http://www.epa.ie/pubs/advice/ea/guidelines/EPA_advice_on_EIS_2003.pdf

personal health information, which is confidential, and therefore, only in exceptional circumstances where communication with the media is required to protect the public, will public health doctors “go public”.

Recommendation 1: That public health risks are assessed and analysed in relation to Food Harvest 2020. The purpose of this is to ensure that the public is protected from possible detrimental impacts. This will also help to reduce risk to Ireland’s green reputation.

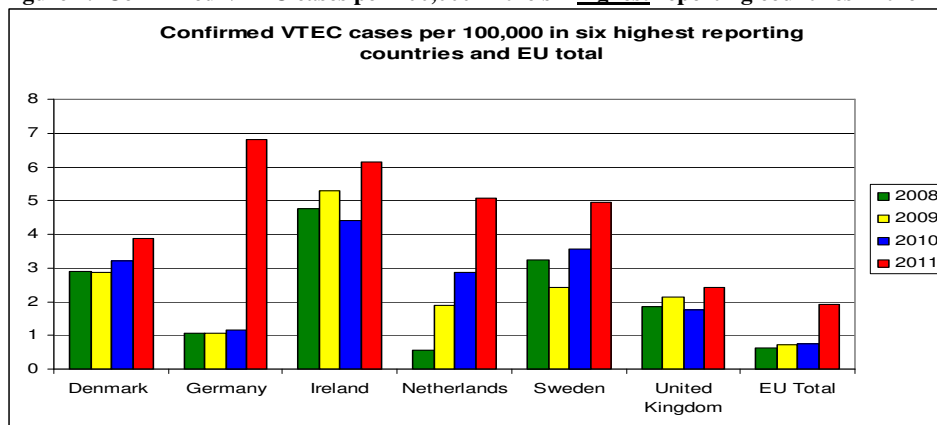
Public Health threat to Green Reputation

Microbiological risks to the public, especially from Verotoxigenic *E. coli* (VTEC), may be a threat to Ireland’s green reputation. VTEC is shed in the faeces of animals, particularly cattle, and while this organism causes no disease in farm animals, it can and does cause serious gastrointestinal illness and can be fatal in humans. For example:

- For one subtype of VTEC, *E. coli* O157:H7, about 15% of children have been reported to develop Haemolytic Uraemic Syndrome (HUS)³. HUS can cause irreversible kidney and other organ damage and is fatal in about 5%.
- During the German VTEC O104:H4 outbreak in 2011, there were 3168 cases of VTEC, 908 cases of HUS and 50 deaths reported to the World Health Organization (WHO) by 22/7/2011⁴. While the transmission route in the German outbreak was found to be foodborne use of Fenugreek sprouts, the source of the original contamination of the seeds is likely to have been related to contaminated fertiliser or irrigation water.

Ireland has the highest rates of VTEC in Europe almost every year and the rates are increasing in Ireland annually. **Figure 1** shows that Ireland had the highest VTEC notification rate in the EU in all years from 2008 apart from 2011, when Germany’s foodborne VTEC outbreak resulted in slightly surpassing Ireland’s rate of 6.14/100,000 population. It should be noted that Ireland’s notification rate in 2012 doubled to 12/100,000 and in the HSE Midlands region, which covers the rural counties of Laois, Offaly, Westmeath and Longford, the rate was 29/100,000 population. Part of the high rate in the Midlands was explained by a series of VTEC outbreaks associated with contaminated drinking water.

Figure 1. Confirmed VTEC cases per 100,000 in the six highest reporting countries in the EU



Source: *EU summary report on zoonoses, zoonotic agents and food-borne outbreaks 2011, EFSA Journal 2013, 11 (4):3129*

³ Control of Communicable Diseases Manual. An official report of the American Public Health Association. 19th edition.

⁴ EPI-NEWS No 27-33 – 2011. Available at: <http://www.ssi.dk/English/News/EPI-NEWS/2011/No%2027-33%20-%202011.aspx>

Cryptosporidiosis, caused by *Cryptosporidium parvum*, is another common potentially life-threatening infectious disease, that can be carried by livestock, particularly calves and lambs, and many outbreaks have been associated with contaminated drinking water.

This submission aims to highlight the issues relevant to agriculture that may lead to public health risks through contamination of the environment, and especially to the risk of contamination of drinking water by infectious diseases such as VTEC. It is essential that Food Harvest 2020 includes this risk in its risk assessment and management strategy. The demand on Ireland's agriculture sector for growth in the foreseeable decades requires planning at this stage to mitigate these current health risks and control the risks to health into the future. It is not clear that current environmental protection measures and hence the environmental analysis take this risk into account sufficiently.

Comments on Section Four - Water

This Environmental Analysis Report does not mention the human health impact of waterborne infectious diseases as a key area to review.

The human health impact should be addressed as there is evidence linking numerous cases and outbreaks of serious infectious diseases with contaminated drinking water in Ireland annually. These cases and outbreaks have a significant health impact on those affected – illness, hospitalisations, deaths, long-term need for health follow-up and risk of deterioration of health due to organ damage. There is also an economic impact on people and areas affected, such as closure of a business until the outbreak is under control, exclusion from work or crèche, cost of providing bottled water in hospitality industry and reputational damage e.g. effect on tourism during cryptosporidium outbreaks. There is a cost to the health service too, as many people who develop HUS require intensive care treatment, and/or kidney dialysis which may be required on an on-going basis. Even for non-complicated VTEC, bloody diarrhoea can be so severe that people often need to be hospitalised. There have been several deaths from HUS in 2013.

The Environmental Analysis Report acknowledges issues related to risk to human health, but doesn't explore these further.

These risks can be described as elements of an exposure pathway⁵ as follows:

Element 1 - Contaminant source or release: The reservoir for VTEC (including subtypes such as *E. coli* O157 and O26) is generally ruminant animals, particularly cattle, in Ireland. As VTEC apparently does not cause illness in these animals, it is not considered important in agriculture. Prevalence in herds appears to vary over time and “super-shedding” can occur, which infects others in the herd. VTEC is released into the environment in the animal faeces. One of the programmes reported by the EPA STRIVE Report no 89 (2012)⁶ developed microbial source tracking methods during its study research period and found that ruminants were the dominant source of microbial contamination in the areas studied. Density of cattle may therefore be of relevance in assessing risk of contamination. The variation in density of cattle per hectare of farmed land across Ireland⁷ may indicate some variation in potential burden of VTEC and therefore risk of VTEC. For example the density of cattle in Dublin, Donegal and Leitrim is low (≤ 0.75 total cattle/hectare area farmed) whereas in Kilkenny, North Tipperary and Waterford the density is considerably higher (> 1.9 total cattle/hectare area farmed).

⁵ ATSDR. PHA Guidance Manual - Chapter 6. Exposure Evaluation: evaluating exposure pathways

⁶ EPA. STRIVE Report no 89. Enhancing human health through improved water quality. Available at: <http://erc.epa.ie/safer/downloadCheck.jsp?isoID=272&rID=10424&atID=3131>

⁷ CSO Agrimap at: <http://census.cso.ie/agrimap/>

Element 2 - Environmental fate and transport: VTEC organisms survive in the environment for weeks and months unless specific treatment is used – such as effective chlorination of drinking water. The organisms can be transported in the animal faeces through the environment by the animal or through farming practices such as slurry spreading and contamination of machinery, footwear etc. Further transport of the contamination can occur if the material enters waterways, unprotected wells, etc. Abandoned boreholes can be a route of contamination for groundwater, as can poorly installed boreholes which allow superficial contamination around the wellhead to enter the groundwater. The recently published *EPA Drinking Water Advice Note no 14: Borehole Construction and Wellhead Protection*⁸ addresses the issues of the structure of wells, and identifies these risks. This document notes that the emphasis up until now has been to obtain a quantity of water, rather than focusing on the importance of abstracting uncontaminated water (quality). As the Environmental Analysis Report notes, groundwater vulnerability affects the risk of contamination of groundwater. It mentions assessment but doesn't comment on the fact that much of Ireland has high groundwater vulnerability and so groundwater protection depends very much on control efforts to prevent contamination, rather than being able to rely on natural filtration. A superficial analysis by county, using the GSI Groundwater online mapping facility, of groundwater vulnerability indicates that in numerous counties, such as Carlow, Kilkenny, Laois, Galway, Mayo and Kerry, areas of high groundwater vulnerability appear to be dominant. No information is provided in the Environmental Analysis Report as to the extent and quality of groundwater protection across Ireland.

Experiences from investigation of VTEC outbreaks indicate that in at least some areas of Ireland, there is limited or no evidence of implementation of legislation to protect groundwater. For example, in one outbreak on a large regulated private supply, there was a comprehensive audit as part of the investigation. Findings included that there was no establishment of source protection zones, no enforcement of GAP regulations and no written advice to adjacent owners regarding setback distances. In addition, there was no evidence of: safe decommissioning of abandoned boreholes; security around borehole or treatment area; insulation of water treatment area; best practice in relation to wellhead construction; information about the water supply infrastructure – such as borehole logs; turbidity monitoring; appropriate chlorine residual monitoring or risk assessment as to required frequency of monitoring of water quality. There appears to be limited supervision of smaller private water schemes and a lack of effective information to private supplies that are exempt from regulation. The HSE has tried to redress the latter by the development of a leaflet advising on the risk of illness from well water⁹.

Heavy rainfall increases the risk of intermittent contamination of water supplies⁶. For example, the high level of VTEC in the Midlands in 2012 was associated with heavy rainfall:

- During the summer of 2012, an “open season” for slurry spreading, it was the wettest Summer for 60 years in some stations in the Midlands, according to Met Eireann
- The summer peak of heavy rainfall in the Midlands in 2012 can be seen in Figure 2.
- The peak of non-person-to-person-spread VTEC cases (turquoise colour) occurred after the rainfall peak (see Figure 3)

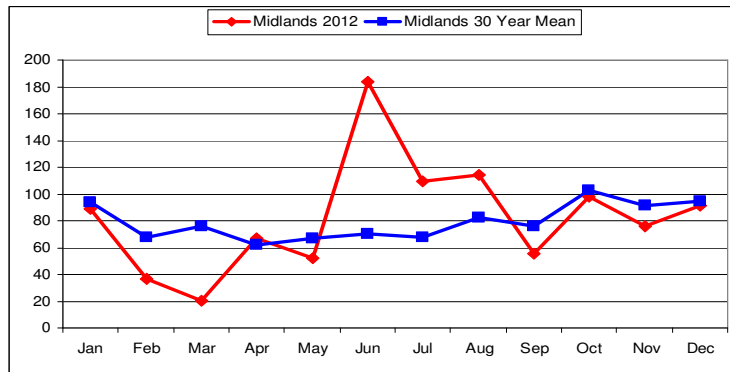
⁸EPA DRINKING WATER ADVICE NOTE. Advice Note No. 14: Borehole Construction and Wellhead Protection. Available at:

http://www.epa.ie/pubs/advice/drinkingwater/EPA_DrinkingWater_AdviceNoteNo14b_web.pdf

⁹HSE. Risk of Illness from Well Water. Available at:

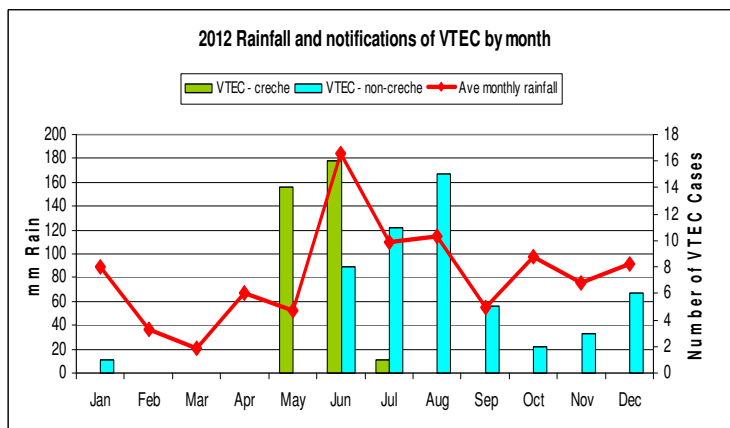
http://www.lenus.ie/hse/bitstream/10147/294332/2/A4_Precautions%20and%20advice%20for%20reducing%20risk%20of%20illness%20from%20well%20water.pdf

Figure 2. Summer peak rainfall in the Midlands 2012.



Source: www.met.ie - Rainfall stations- Mount Dillon, Mullingar, Gurteen and Carlow.

Figure 3. Monthly VTEC cases Midlands plotted against rainfall Midlands in 2012. Green cases= person to person spread in large two-creche outbreak, blue cases= all other VTEC cases



Recommendation 2: We understand that farmers are expected to “farm by calendar”. We recommend that farming practice should consider public health risk rather than calendar. Development of guidance including suitable risk assessment may be needed.

Element 3 - Exposure point or area: Exposure points include: untreated drinking water; inadequately treated drinking water (where the level of contamination overwhelms the treatment system); bathing or other recreational waterways, contaminated food and contaminated hands. The Environmental Analysis Report notes (p. 104) that about 13% of supplies are private (0.7% small private supplies and 12.3% private wells) and that “the majority of private wells do not undergo any treatment prior to use” (p. 112). However the report doesn’t identify that there is very wide variation in use of private supplies in Ireland and that the risk from untreated wells is not uniform across the country. CSO Census 2011 data relating to type of supply by county indicates that only 0.32% Dublin households report using “other private sources” (the category that covers all private supplies except private group water schemes) while >25% of Kilkenny and Wexford householders report using “other private sources”. As would be expected, the untreated privately operated wells are more common in rural areas, where the risk of contamination from agricultural sources is higher, so the risk tends to concentrate in rural areas. Additionally, anecdotal accounts indicate an increasing numbers of facilities used by the public (schools, crèches, hotels etc) which use privately sourced water, perhaps in an effort to avoid water rates.

The Environmental Analysis Report states that “as a minimum, all drinking water supplies should be disinfected to ensure the safety of the final water for drinking” (p. 105). However, the Environmental Analysis Report doesn’t explore the feasibility of this happening. It is not clear

whether disinfection sufficient to “ensure the safety of the final water for drinking” in the context of Ireland’s risks is achievable, in the context of:

- widespread use of supplies exempt from regulation
- limited awareness of VTEC by many stakeholders
- variable and unpredictable rainfall patterns – which may overwhelm disinfection systems
- limited source protection etc
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Recommendation 3: In order to achieve effective disinfection of all drinking water supplies, significant investment in infrastructure, training and monitoring is required.

Recommendation 4: Effective awareness-raising of all water quality issues is required for those whose responsibility it is to provide potable water.

Element 4- Exposure route: Exposure occurs through ingestion of contaminated material such as drinking water, recreational water, food or from contaminated hands. It is important to note that VTEC has an exceptionally low infectious dose - doses as low as 1-10 VTEC organisms can cause serious infection in humans so very slight contamination can cause severe health problems. Low doses of cryptosporidium can also cause infection. Examples of outbreaks associated with drinking water include:

- Various cryptosporidium outbreaks in towns / cities in Ireland such as: Mullingar, 2002¹⁰, Mullingar 2004¹¹, Galway 2007¹² and several in County Roscommon in 2013.
- In several of the VTEC outbreaks in the Midlands in 2012, the same subtype of VTEC was found in the water as was found in the cases, providing strong epidemiological evidence that the well was the source of human infection.

Element 5- Potentially exposed populations: Everybody is potentially at risk of serious illness with VTEC and *Cryptosporidium parvum*. While VTEC usually affects the young and the old more than other age-groups, in 2011 there was a massive VTEC outbreak in Germany which was also notable for affecting healthy adults. Immunity to VTEC isn’t fully understood, for example it is not fully understood if infection with one subtype can protect against infection with another. Anecdotally, public health doctors often find that in households with contaminated wells, the householders may not report illness, but visitors get sick so there is probably some level of immunity from ongoing exposure to contaminated water. Vulnerable groups for cryptosporidiosis include people whose immune systems are not working properly (immuno-compromised) and this particular group may not be able to clear the parasite from their gastro-intestinal tract and so are at greater risk of dying from the disease.

Summary of exposure pathway approach to risk assessment

Using an exposure pathway exploration approach shows how reservoirs of serious zoonotic diseases such as VTEC and *C. parvum* from agricultural sources can impact on human health. In addition, there is an unequal risk across the country. While it does summarise the current status of surface waters and groundwaters in Ireland, the Environmental Analysis Report focuses on national and regional data – which may obscure the considerable variation in risk across the country. Some populations live in urban areas provided with appropriately monitored and treated public drinking water supplies, whereas in other parts of the country, populations live in areas where most households have untreated private supplies. This latter group are also more likely to be in rural agricultural regions where the VTEC burden is higher in the environment. In addition,

¹⁰ Cryptosporidiosis outbreak linked to public water supply. Eurosurveillance May 2002 Available at: <http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=2089>

¹¹ Cryptosporidium Outbreak in a Continuously Tested Public Water Supply. Epi-Insight, October 2004. Available at: <https://www.hpsc.ie/hpsc/EPI-Insight/Volume52004/File,906,en.pdf>

¹² Epidemiology of Cryptosporidiosis in Ireland, 2007. Available at: <http://www.hpsc.ie/hpsc/A-Z/Gastroenteric/Cryptosporidiosis/Publications/EpidemiologyofCryptosporidiosisinIrelandAnnualReports/File,3475,en.pdf>

high groundwater vulnerability is very common in Irish landscapes, and this increases the risk of groundwater contamination.

Recommendation 5: Environmental analysis of areas likely to be most severely affected should be considered, so that appropriate measures can be taken to mitigate the risk.

Recommendation 6: Reducing the prevalence of VTEC in ruminants should be considered as a VTEC control measure¹³, taking into consideration international research¹⁴.

Comments on Section 5 – Soils

The human health effects of soil contamination relate mainly to its effects on water quality and our concerns are outlined in the water quality section.

Landslides and floods are of concern to the health sector because of the potentially significant risk to health and safety and we welcome the report's identification of the need to consider and address the potential impact of climate change on this human health risk.

Comments on Section 6 – Air Quality

Ireland is vulnerable to breaching air quality emissions ceilings in relation to ammonia and nitric oxide and the requirement to continue research towards reducing emissions is supported by this group.

Comments on Section 8 - Climatic factors including impacts on greenhouse gas emission levels

The effect of climate change on the environment in Ireland, and therefore human health in Ireland is challenging to predict. But even minor changes in climate may have very serious public health impact in Ireland and elsewhere. For example, in the comments on water quality, we made reference to the risk to water quality, and therefore waterborne infectious diseases, from unusually heavy rainfall.

Ireland is vulnerable to breaching EU 2020 greenhouse gas emission targets, therefore effective mitigation efforts should be employed to ensure this does not happen. Obviously climate change is a global phenomenon. While Ireland's impact on climate change is limited by the size of the country and the sum of its economic activity, all contributions are important and Ireland might strive to lead by example in emission reduction. This would enhance Ireland's green reputation.

Comments on Section 9 – Interrelationships between environmental aspects

Consideration could be given here to the dependence of humans on clean air, water and soil, and the vulnerability of humans to potential effects of climate change.

Comments on Section 10 – Sectoral Scenario and Analysis

As the public health impact of Food Harvest 2020 has not been addressed directly in this Environmental Analysis Report, it is not possible to comment on this section, except to say that analysis should be carried out taking public health risks into account.

Comments on Section 11 – Mitigation and Monitoring

Mitigation and monitoring are essential elements of protecting the health of the population and environment. However, as public health risks have not been addressed directly in this Environmental Analysis Report, the appropriate mitigation measures to protect health cannot be

¹³ Organic Livestock Research Group, VEERU, University of Reading. Available at: <http://www.veeru.reading.ac.uk/comp2/Cattleweb/disease/ecoli/ecoli1.htm>

¹⁴ Bioniche E. coli O157 Vaccine to be Used in an On-Farm Intervention Study in Sweden. Available at: <http://www.prnewswire.com/news-releases/bioniche-e-coli-o157-vaccine-to-be-used-in-an-on-farm-intervention-study-in-sweden-203667281.html>

accurately identified. It should be noted that environmental monitoring programmes may not be sensitive enough to protect human health. Highly pathogenic organisms, such as VTEC and Cryptosporidium, have very low infectious doses and risk may not be identified by minimum frequency or non-risk-based drinking water quality monitoring. The potential Food Harvest 2020 monitoring indicators in relation to water quality – pp255-256 - appear to be very general measures and are not indicators of the risk to public health.

Recommendation 7: We recommend that the integrated and iterative monitoring programme for key indicators (as outlined in Section 12) should be informed by public health risk and should be sensitive enough to identify risk to the health of the public.

Comments on Section 12- Findings and Recommendations

While the Environmental Analysis Report appeared to be comprehensive in other areas, the gap in relation to consideration of public health risks needs to be addressed, particularly in relation to water. Contamination of water by pathogenic organisms was not identified as a pressure so the risk analysis is not complete. The report's conclusions appear to be based on the assumption that legislation is implemented with full compliance. This assumption needs to be tested i.e. consideration of the feasibility of implementation of control measures, for example, cost to local authorities. This is especially important as the Environmental Analysis Report found that strict adherence to existing legislation and codes of good farm practice is necessary to result in slight negative impact on water quality.

We support the recommendation to promote improved environmental outcomes through strict adherence and enforcement of existing legislative and best practices codes.

Recommendation 8: Assessment of current adherence to existing legislation and codes of good farm practice is required. This baseline information is needed to assess how much improvement is feasible. The local authorities are the statutory authority for implementation of the relevant legislation. Their input would be needed to assess this.

Recommendation 9: Assessment of current adherence to best practice and legislation in relation to treatment and monitoring of drinking water is also required.

The report's finding that mitigation measures are necessary to manage air quality and climate change requirements are supported.

Recommendation 10: The planning process and grant approval should routinely require inclusion of such mitigation measures.

The lack of input by public health or animal health expertise, to scope and screen the Environmental Analysis Report for Food Harvest 2020, is noted.

Recommendation 11: That Public Health and Animal Health input and expertise should be incorporated in all aspects of Food Harvest 2020.

We welcome the report's recommendations with regard to investment in education, training and knowledge transfer.

Recommendation 12: In addition to disinfection, as per Recommendation 2, topics related to public health risk, especially infectious diseases risk, should be incorporated into the knowledge base and up-skilling of all appropriate personnel in the agricultural sector

An integrated and iterative monitoring programme for key indicators impacting water quality is welcomed, but please note our recommendation in relation to this (Recommendation 7).

Drinking water guidance from the EPA sets out the minimum frequency of sampling for check and audit monitoring¹⁵. The minimum frequency is based on volume of drinking water distributed in a supply zone. However, the guidance document notes that increased frequency of monitoring may be required in certain circumstances, such as perceived risk to the supply. The EPA STRIVE Report no 89 identifies breakthrough contamination events after heavy rainfall which may overwhelm treatment systems (if there is treatment) and states “*Microbiological sampling of groundwater sources should be based on a structured plan that includes sampling after periods of heavy rainfall. This is particularly true for those groundwater supplies that are categorised as severely vulnerable to contamination. Systems for treatment of water from identified vulnerable supplies should be designed, assessed and operated so as to ensure that they have the capacity to cope effectively with transient surges in microbial contamination*”. Considering there is widespread high-groundwater –vulnerability, many supplies are at risk. However, there is limited evidence that monitoring frequency is based on a risk assessment. Experiences from investigating outbreaks indicate that systems may not be designed, assessed and operated to cope with spikes of contamination. Considering the low infectious dose of VTEC, any failure of treatment may be sufficient to cause serious infection.

Recommendation 13: Assessment of implementation with regard to effective monitoring of drinking water quality (effective for protecting the public) is required

Good Agricultural Practice legislation appears to aim to protect human health from contaminated water in that it describes set back distances to protect drinking water sources. However, it doesn't mention the main human health risks, namely zoonotic infectious diseases, such as VTEC, that can be transmitted through drinking water.

The Teagasc *Explanatory Handbook for Good Agricultural Practice Regulations*¹⁶ does not mention human health effects of contaminated water, and while it mentions water quality, it doesn't explain what this is. There is a large emphasis on Nitrates control, but doesn't explain why. It is not clear if the purpose is to protect the environment or to protect human health, or to protect both. Pollution of waters with nitrates can damage the ecology of the waterways through eutrophication, so reducing nitrates is important for the health of the environment. In addition, high levels of nitrates can have deleterious effects on human health so control is important from a human health point of view also. However, there are many more cases of human illness annually associated with microbiological hazards such as VTEC and *C. parvum* rather than from chemical hazards from organic waste such as Nitrates. If the legislation is trying to protect human health it may need to be more explicit about what protecting human health involves.

Recommendation 14: Clarity is needed as to whether Good Agricultural Practice legislation aims to protect human health.

Recommendation 15: If GAP legislation aims to protect human health, risks to public health need to be taken into account in its implementation. The health sector and the agricultural sector need to communicate on an on-going basis about the current human health risks that may be associated with agriculture so that information is accurate and timely towards mutual efforts to protect health.

¹⁵ EPA. Handbook for implementation for Water Services Authorities for private water supplies. Section 3. Available at: <http://www.epa.ie/pubs/advice/drinkingwater/privatewatersupplieshandbook/Section%203.pdf>

¹⁶ Teagasc Explanatory Handbook for Good Agricultural Practice Regulations. Available at: <http://www.agriculture.gov.ie/media/migration/ruralenvironment/environment/nitrates/NitratesExplanatoryHandbook030713.pdf>