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**THE DEVELOPMENT OF A KNOWLEDGE MODEL FOR HOME OWNERS TO  
BETTER UNDERSTAND AND MANAGE THEIR ON-SITE WASTEWATER  
TREATMENT SYSTEMS.**

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Submitted in Partial Fulfilment of the Requirements of the Degree of Doctor  
of Philosophy, 2015

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## **DEDICATION**

This Thesis is dedicated to my family for their everlasting patience and support and especially to Rosie who sadly didn't get to see the conclusion.

**ABBREVIATIONS**

|        |   |
|--------|---|
| BOD    | Biological Oxygen Demand                                      |
| CIB    | Citizens Information Board                                    |
| COD    | Carbon Dioxide Demand   |
| CoP    | Code of Practice  |
| CSO    | Central Stastics Office                                       |
| DoEHLG | Department of the Environment, Heitage and Local Government   |
| EC     | European Commission   |
| EEC    | European Economic Community                                   |
| ECJ    | European Court of Justice                                     |
| EDSS   | Environmental Decision Support Systems                        |
| EPA    | Environmental Protection Agency                               |
| ERTDI  | Envoronmental Research Technological Development & Innovation |
| EU     | European Union  |
| GSI    | Geological Survey of Ireland                                  |
| IAB    | Irish Agreement Board   |
| IFA    | Irish Farmers Association                                     |
| IPA    | Institute of Public Administration                            |
| IOWA   | Irish On-site Wastewater Association                          |
| NDP    | National Development Plan                                     |
| NPWS   | National Parks & Wildlife Service                             |
| NSPPP  | National Source Protection Pilot Project                      |
| NSAI   | National Standards Authority of Ireland                       |
| OSWTS  | On-site Wastewater Treatment System                           |
| PBE    | Practice Based Experience                                     |
| PWS    | Public Water Supplies   |
| RBD    | River Basin District  |
| SADT   | Structured Analysis & Design Technique                        |
| SERBD  | South East River Basin District                               |
| SI     | Statutory Instrument  |

|      |                                      |
|------|--------------------------------------|
| SS   | Suspended Solids                     |
| SWAN | Sustainable Water Network of Ireland |
| UN   | United Nations                       |
| WFD  | Water Framework Directive            |

## ABSTRACT

In Ireland many people live in homes that are rurally located and not connected to public wastewater treatment systems. Where this is the case, the treatment of the wastewater produced must be undertaken by a private on-site wastewater treatment system (OSWTS). Properly built and maintained private on-site wastewater treatment systems can treat effluent in an ecologically sound manner and return the water to the environment. Nevertheless, inappropriately designed, installed and maintained systems can lead to the contamination of ground and surface water resources (Gray 1994; Daly, 2001; Flynn & Kroger, 2003; Gray, 2004; Gill *et al*, 2005; EPA, 2008; Daly & Craig, 2009 & Gormley, 2009). Such contamination can lead to significant threats to human health as well environmental degradation.

The very high dependence by Ireland on these OSWTS's for domestic wastewater treatment means that it is imperative that the performance and management of the systems is effective and robust. Unfortunately however there is evidence that a huge proportion of OSWTS's are poorly managed, maintained and operated (EU, 2008; IOWA 2012 & GSI, 2013). This poor performance and management of OSWTS's has resulted in significant prosecutions and fines for Ireland by the EU with clear and unambiguous conditions set down for what Ireland needs to do to avoid further sanctions.

The existing legislation in Ireland for OSWTS's and some recent amendments as a consequence of the prosecutions by the EU have made it very clear that the ultimate responsibility lies with the homeowner for their wastewater treatment system. Provision is made in the legislation for a new inspection regime that will seek to identify pollution from OSWTS's and attempt to mitigate the contamination of ground and surface waters in accordance with the requirements of the Water Framework Directive (WFD). This new inspection regime and the revisions to the legislation are required for Ireland to comply with the directions of the ECJ ruling (C188-08) in relation to OSWTS's and so that the daily fines being imposed against Ireland are suspended.

There has been little time available on foot of the ECJ (2008) ruling to educate homeowners on how they should be properly managing and maintaining their OSWTS's to ensure that they operating effectively and efficiently. Existing research has identified that even where homeowners are aware of their responsibilities towards their OSWTS that they tend not to care with an 'out of sight out of mind attitude (Gray, 2004). Clearly therefore the issue facing Ireland is not just a knowledge deficiency towards OSWTS's but also a behavioural change issue where people tend not to care about how their OSWTS performs.

This thesis will examine the evolution of legislation in Ireland relating to OSWTS's and how circumstances have led to the prosecution of Ireland (ECJ, 2009) for non compliance with the relevant EU Directives. Comprehensive literature reviews will outline existing research undertaken on the contamination of water resources by OSWTS in Ireland and also on techniques that could be utilised to educate homeowners on what they need to do to ensure that their individual wastewater treatment system is compliant with the relevant legislation. The research will adopt a number of research methods such as questionnaires and interviews to collect the data that is required to determine the knowledge that homeowners require about their OSWTS and this will shape the homeowner knowledge model that is to be developed.

The publication of the research findings will inform the wastewater industry and the legislature of the key areas where homeowners are deficient in knowledge and understanding towards their OSWTS. These findings will also shape the knowledge model that will seek to address the knowledge and behavioural deficiencies that have led to Ireland being in the precarious position that it now finds itself in from the pollution, contamination and health threats associated with poorly performing and managed OSWTS's. The implication of having relevant information and a clear understanding of where Ireland currently stands in relation the homeowners and their interaction with their OSWTS's will be of benefit to a whole range of sectors such as academia, industry, local authorities and the EPA. An accurate diagnosis of the problems relating to homeowner knowledge and behaviour towards OSWTS's will provide a framework to develop a lasting

solution that will help in addressing pollution, groundwater contamination and the associated health risks from poorly constructed, managed and functioning OSWTS's.



## **CHAPTER 1: INTRODUCTION**

### **1.0 Context and rationale**

The purpose of this first chapter is to provide an introduction to the study; the need, aim and objectives, and to outline how this thesis is to be designed and structured. It begins by presenting a background to the research and illustrating the very precarious position that Ireland finds itself in presently in the area of domestic wastewater disposal where there is no municipal wastewater facility available (Gray 1994; Daly, 2001; Flynn & Kroger, 2003; Gray, 2004; Gill *et al*, 2005; EPA, 2008; Daly & Craig, 2009 & Gormley, 2009). Appropriately built and maintained private on-site wastewater treatment systems can treat effluent in an ecologically sound manner and return the water to the environment (Hill, 2004). However, inappropriately designed, installed and maintained systems can lead to the contamination of ground water resources as is the case in Ireland (EPA, 2012). The Irish domestic on-site wastewater treatment process will be examined to identify the shortcomings which have led to this widespread contamination of groundwater resources and the consequences that will prevail for the homeowners who are responsible for these inappropriately designed, installed and maintained systems. The existence of shortcomings in the process forms the motivation for this research study and from this the aim and objectives of the study are formulated and presented. Finally a brief description of the following Chapters is outlined.

### **1.1 Research Background & Context**

Groundwater is a valuable natural resource which provides a significant portion of the drinking water supply in Ireland (EPA, 2008). In many rural areas domestic houses source their drinking water supply from the same groundwater resource that they discharge their wastewater to. Clearly therefore the health of both human beings and the environment is critically dependent upon efficient and effective OSWTS's which ensure wastewater is adequately treated before it reaches

groundwater. Unfortunately this appears not to be case and drinking water is often contaminated by inadequate wastewater treatment systems (Daly, 2003; Gill et al, 2005; EPA, 2009). The most significant contaminants of drinking water are faecal bacteria, viruses and other microbiological contaminants (EPA, 2006). The health implications for those who derive their drinking water from such contaminated sources are stark and clearly in a developed country such as Ireland this is unacceptable. The contamination of groundwater from OSWTS's is not a recent phenomenon in Ireland and the failure of Ireland's government to address the problem has led to the intervention of the EU and specifically the prosecution of Ireland by the ECJ (C188-08) in 2009. This prosecution centred on Ireland's failure to adhere to a number of Directives and most notably Directive 75/442/EEC on waste and the Water Framework Directive 2000/60/EC. Under these Directives there are strict obligations on member states to ensure that water bodies such as groundwater see an improvement in quality and this improvement must be monitored. Furthermore it is prohibited under the Directive for contamination from sources such as OSWTS's to occur and member states are required to undertake inspections on OSWTS's to monitor performance and compliance with the relevant regulations (EPA, 2008). The ECJ (2009) in making its judgement reviewed the various powers of local authorities under Irish law to regulate, inspect and enforce environmental standards on septic tanks, including the Public Health (Ireland) Act 1878, the Local Government (Water Pollution Acts, 1977 and 1990, the Building Control Acts 1990-2007 and Building Regulations and Technical Guidance, and the Planning and Development Acts 2000-2006 and found that Ireland had completely failed in its responsibilities (IPA, 2009). The ECJ adjudicated that Ireland was guilty of failures to that date in relation to OSWTS's and that immediate action was required.

In December 2012 the European Commission referred the case back to the ECJ (C374-11) due to Ireland's inaction and the ECJ found on this occasion that Ireland was still not complying with EU law, notably where disposal of domestic wastewater in the countryside through numerous septic tanks and other individual waste water treatment systems are concerned. It also found that not all required laws and regulations were in place and that an inspection plan for OSWTS's was

still lacking (IPA, 2012). According to the ECJ (2012) in its ruling stated that Ireland was already nineteen years late in complying with the WFD and because this was an issue of the protection of human health and the environment that the infringement is a matter of “undisputable gravity”. A lump sum fine of €2.7 million was imposed on Ireland and a daily penalty of €26,173.00 for each day of delay in adopting the measures necessary to ensure full compliance with ECJ judgement (C188-08). This led to the enactment of the Water Services (Amendment) Act 2012 by the Irish government and under this act provision was made for a ‘National Inspection Plan’ for OSWTS’s. The act also made provision of fines, penalties and imprisonment of homeowners who were found to have poorly performing or installed systems and did not address the associated pollution from the systems. The imposition of the fines by the ECJ (2012) led to the hurried commencement of the National Inspection Plan in 2013 and homeowners are required to register their OSWTS with their local authority so that a national register of OSWTS’s can be formed. There are other legal requirements now placed on homeowners in relation to their OSWTS and these include ensuring that it is operating and being maintained properly, having it de-sludged when necessary from registered contractors, maintaining a record of remedial works and ensuring that OSWTS is fit for purpose (CIB, 2014). The EPA (2013) have outlined that owners of OSWTS’s are required to operate and maintain their systems so that they do not pose a risk to human health or the environment on foot the new legislation which was introduced in 2012 outlining the responsibilities of system owners. The EPA (2014) have confirmed that just 47% of OSWTS’s inspected so far under the National Inspection Plan have passed and that the remainder or 53% are not properly constructed, installed, maintained or operating properly. If this rate is applied to the 500,000 OSWTS’s in Ireland (CSO, 2012) then there are approximately 265,000 that have or will fail. The legal responsibility for any pollution caused from these failed OSWTS’s will be the homeowner and this may be something that they are not even aware is happening. Nevertheless if certain simple steps were taken by homeowners then many of the systems would not have failed (EPA, 2014). The hurried implementation of the Water Services (Amendment) Act 2012 and the National Inspection Plan (2013) for OSWTS’s has given little opportunity for homeowners to be guided or

educated on these steps that could be taken to ensure that their systems are working properly.

Some guidance for homeowners is provided on the EPA web-site but this assumes that the homeowner will research the guidance themselves. In other words if the homeowner doesn't take the conscious decision to undertake the research and their system is causing pollution or nuisance then they may be liable to prosecution. Furthermore until all of the OSWTS's in Ireland are inspected there still continues to be the problem of groundwater contamination. It is this gap that exists between the legislation and everyday life of homeowners that this research intends to address so that homeowners are aware of their legal responsibilities and how to properly manage, maintain and operate their OSWTS.

## **1.2 The Research Need**

The issues identified in section 1.1 clearly illustrate that Ireland has serious problems with the management, maintenance and performance of OSWTS's (ECJ, 2009; ECJ 2012; EPA; 2012 & IPA, 2012). These problems have not manifested themselves overnight and the reference by the ECJ (2009) to Ireland being nineteen years late in complying with the WFD illustrates that a country lovingly referred to as the 'Green Isle' has much to learn when it comes to environmental management. Moreover, it is not just the environment that is suffering from OSWTS's however and the ambient threats to public health from poorly performing and poorly maintained systems cannot be underestimated. Poorly performing OSWTS's have been linked to groundwater contamination outbreaks (EPA, 2015) which cause risks to drinking waters and have enormous negative health impacts particularly by contamination from E.coli and cryptosporidium. These risks have seen some very hurried legislation implemented in response to the significant fines and penalties imposed on Ireland by the ECJ (2009) and this has led to knee jerk reactions from stakeholders and accusations that this new legislation is a threat to rural society and rural life (IFA, 2013).

From a homeowner's perspective there is evidence that there is a lack of knowledge and understanding of OSWTS's and it would seem that in many cases there is no intention by the homeowner of maintenance on their OSWTS or realisation that any attention was necessary (Gray, 2004). Gray (2004) goes on to identify that where homeowners are aware of their responsibility to maintain their OSWTS that unfortunately this responsibility is not always taken seriously, with the attitude 'out of sight out of mind'. This research investigation seeks to understand the nature of the problem amongst homeowners on why their OSWTS's are not properly managed and maintained and ultimately causing contamination of groundwater. This understanding will help to identify the 'gap' that exists in the literature and Chapters Two and Four will expose this gap in more explicit details. In addressing the gap in the literature this thesis will make a novel contribution to knowledge.

### **1.3 Research Aim & Objectives**

The aim of this research is to develop a knowledge model for homeowners to better manage and maintain their on-site wastewater treatment systems.

The objectives of this research are as follows;

- To examine existing legislation and governance for on-site wastewater treatment systems in Ireland.
- To review and evaluate wastewater management from OSWTS's to understand where problems exist in their management and maintenance.
- To evaluate the use of modelling for its applicability in an OSWTS context
- To develop a knowledge model to improve homeowner understanding of their on-site wastewater treatment systems and their legal responsibilities.

- To validate the knowledge model that has been developed

## **1.4 Outline Research Design & Structure**

The completed thesis will have eight chapters in addition to a comprehensive bibliography and relevant appendices incorporated. The following is a brief summary of the structure and chapters contained in the thesis and Figure 1.1 provides a graphical representation of the design;

### **Chapter One:-**

This chapter introduces the research problem and the aim and objectives of the research. It also illustrates the justification for the research and provides a concise statement of some key relevant issues. The structure of the thesis is also set out and outlines what will follow in the coming chapters.

### **Chapter Two:-**

This chapter provides a comprehensive analysis of published definitions on the key concepts relevant to the research. Sustainable development, wastewater, on-site systems and groundwater will be defined. Relevant EU and Irish policies such as the WFD and Water Services Act, 2007 will be examined in detail. There will also be a detailed overview of relevant codes of practice such as those provided by the EPA in the context of this research topic. Chapter Two also examines historical and up to date research for OSWTS's and also for their impacts on groundwater resources. This examination encompasses an analysis of current pollution levels from existing knowledge. The existing knowledge on homeowner behaviour and attitudes towards OSWTS has been assessed from research already undertaken in this area. There is also an examination of the health implications for groundwater contamination from OSWTS and the illnesses that can affect people who consume this contaminated water source. This chapter then examines the

drivers and barriers that exist in the operation of a sustainable on-site wastewater treatment process for domestic homes.

#### Chapter Three:-

Chapter Three will critically review different modelling techniques and provide definitions for the concept. Existing models will be examined and examples of their application will be analysed. The critical review will look at the strengths and weaknesses of these models from the examples and published research. The findings of this literature search can be brought forward into the exploratory stage in Chapter Five where the model for homeowners and their OSWTS will be developed.

#### Chapter Four:-

This chapter will examine the researcher's philosophical standpoint and view of the world. From this overarching philosophical viewpoint the research methodology adopted for this research will be defined. This methodology will recognise the paradigmatic assumptions of the researcher and set out the methods to be used to gather the data required to produce valid and reliable new knowledge in the form of the knowledge model for homeowners regarding their OSWTS.

#### Chapter Five:-

This chapter illustrates the findings of the practice based experience (PBE) from the workshops undertaken in the exploratory stage of the research. These workshops have been undertaken with experts in the area of on-site wastewater treatment and those who have a comprehensive knowledge and understanding of the legal responsibilities of homeowners in relation to OSWTS's. These experts have provided insights into the barriers and drivers for sustainable wastewater treatment from domestic houses and these can complement those set out in Chapter Three. The knowledge model developed for homeowners has been

shaped from the findings of the workshops in conjunction with the comprehensive literature reviews.

#### Chapter Six:-

In this chapter the knowledge model will be developed from the findings of the literature review and workshops undertaken to determine the PBE in the subject area. The development of the knowledge model will reflect the requirements of the Water Services (Amendment) Act 2012 and the obligations on homeowners in the on-site wastewater treatment process.

#### Chapter Seven:-

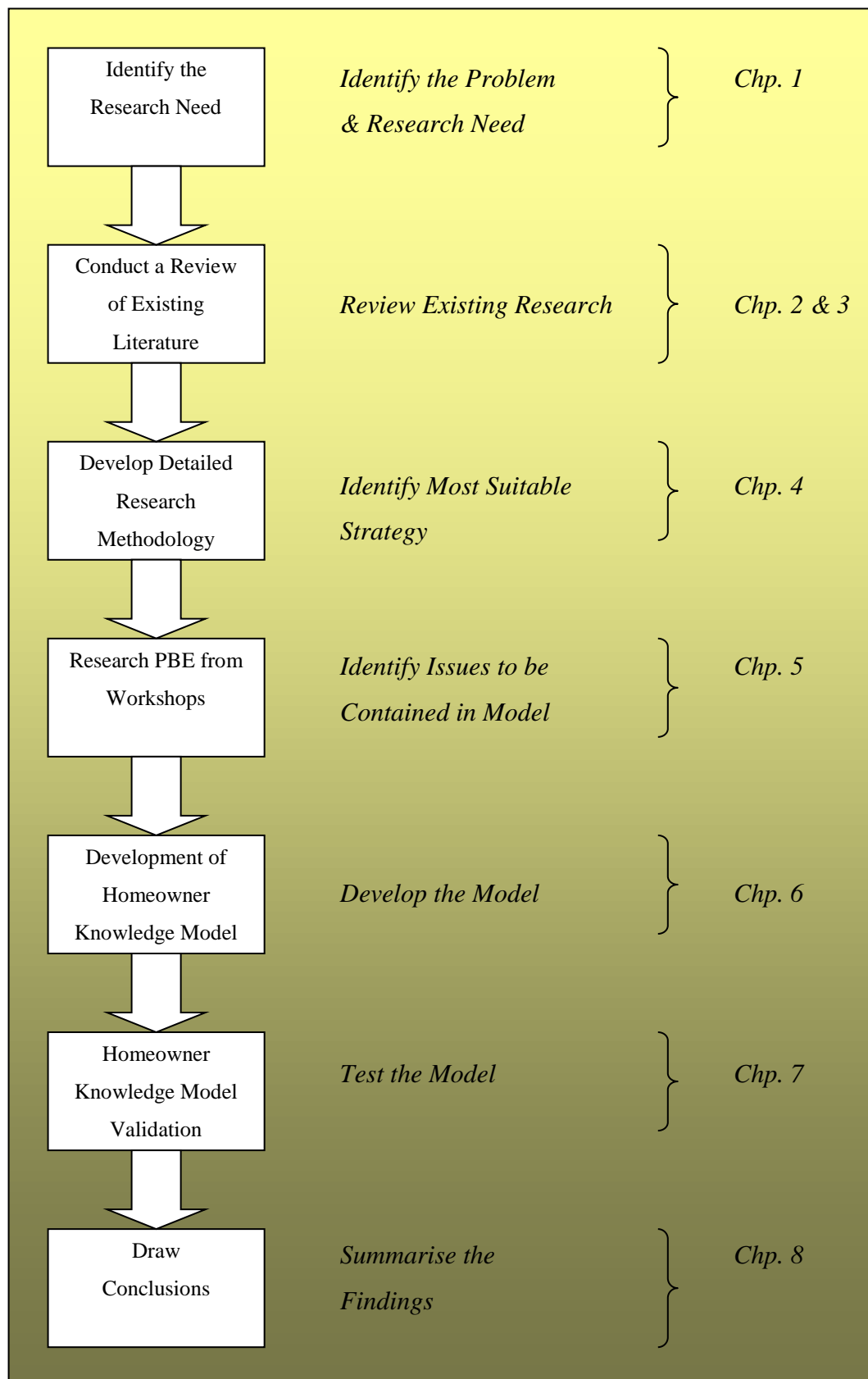
This chapter will validate the knowledge model that has been developed in the exploratory stage from the key findings of the literature review and workshop. It will be presented to stakeholders involved in the OSWTS industry through questionnaires and structured interviews. Homeowners will also be interviewed as part of the validation process and the structured nature of the interviews will determine opinion on the model's suitability and relevance. This will provide the validation phase of the research.

#### Chapter Eight:-

Chapter Eight will summarise the key research conclusions and reflect upon the research process. There will be a discussion surrounding the research limitations and recommendations for future research from the conclusions reached. Figure 1.1 now provides a graphical representation through the research through to completion.



Figure 1.1: Graphical Presentation of Research Structure &amp; Design



## **1.5 Research Significance & Contribution**

This study has been conducted in parallel with Ireland's development of a comprehensive registration and monitoring regime for OSWTS's and also a comprehensive framework for the prosecution of homeowners who own and operate systems which cause pollution and nuisance. The frustration of the EU with Ireland's slow pace of responding to ECJ Ruling C188-08 has resulted in substantial fines being requested for Ireland (IOWA, 2011). This has resulted in the rapid preparation of the Water Serviced Amendment Act 2012 which has left little time or opportunity to educate or inform homeowners in the subject area.

This research aims to complement the implementation of the Waster Services (Amendment) Act 2012 by identifying and addressing the deficiencies in homeowner knowledge and understanding in relation to OSWTS's. This will encompass the research of professionals who are familiar with such systems and the owners and operators of same such as Planners, Architects, Engineers, On-site Assessors, System Manufacturers, Builders, Geologists, Academics and other relevant professional groups. By developing a knowledge model shaped on the deficiencies outlined above it can be targeted at homeowners to assist in achieving compliance with the Water Services Amendment Act, 2012.

## **CHAPTER 2: LITERATURE REVIEW**

### **2.0 Introduction**

The unspoiled nature of the Irish environment is a source of pride to those who live here and a powerful image in the hands of those who sell Ireland and its products and services abroad. It was only relatively recently however that the realisation had dawned that this fortunate position was not only being threatened, but that urgent action would have to be taken if it was to be preserved and in some cases the deterioration reversed (Wilson, 1998). The Census of Population outlines that 39% of the Irish population live in homes that are rurally located, predominantly not connected to public wastewater treatment systems (CSO, 2006). This equates to approximately 1,665,535 people from the total population of Ireland of 4,239,848. According to Meredith (2006), Ireland has experienced a period of rapid population growth resulting in significant increases in rural population. Where this is the case, the treatment of the domestic wastewater produced must be undertaken by a private on-site wastewater treatment system (OSWTS). According to Daly (2003) “almost 36% of new houses in recent years are ‘one off’ using on-site wastewater treatment systems such as septic tanks, mechanical aeration systems, percolation areas and filter systems”.

On-site wastewater systems consist of an underground tank and a leach or drain field that work to cleanse and purify household wastewater. Appropriately built and maintained private on-site wastewater treatment systems can treat effluent in an ecologically sound manner and return the water to the environment (Hill, 2004). Nevertheless, inappropriately designed, installed and maintained systems can lead to the contamination of ground water resources. The contamination of these groundwater resources is in contravention of the EU Wastewater Directive and one which will have serious economic and social costs in the future. Groundwater is an important water resource in Ireland and accounts for up to 15% of total water supplied by local authorities and about 25% of all water supplies (Daly, 1993). The EPA (2006) has identified that the most significant

groundwater contaminants and/or contaminant indicators in Ireland are faecal bacteria, viruses and other microbiological contaminants. On-site wastewater treatment systems contribute to these contaminants as identified by Daly (2003), Gill et al (2005) & EPA (2009). Recent UN figures suggest that by 2025 two-thirds of the world's population will experience water shortages, with severe lack of water blighting the lives and livelihoods of 1.8 billion people worldwide. It is critical therefore that we act to preserve our valuable groundwater resource before it is too late. This chapter provides a detailed literature review of the prevailing wastewater treatment situation in Ireland and begins by defining the need for wastewater treatment then moving on to examine how wastewater is treated and concludes with the identification of some significant issues of concern regarding wastewater treatment. These issues of concern form the basis of the need for further research on the subject so that wastewater treatment can be improved into the future and specifically in accordance with national and EU legislation. In consideration of the above, the overall aim of this study is to advance the understanding of domestic wastewater treatment for houses not connected to municipal sewage schemes and their impact on water resources. Specifically, within the context of on-site wastewater treatment for un-sewered property, the objectives of this research can be summarised as;

1. Identify water quality trends for groundwater in Ireland and examine the legislation that currently exists for groundwater protection.
2. Evaluate wastewater that is generated by on-site wastewater treatment systems as well as examining the legislation and guidance that refers such systems.
3. Explore the assessment procedure for on-site wastewater treatment systems as well as examining the on-site systems that exist in Ireland. Existing research that has been undertaken on the subject will also be explored.

4. Formulate recommendations for primary research that should be carried out as part of the larger doctoral study that is to be undertaken.

## **2.1 Definition of a Literature Review**

A good literature search demonstrates the ability to search, identify and select materials relevant to the topic and which need to be reviewed at a level appropriate to the project (Hart 2001). To ensure that the literature search does not get too broad, the following parameters have been established. The Water Directive is an EU policy but the focus for this research relates to Ireland's attempt to comply with its requirements to improve water quality. Therefore, the search for relevant practice based studies and policy guidance concentrates primarily on Ireland. The WFD was transposed into law in Ireland in 2000 as was the EPA Wastewater Manual for Ireland. There are some relevant acts and regulations that pre-date 2000 however and these will also be examined. A number of consultation papers have been produced on behalf of the Irish government in recent times which focus specifically on Ireland's progress in achieving the targets set down by the Water Directive. The contents of these papers are invaluable to this review.

## **2.2 The Literature Search Strategy**

A significant portion of the knowledge base that is relevant to this research has already been published in books, journals, practice guides and policy documents. Therefore, the literature review will focus mainly on explicit knowledge sources in the published form. Nevertheless, there is an element of tacit knowledge which is defined as being based on the experience of individuals, expressed in human actions in the forms of evaluation, attitudes, points of view, commitments and motivation (Nonaka et al 2000). The tacit knowledge has been developed by the experiences of on-site suitability assessment procedures as outlined in this review. There is a technical and cognitive dimension to the tacit knowledge as follows;

Technical Dimension – Information and expertise in the know how of protocols and procedures

Cognitive Dimension – The beliefs and values associated with the role of a wastewater assessor

The literature review is a review of the explicit knowledge which it is hoped will provide a framework for further research to be undertaken in the larger doctoral study. This will assist in the later stages of the research and lead to the development of new knowledge that is worthy of publication. In the development of a search strategy for the literature to be reviewed, the following issues have been considered;

1. What I need to know?
2. Consideration of the overall research aims and objectives
3. What I already know?
4. What literature do I currently have?
5. What information sources do I have access to?

The responses to the above questions have directed the research strategy that has been developed for this literature review.

## **2.3 Drinking Water in Ireland & Current Legislation**

Only 1 percent of the world's fresh water is available for human use and development patterns, increasing population pressure and the demand for better livelihoods are contributing to a global water crisis. Addressing this crisis will require maintaining a sustainable relationship between water and development (World Bank, 2010). This overview is reflective of Ireland and development pressures have resulted in significant degradation of natural water resources. This degradation will impact on the environment as well as impacting on future supplies of water for human needs. Critically also, it may have a significant

impact on the health and well being of Ireland's population. This study is specifically concerned with the contamination of groundwater from what are called on-site wastewater treatment systems. These systems are used to treat domestic wastewater in homes that do not have a connection to a public municipal sewerage facility. Such systems have been increasing in large numbers in recent times in Ireland (Daly & Craig, 2009) and therefore the potential threat of contamination of groundwater is ever increasing. An explanation of how these systems can impact on drinking water is discussed later in this chapter as well as an examination of the potential impacts of drinking water contamination on human health and some recent trends in Ireland's water quality. Specifically this examination will focus on groundwater and groundwater trends with some comparative analysis from across the EU. The Water Directive which has been developed by the EU and adopted by Ireland will be explained and its objectives will be explained specifically in relation to groundwater. Some statistical data on the contribution of groundwater to Ireland's drinking water supply will also be outlined.

### **2.3.1 Health Implications of Contamination from OSWTS's**

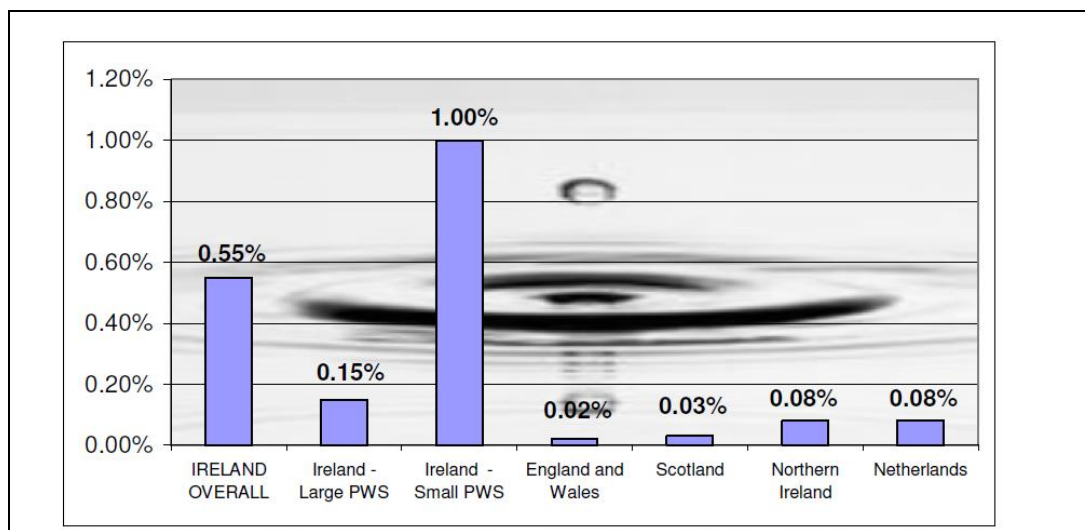
Although the data available for individual private wells in Ireland is sparse (Misstear & Hynds, 2007), the evidence from the EPA (2009) on *E. coli* in larger supplies illustrates that Ireland has significant drinking water contamination. As outlined earlier the principal risks to drinking waters are those that have a health impact, particularly contamination from *E.coli* and cryptosporidium. To put things in perspective, Ireland has *E.coli* levels seven times that of Northern Ireland and the Netherlands, eighteen times that of Scotland and twenty eight times the levels recorded in England and Wales (Nix, 2010). The main water contaminants of concern in terms of health are microbiological pathogens. The term pathogenic is applied to those organisms that either produce or are involved in the production of a disease (Bradley 1974).

These organisms include (GSI, 2007):

- Bacteria, such as verocytotoxinogenoc – *Escherichia coli*
- Viruses, including rotavirus
- Protozoa, notably *Cryptosporidium parvum*

*Cryptosporidium* is a microscopic protozoan parasite that can be present in faecal material. The first recorded outbreak of *cryptosporidium* in Ireland associated with a public water supply occurred in April 2002. There have been a number of outbreaks since (EPA, 2008b). This is occurring against a backdrop of the WFD implementation and the fact that human health is being considered a water related issue (EPA, 2008). According to Gray (1994) the three micro-organisms outlined above can be transmitted via drinking water. They are all transmitted via the faecal – oral route and so largely arise either directly or indirectly by contamination of water resources by sewage. The presence of even a single *E.coli* in drinking water is unacceptable as it indicates that the source is contaminated with faecal matter (EPA, 2009). Figure 2.1 illustrates the excessively high levels of *E.coli* in Ireland overall as well as specifically referring to large public water supplies (Large PWS) and small public water supplies (Small PWS).

**Figure 2.1: Comparative E.coli Statistics for Drinking Water Supplies**

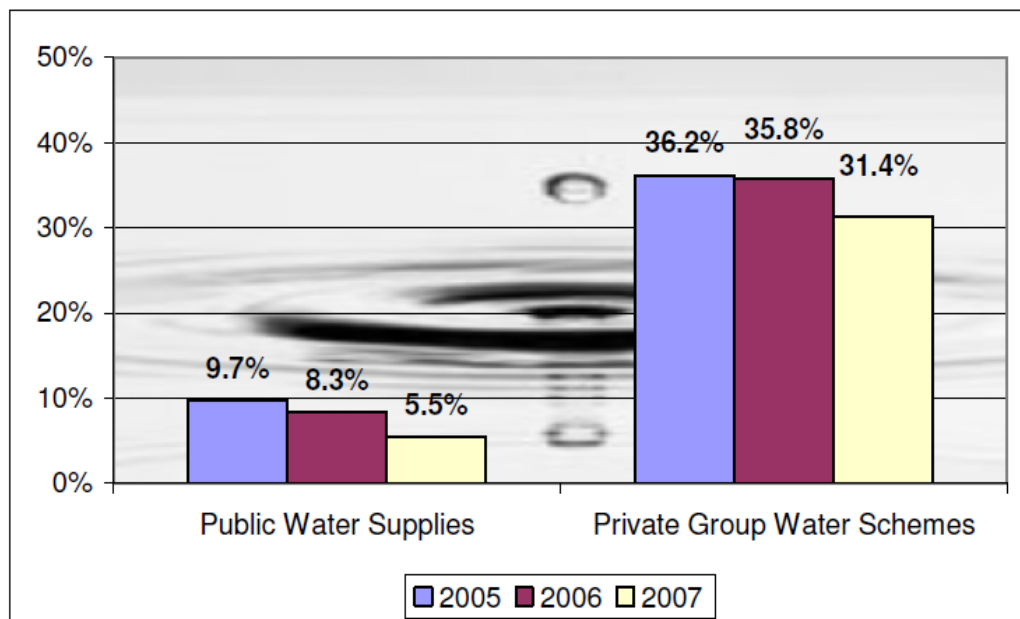


Source: EPA (2009)



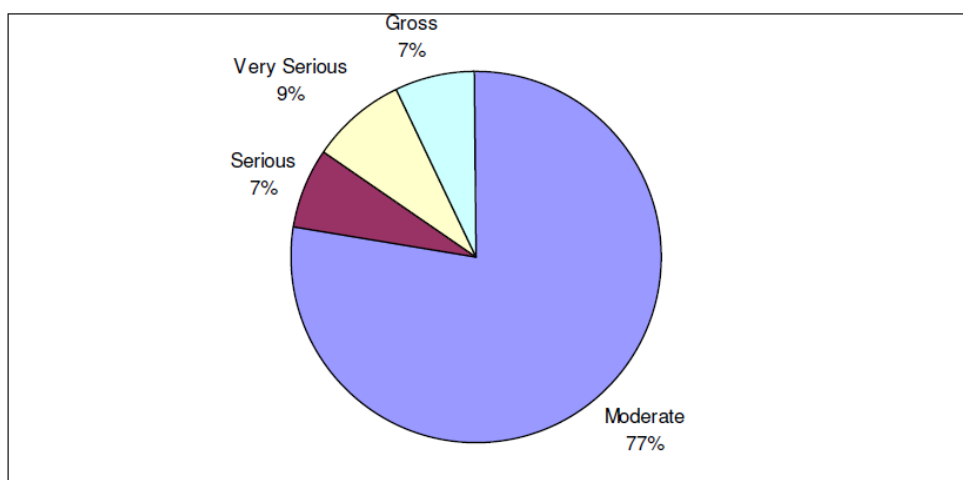
Recent research does demonstrate there is some moderate improvement in E.coli contamination of public and group water supplies. Figure 2.2 below illustrates the levels recorded over 2005 – 2007 but again the absence of research on individual private drinking wells means that no assumptions can be made thereto. Figure 2.3 goes on to illustrate that the majority of samples that were found to be contaminated are moderate. Nevertheless, 23% of the samples were recorded as being either; serious, very serious or gross. Clearly these samples mean that those who derive their drinking water supplies from these sources are in imminent danger to their health. Figure 2.4 highlights that the highest levels of contamination are found in the north-west of Ireland where the highly productive aquifers are identified earlier in Figure 2.2.

**Figure 2.2: Percentage of Public & Group Water Supplies Contaminated with E.coli During the Period 2005 - 2007**



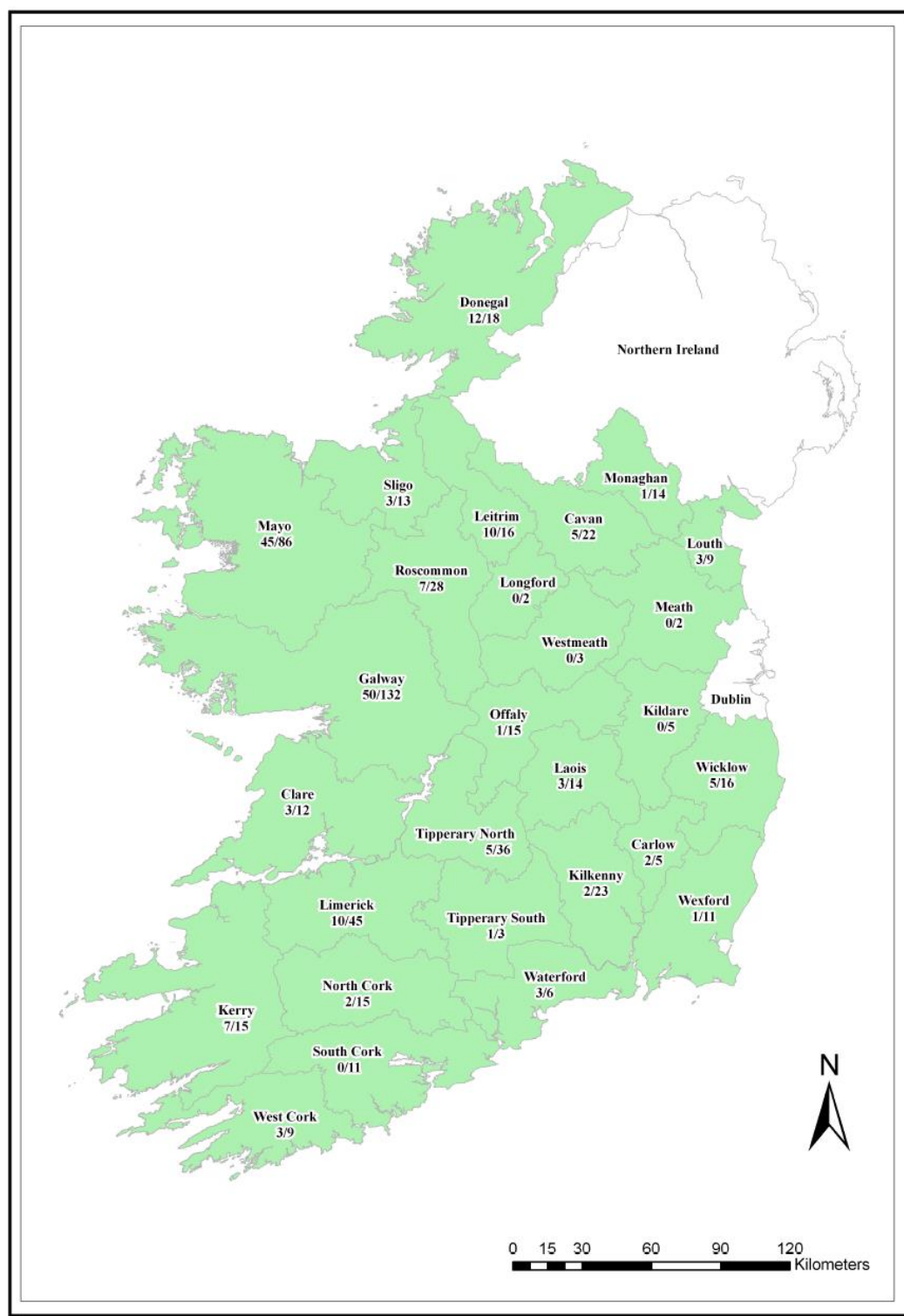
Source: EPA (2008)

**Figure 2.3: Classification of the Severity of E.coli Contamination During the Period 2005 - 2007**



Source: EPA (2008)

Figure 2.4: Number of Samples Contaminated with E.coli per County during 2007



Source: EPA (2008)

The following can summarise the main findings in relation to E.coli from research by the EPA (2008);

- E.coli was detected in 5.5% of public water supplies down from 8.3% in 2006
- E.coli was detected in 31.4% of private group water schemes, down from 35.8% in 2006
- 54% of private group water schemes failed to meet the coliform bacteria parametric value even once in 2007

The Water Quality Report in Ireland 2010 – 2012 which was published by the EPA (2012) is the most recent national research and this identified that there has been some improvement in water quality from contamination from E.coli and other bacterial threats to drinking water quality. The tables produced in Figures 2.1, 2.2, 2.3 & 2.4 are however the most up to date available data in published form. Section 2.7.12 later in this chapter will set out how the research of water quality lost some emphasis during the economic recession that decimated the Irish construction industry.

### **2.3.2 Ireland's Natural Water Resource**

Unintended of course and almost un-noticed, we have allowed that treasure of a richer natural water-world to become tarnished and diminished in our short lifetime (Feehan, 2008). As eluded in section 2.3.1 the need for the treatment of wastewater in rural Ireland is imperative not only to service the growing number of rural inhabitants but more importantly, from the country's economic and social perspective. The EPA (2008) outlines that groundwater is a valuable natural resource in Ireland that is used in food and industrial processing, as well as being an important source of drinking water, but is often contaminated by inadequate wastewater treatment systems (Daly, 2003; Gill et al, 2005; EPA, 2009), the most significant being faecal bacteria, viruses and other microbiological contaminants (EPA, 2006). Approximately 17% of the total public drinking water supply in

Ireland is provided by groundwater or spring sources (EPA, 2008). If private supplies are included, then groundwater and springs account for approximately 26% of the total drinking water supplied in Ireland. The DoEHLG (2009) suggests that approximately 25% of the population depend on groundwater for their water supply. There seems to be consensus therefore between these reliable sources at 26 & 25% respectively. In regional locations however these percentages can be significantly higher. In certain counties, particularly in the midlands, the proportion is much greater such as north Cork 90%, Roscommon 86% Offaly 60% Laois 54% and Kilkenny 52% (EPA, 1999).

County Roscommon has even been reported to derive approximately 75% of drinking water supplies from groundwater (EPA, 2007) and thereby the impact of inadequate waste water treatment systems is colossal. According to Wright (1999), there are an estimated 200,000 wells and springs in use in Ireland. This figure varies somewhat between sources and according to the CSO (2004) there is estimated to be 138,000 households in Ireland that have a private well and an additional 50,000 dwellings obtaining their water from a private group water scheme. Individual drinking wells located on the site of the home serve approximately 10% of the population (EPA, 2009). Private water wells can provide a safe, reliable and inexpensive source of water supply to a private household, provided care is taken in the location, design and construction of that well. Unfortunately, many wells in Ireland are poorly sited and constructed, resulted in potential health risks to the consumer (Misstear & Hynds, 2007). Gill et al. (2005) outlines that groundwater is an important resource in Ireland which is under increasing risk from human activities with contamination arising from both ‘diffuse’ (generally agriculture) and ‘point sources’, the latter being exemplified by farmyards and septic tank systems. Prevention of groundwater contamination is of critical importance and presents significant challenges to land use planning policy in Ireland (Manning, 2004). According to the SERBD (2009) water is a fragile resource that needs to be protected.

The decline of water quality in Ireland and the pollution of surface and ground waters has been described as the most serious challenge facing Ireland today

(OECD, 2000). The continuing decline in Ireland's water quality was highlighted by Lucey et al (1999) and also by Irvine et al (2000) where they recognised that Ireland's responses to water pollution were completely ineffective. According to Daly (2003) there is evidence to suggest that Ireland has among the most microbially polluted groundwater in the EU. This opinion is buoyed by Fairly et al (2002) where they outline that water quality management has had little influence generally on informing the control of polluting land use activities under traditional policy regimes. Ireland has not been alone however in experiencing water quality decline however (Bloch, 2002). Due to an increase in pollution from various economic activities and in the absence of nutrient management programmes, a significant decline in water quality was observed across EU member states throughout the 1980s. Legislation such as the Nitrates Directive has moved issues relating to groundwater to the forefront of environmental considerations however (Fitzsimons et al., 2003).

### **2.3.3 Groundwater Monitoring & Water Quality Trends**

Such that groundwater safety is a major concern in Ireland, the GSI has undertaken groundwater assessment at certain locations for the past 35 years. However, the first national monitoring network was not established until 1995 when the EPA initiated a national groundwater quality monitoring programme. The EPA takes groundwater samples twice a year from approximately 300 locations nationally and the trends are reported in the EPA Water Quality Report every 3 years (GSI, 2007). Groundwater has been further prioritised by the WFD and this has revolutionised the monitoring of groundwater quality and will be discussed in further detail in Section 2.3.5. The WFD established a comprehensive groundwater quality programme which was to be operational by the 22<sup>nd</sup> December, 2006. According to Craig et al. (2006) the WFD required a thorough review of existing groundwater monitoring networks followed by the establishment of carefully selected new networks to monitor groundwater.

There are four new networks established and a brief outline of each is as follows;

- A quantitative monitoring network based on water levels and water balance estimations
- A surveillance water quality monitoring network
- An operational water quality monitoring network
- Appropriate monitoring to support the achievement of protected area objectives. For example, drinking water and habitats protected areas.

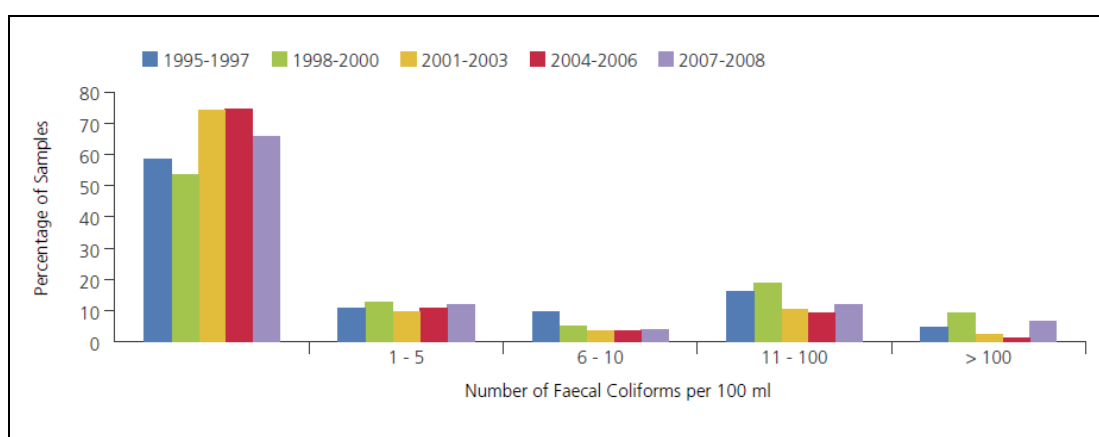
Although there has been growing concern for safe groundwater through the establishment of government led networks, Craig et al. (2006) raises concerns that the networks are based on the conceptual understanding of groundwater flow and pollutant attenuation (such as that from on-site wastewater treatment systems). These conceptual models make standardised assumptions about groundwater and such assumptions can overlook the possibility of changes in groundwater characteristics. The GSI (2007) have outlined however that the new monitoring networks are exciting and challenging and from these expanded and improved monitoring programmes our understanding of groundwater chemistry, quality and flow will improve as will our understanding of their relationship to land uses. They anticipated that these will provide an essential basis for establishing and evaluating programmes of measure as required by the WFD.

The lead monitoring authority for the new government led networks is the EPA who are supported by local authorities and the National Parks and Wildlife Service (NPWS). The EPA is also responsible for the implementation of measures to achieve compliance with the WFD. The EPA do not carry out water quality surveys on individual private drinking wells but instead, carries out surveys on monitoring stations located around the country. The following demonstrates some concerning data from existing surveys carried out to date. In the survey of water quality for the period 1998 – 2000 (EPA, 2002) positive faecal coliform counts were found in 38% of samples taken at 134 monitoring stations. Some 20% of samples had faecal coliform counts greater than 10/100 ml indicating gross contamination (Daly, 2003). Once again there are regional locations which

demonstrate significantly higher levels of contamination than those found by the EPA. A study of private group water schemes in County Roscommon was undertaken in 2000 and this found faecal coliforms in 58% of water samples taken (Roscommon County Council, 2000). Referring back to 1993, in some areas more than 50% of wells were polluted in some areas and septic tanks were accounted to be a major source of this pollution (Daly et al, 1993). The GSI (2003) outline that the degree of microbial contamination of groundwater in Ireland is very high and probably higher than any other country in the EU with at least 30% of private domestic wells currently polluted.

The GSI (2003) go on to estimate that more than 70% of private drinking wells have been contaminated with faecal bacteria at some point. Figure 2.5 illustrates trends in faecal contamination of groundwater over the period of 1995 to 2008 and also the varying levels of contamination. The presence of a single faecal coliform in a drinking water supply is a breach of the Drinking Water Regulations in Ireland under Statutory Instrument No. 278 of 2007. Therefore, the samples testing positive across all ranges are in breach of SI 278 of 2007.

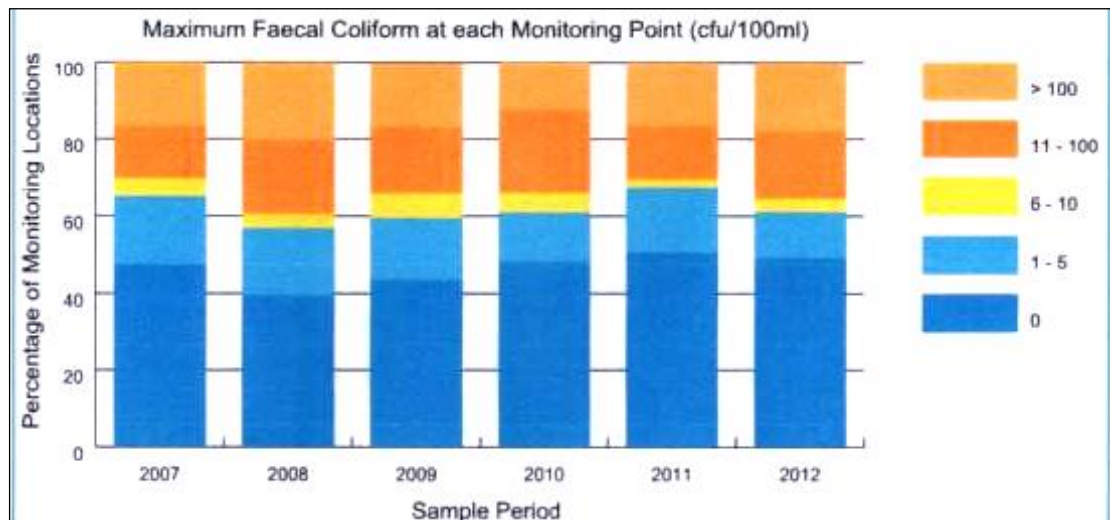
**Figure 2.5: Faecal Contamination in Irish Groundwater 1995 – 2008**



Source: EPA (2009)



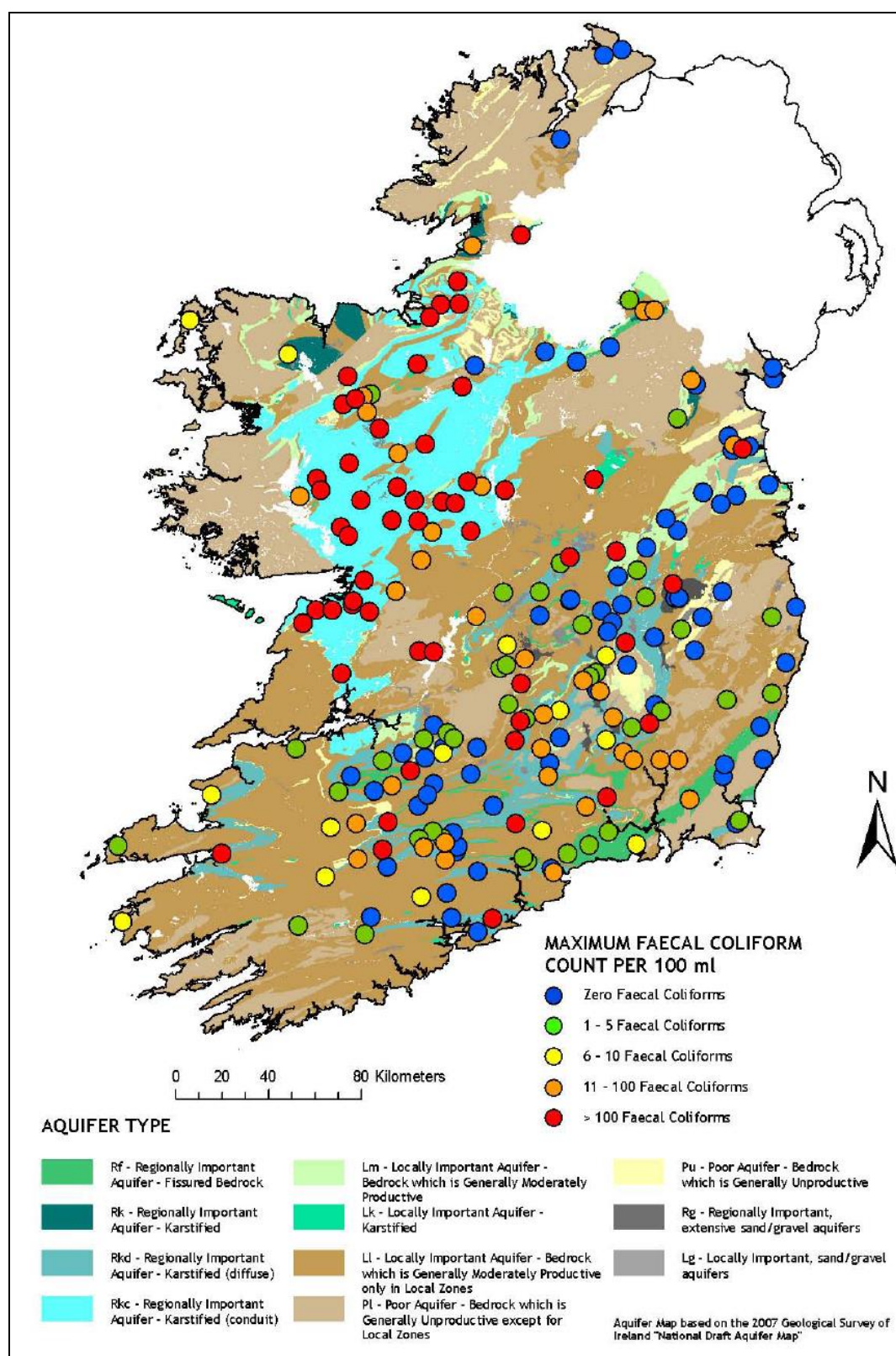
**Figure 2.6: Faecal Contamination in Irish Groundwater 2007 – 2012**



Source: EPA (2014)

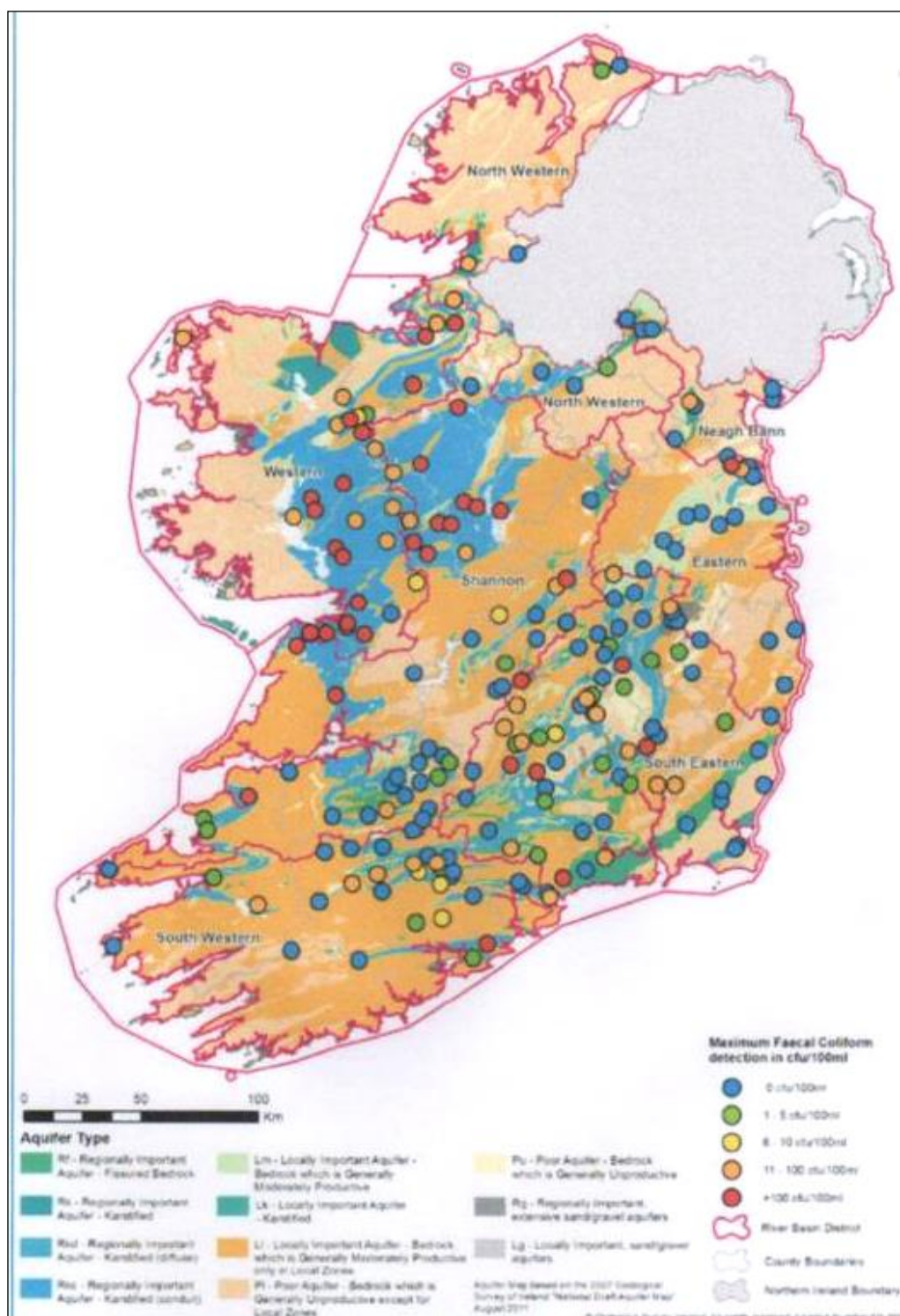
Figures 2.5 & 2.6 above illustrates there has been a significant issue with faecal contamination of groundwater over the years up to 2012 which is the latest date of data published by the EPA (2014). Figures 2.7 & 2.8 go on to identify the locations across the country where the contamination is most prevalent and significantly there are incidences of high levels of contamination where there are also productive aquifers. This poses an increased risk as an aquifer is defined as productive if it can provide a significant source of drinking water. Notably the north-west of Ireland has experienced the highest level of faecal contamination whilst deriving significant water supplies from its regionally productive aquifer as outlined in Figures 2.7 & 2.8. To comply with SI 278 of 2007 all areas of the country should be highlighted with zero coliforms or blue dots.

Figure 2.7: Maximum Faecal Contamination in Relation to Productive Groundwater



Source: EPA (2009)

Figure 2.8: Maximum Faecal Contamination in Relation to Productive Groundwater



Source: EPA (2012)

### **2.3.4 Impact of OSWTS's on Water Resources**

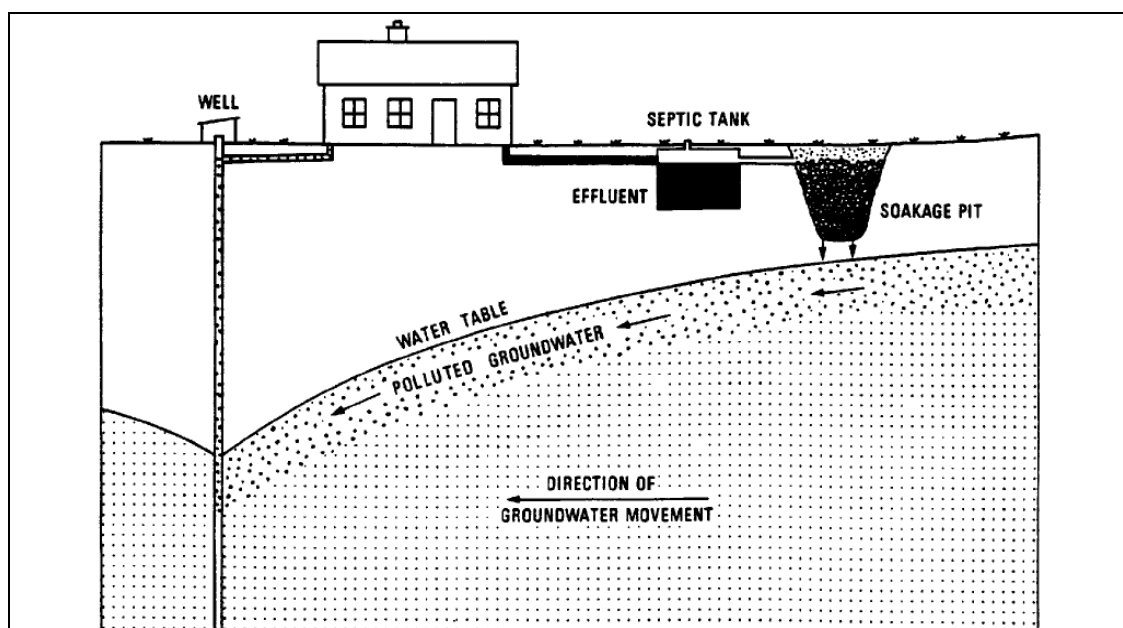
As groundwater accounts for up to 15% of total water supplied by local authorities and about 25% of all water supplies in Ireland (Daly et al, 1993); the prevention of groundwater contamination from on-site domestic sewage effluent is of critical importance as groundwater remediation is usually expensive and often practically impossible (Gill et al., 2005). The effluent discharged from waste water treatment systems such as septic tanks is highly polluting as it contains faecal bacteria and high levels of nitrogen, phosphorous and other constituents. Therefore, if effluent enters water without being adequately treated it causes pollution. The amount of effluent discharged to ground in Ireland is considerable, about 80 million cubic metres per year. As much of this effluent ultimately enters groundwater, the risk to human health is obvious (Daly et al, 1993). Crucially the volume of effluent expressed above has significantly increased in line with the increase in on-site wastewater treatment systems as identified at approximately 500,000 (CSO, 2012). Many of these wells and group water schemes will be in rural areas which are also un-sewered. Therefore, the houses that extract groundwater for a drinking resource are also likely to be discharging domestic effluent to that same resource. If this effluent is inadequately treated it will lead to the contamination of the drinking water supply. According to the EPA (2009) untreated water is rarely suitable for drinking without some form of treatment, except where there is an adequately protected bore-well with a small distribution network, for example, a house with a private well. The degree of microbial contamination of groundwater in Ireland is extremely high, significantly higher than in any other country in the EU as outlined in Figure 2.6. In many areas at least 30% of private domestic and farm wells are polluted; in some highly vulnerable areas more than 50% are polluted, usually intermittently usually by faecal bacteria (Daly, 2003). The EPA (2006) indicated that approximately 30% of groundwater and spring samples tested for group water supplies between 2003 and 2005 contained faecal coliforms, with 36.1% testing positive for E.coli during the year 2005.

These are worrying statistics, and perhaps of equal concern is the lack of corresponding information for individual private drinking water supplies. Misstear & Hynds (2007) suggest though that given the fact that the majority of private groundwater supplies in Ireland are untreated, the water quality situation with respect to private sources for individual dwellings is likely to be worse than for the group water supplies. Yates (1985) gives examples of pollution problems in areas of high densities of un-sewered houses such as in the US and concludes that “the most important factor influencing groundwater contamination by septic tanks is the density of systems in the area”. According to Macler & Merkle (2000) in the United States up to half of all private wells tested in studies showed evidence of faecal contamination. They estimate that between 750,000 and 5 million illnesses per year are attributable to groundwater based community water supply schemes. They further suggest that some 1,400 to 9,400 deaths per years relate to this contamination. It is likely to be a similar case in Ireland. Vaury (2003) has tentatively estimated that there could be in the region of 94,000 – 137,000 waterbourne illnesses per annum in Ireland attributable to the consumption of water from private wells and group water schemes. Misstear & Hynds (2007) assert though that there are significant uncertainties involved in this computation.

There is clear evidence that in areas where excessive densities of rural houses have been built there is a heightened threat to groundwater quality. Daly & Fitzsimons (2002) argue that density is not the most important factor influencing groundwater pollution in Ireland. They argue that the significant portion of land area underlain by Gley (impermeable) soils is the biggest issue. According to Gardiner & Radford (1980) some 24.3% of Ireland is underlain by such Gley soils and it is fair to conclude that on-site wastewater systems cannot function in these locations as effluent cannot discharge through its impermeable characteristics. This can be contrasted with Daly (2001) where he suggests that up to 50% of Ireland may be unsuitable for conventional septic tank systems. Figure 2.9 below outlines how an on-site wastewater treatment system can impact on a private drinking well whilst demonstrating how the direction of groundwater flow is a critical issue for possible contamination.



**Figure 2.9: Interaction of On-Site Wastewater Treatment System & Drinking Water Supply on a Typical Site**



Source: Daly (1993)

### 2.3.5 The Water Directive (WFD)

Efforts to protect the valuable groundwater resource in Europe began in the 1970's resulting in the adoption of the first Groundwater Directive (80/68/EEC). However this early directive was limited in scope, focussing on the control of emissions of substances from industrial and urban sources. Despite additional directives aimed at controlling diffuse pollution from agricultural and industrial sources it became increasingly clear during the 1990's to the EU that there was a need for further action to avoid long term deterioration of quality and quantity of all freshwater resources, including groundwater across Europe. This led to the adoption of Directive 2000/60/EC (DoEHLG, 2009). Directive 2000/60/EC which has become more commonly known as the WFD establishes a framework for community action in the area of water policy. According to the EU Commission (2009) the new European Water Policy will get polluted waters clean again, and ensure clean waters are kept clean. European water policy has undergone a thorough restructuring process and the new WFD will be the operational tool setting the objectives for water protection into the future.

The WFD regulations require the identification of any significant and sustained upward pollution trends and the reversal of such trends where they are posing an environmental risk (DoEHLG, 2009). Groundwater pollution from on-site wastewater treatment systems would fall under this category. The WFD is probably the most significant legal instrument in the water field to be introduced on an international basis for many years. It stems from concerns amongst the member states over the disparate ways in which water is currently protected within the community and reflects towards integrated environmental management outlined in the environmental action programmes of the community. It took ten years to develop and to the end, engendered intense scientific and political debate. The EU itself had enacted a large number of individual legislative instruments by the early 1990's. However, these directives had been largely developed piecemeal to address specific problems. There was concern that groundwater was not adequately protected, both in terms of its quality and the ever increasing need for water supply (Chave, 2001). The WFD entered into force on the 22<sup>nd</sup> December, 2001 and aims to consolidate and reform EU water law. Six other water directives will be progressively repealed as a result of the WFD and these are:

- 76/464/EEC (Art. 6 only) on Dangerous Substances
- 75/440/EEC on Surface Waters
- 79/659/EEC on Fish Life
- 79/923/EEC on Shellfish Waters
- 80/68/EEC on Groundwater
- 76/464/EEC (Except Art. 6) on Groundwater

The legislation that specifically transposed the WFD is the European Communities (Water Policy) Regulations 2003. Statutory Instrument No. 722 of 2003 refers to the Irish transposition of the Directive. Article 3(1) of the Directive requires that member states co-ordinate the administrative arrangements with River Basin Districts (RBDs) that are geographically or hydrologically connected. Article 4 requires the implementation of necessary measures to prevent the deterioration of the status of all bodies of surface and ground water and aim to achieve good surface water status by the 22<sup>nd</sup> December, 2015, good groundwater

status within 15 years and certain objectives for protected areas must be achieved by 2015. Under Article 4(1)(a)(i) and (b)(i) respectively, Ireland must implement the measures necessary to prevent the deterioration of the status of all bodies of surface and groundwater. There is a brief synopsis of these sections of Article;

Article 4(1)(a)(i): Surface Waters - This mandates Ireland to avoid any deterioration in the status of all bodies of surface water.

Article 4(1)(b)(i): Groundwaters - This mandates that Ireland shall prevent or limit pollutant inputs and shall prevent the deterioration of the status of all groundwater bodies, subject to some exceptions. Effectively Ireland must ensure that there no further deterioration occurs or as suggested by Scannell (2006) it is a “non-deterioration” requirement.

The following key dates provided by Chave (2001) illustrate the overall timetable for the implementation of the WFD;

| Activity:  | Key Date: |
|--|-----------|
| Transpose WFD into national legislation            | 2003      |
| Define river basins, appoint competent authorities | 2003      |
| Complete surveys                                   | 2004      |
| Commence monitoring programmes                     | 2006      |
| Statement of issues                                | 2007      |
| Publish draft river basin management plans         | 2008      |
| Commence river basin management plans              | 2009      |
| Enact programme of measures                        | 2009      |
| Introduce water pricing                            | 2010      |
| Implement all programmed measures                  | 2012      |
| Achieve good water status                          | 2015      |
| First review of river basin plans                  | 2015      |
| Second review of river basin plans                 | 2021      |
| Where extensions apply achieve good water status   | 2027      |
| Third review of river basin plans                  | 2027      |



### Exceptions & Derogations:

Article 4 of the WFD makes provision for limited derogations from these objectives. Member States may be able to postpone the 15 year deadline for a given groundwater body by up to 12 years in certain circumstances. In order to avail of such an extension, the pre-conditions set out in Article 4(4) must be met and complied with.

The maximum limit on time extensions is 2021, except in cases of adverse natural conditions. Article 4(4) also prohibits any further deterioration in the status of the water bodies concerned. The Member State must set out the details of the extension and the consequent measures in the management plan and to comply with the requirements and standards set under existing EU environmental legislation. Under the WFD the status of groundwater will be classified using two parameters. These parameters refer to quantitative status and chemical status and these can be classified as either good or poor. The WFD Groundwater Working Group from the EPA (2004) identified that approximately 61% of groundwater bodies in Ireland were at risk from anthropogenic pressures. A risk assessment of groundwater bodies in Ireland which was completed as part of the characterisation process required under Article 5 of the WFD indicated that groundwater underlying approximately 26.7% of the land area of Ireland was identified as at risk of failing ‘good status’ (EPA, 2009). The EPA goes on to state that “there is a need for improved protection of groundwater, especially in the context of achieving the WFD objective of ‘good status’ for all groundwater by 2015”. The magnitude of the task facing Ireland has been highlighted by the EPA (2005) and they state that “achieving at least good status for all water by 2015 will be a considerable challenge. Significant effort and resources will be required to ensure sustainable water management is implemented on schedule as required by the WFD”.

### **2.3.6 Legal Basis for the Water Directive**

The WFD requires that water quality planning and management be co-ordinated by all competent authorities on the basis of river basins. This requirement was implemented in the European Communities (Water Policy) Regulation 2003. Specified targets must be achieved over the period of 15 years. The Minister for the Environment in Ireland commenced promoting a regional approach to water management in 2001 and several projects have commenced for managing water in combined river basins in the same region. River basin management plans will identify all significant impacts on water quality and quantity, set quality objectives complying with the requirements of the WFD and identify and put in place the necessary monitoring and management measures to achieve those objectives. They will promote an integrated water quality monitoring and management system for all waters in the region, including coastal waters and groundwaters in the context of the information gathered. They are intended to constitute a comprehensive approach to water management involving participation by the relevant county councils and other agencies, the public interests including agriculture, fisheries, flood management and habitat protection interests.

### **2.3.7 Objectives of the Water Directive**

There is a need for improved protection of groundwater, especially in the context of achieving the WFD objective of ‘good status’ for all waters by 2015. Proper management of groundwater resources is required to maintain both the quality and the yield of drinking water sources, and to ensure that groundwater is not having a detrimental impact on surface waters and ecological receptors (EPA, 2008). The EPA (2008) has stated that the WFD establishes a framework for the protection of all waters and is aimed at preventing further deterioration in water quality and achieving sustainable water resources. It promotes an integrated management strategy for the protection of all waters, which will require the development of improved understanding of the interactions between waters.

Crucially the interaction between waters will need to take account of domestic wastewater as a component in the mix outlined by the EPA. Moss (2004) has described the WFD as a 'hybrid approach' towards the achievement of policy objectives. The technocratic, top-down approaches and procedural law aspects of the directive have been described as involving command and control type policy formulae towards achieving its objectives. Demmke (2001) has outlined the imperative for the effective delivery of these control type policies. The delivery of planning at all scales will have to give greater consideration to water and the environment so as to successfully achieve the requirements of the WFD (Howe & White, 2002). Moss (2004) outlines that the WFD involves a departure from previous EU water legislation in seeking to develop a within which member states can address those issues that occur as a result of relationship between water management and land uses. The development of River Basin Management Plans will seek to identify those factors in catchment areas that have an impact on surface and groundwater (Manning, 2004). An example of the factors that would affect a catchment area are of course on-site wastewater treatment systems. According to Manning (2004) the following are the main objectives of the WFD;

- Achieve good status in all waters by 2015 and maintain high water quality environments where they exist
- Extend the scope of water protection to all waters including surface and groundwater
- Develop water management on a catchment management basis
- Use a combined approach of emission limit values and quality standards
- Implement water charges for water and wastewater that reflect the true costs
- Involve the public more closely in the water management process

- Co-ordinate and streamline legislation regarding the water environment

Groundwater can only be protected by appropriate land use planning. Good decision making requires taking account of the site hydrology of specific sites and cumulative impacts on regionally important aquifers. The precautionary principle is recommended for groundwater preservation (Manning, 2004). The EPA (2008) have outlined that the main unit of management of the WFD across Europe is the River Basin District (RBD). A river basin or catchment is an area of land from which all surface run-off flows through a series of streams, rivers and possibly lakes into the sea at a single river mouth or estuary. An RBD comprises one or more neighbouring river basins together with their associated wetlands, groundwaters and coastal waters. Article 23 of the WFD requires Member States to adopt penalties for breaches of the measures put in place to implement the Directive. According to Chave (2001) the Directive promotes a 'combined approach' for the control of polluting discharges to water and suggests that regulatory measures should be complemented by supplementary measures such as the following;

- Economic or fiscal instruments
- Codes of good practice
- Rehabilitation projects
- Educational projects
- Research, development and demonstration projects
- Other relevant measures

The supplementary measures are of particular relevance to Ireland and specifically the codes of good practice as published by the EPA (2000 & 2010).

In section 2.5 there is an overview of the codes of practice that have existed in Ireland for on-site wastewater treatment systems since the year 2000.

## **2.4 Trends for Domestic Wastewater Disposal for Un-Sewered Areas**

The previous section of this chapter introduced how contamination from on-site wastewater treatment systems can impact on water supplies and the consequent health implications that can result. This section moves on to look at what wastewater actually is in the context of domestic houses, its composition and the how the process of wastewater treatment has developed through the last century. Recent demographic statistics demonstrate that the number of on-site wastewater treatment systems is increasing and that Ireland has a significantly higher number of such systems per capita than its EU neighbours. An understanding of this trend is critical so as to express the ultimate need to ensure that on-site wastewater treatment systems work effectively and to ensure that they are not the source of groundwater contamination.

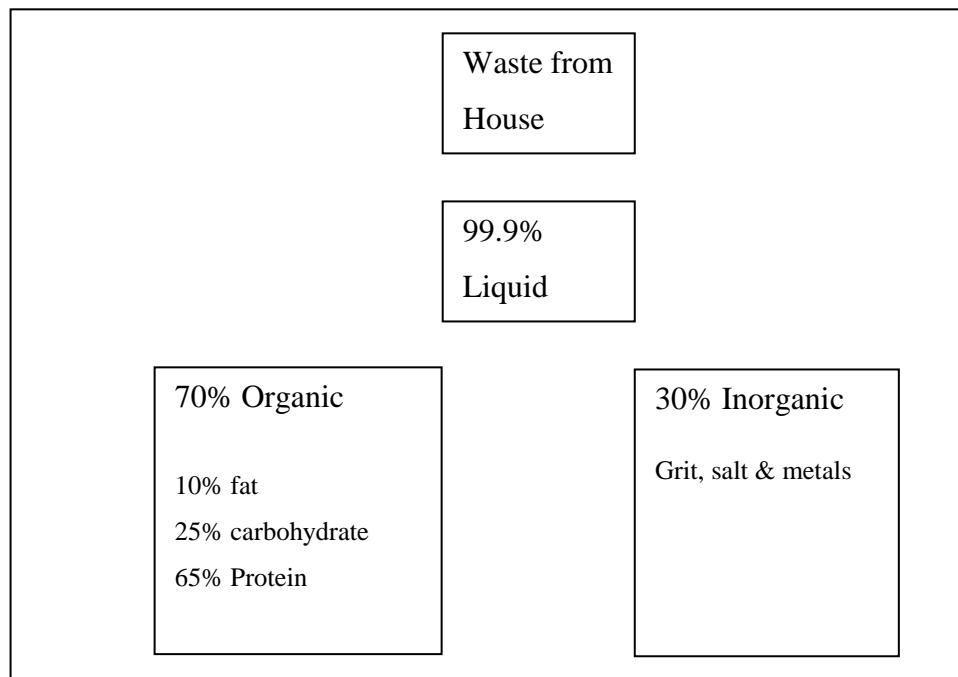
The WFD has been introduced and its objective for groundwater quality across the EU to improve has been explained. The examination of Ireland wastewater trends will help to determine if Ireland is on track to achieve these critical objectives. As outlined, there are significant social, environmental and economic consequences for non-compliance and it is necessary for this study to establish where Ireland stands currently. This will also help to shape the larger doctoral study that is being undertaken.

### **2.4.1 Wastewater & Effluent – A Definition**

According to Bedinger et al (1997), “wastewater refers to the untreated composite of water and wastes (solids and liquids) collected within the household and moved in the wastewater stream to a treatment plant.” Effluent is defined by these same authors as “a liquid emanating from a treatment system after primary or higher

treatment which is available for further treatment or disposal.” The effluent enters buried leach field pipes where it seeps into the surrounding soil. This action filters the liquid, while aerobic bacteria further break it down into various nutrients and chemicals that support plant life. Alth, M. & C. (1991). Grant et al (2000), refers to wastewater from houses as ‘sewage,’ and defines sewage as “a mixture of water and the various types of organic matter that we send through the plumbing – faeces, urine, food scraps, hair and toilet paper for example”. Grant et al (2000) outlines the components of domestic wastewater as Figure 2.10 as follows.

**Figure 2.10: Components of Domestic Wastewater**



Source: Grant et al (2000)

#### **2.4.2 The Early Days of Wastewater Treatment**

Wastewater treatment has taken place since the beginning of time and the process has not been exclusive to the human form. Living organisms that ingest food produce waste which is excreted in one form or another. This excretion becomes a source of energy for other usually smaller creatures.

These micro-organisms will go to work breaking down the organic matter into smaller and simpler fragments. This process of breaking down organic waste can be summarised as;

1. Catabolism - the break-down of molecules into smaller units and the release of energy
2. Disintegration - the process by which waste breaks down or loses cohesion
3. Dissolution - the process of dissolving a solid substance

This naturally occurring process is what occurs, or should occur in an on-site treatment facility and is therefore traceable back to the beginning of time (Grant et al, 2000). On-site sewage treatment and disposal systems were patented around the turn of the century and first used in ancient Europe (National Symposium on Individual & Small Community Sewage Systems, 1998). Approximately 30% of all Americans live in unsewered areas and rely on the use of on-site systems for wastewater treatment and disposal (Nadakavukaren, 1995). According to Lenning (1986) “on-site wastewater systems have been used throughout North America and the world for decades, especially where centralised wastewater collection, treatment and disposal systems were not available”. In Europe the French were apparently the first to use an underground septic tank system in the 1870’s. Ireland too has used septic tanks from the early twentieth century. Even now, more than a century later septic tank systems represent a major household wastewater treatment option.

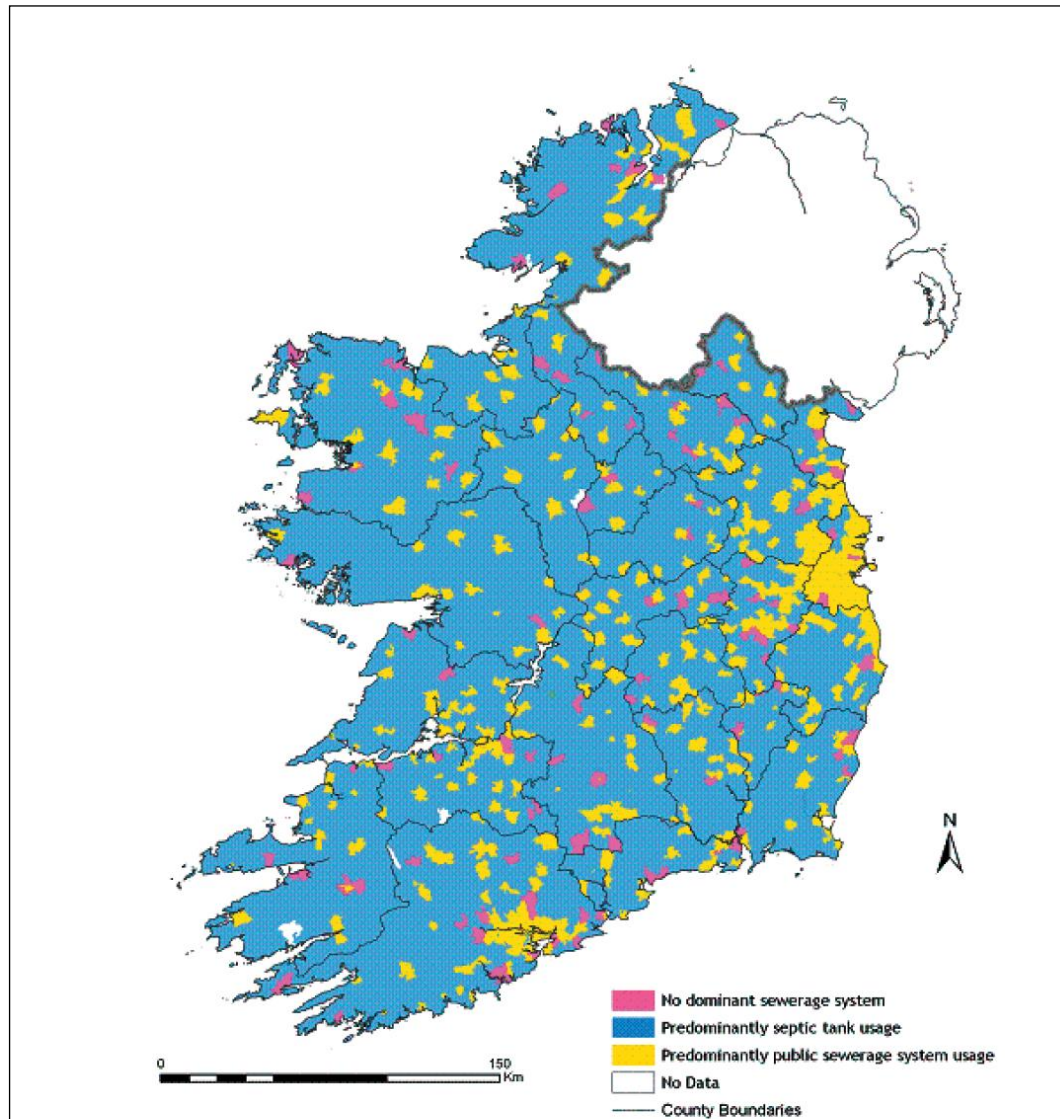
### **2.4.3 Wastewater Treatment in Ireland in Recent Times**

In Ireland, wastewater from over one third of the population is treated by small scale on-site wastewater treatment systems where connection to a sewer is deemed to be unfeasible, usually in rural areas (DoELG et al., 1999). According to the EPA (2000) the most prevalent on-site wastewater treatment system is the

conventional septic tank with over 350,000 systems currently installed. Moore (2005) suggests that conventional septic tanks make up 90% of all on-site wastewater treatment systems in un-sewered areas. The total number of on-site systems, including septic tanks, according to the most recent CSO (2012) statistics is that there are 500,000 such units in operation. According to Daly et al (1993) approximately 300,000 septic tank systems served approximately one million people in that year. Accordingly, this illustrates an approximate increase of 40% in the number of on-site systems over the period of 13 years. Clearly therefore the issue of septic tanks and on-site wastewater treatment systems must be taken very seriously by Ireland. Figure 2.11 illustrates the predominance of septic tanks and on-site wastewater treatment systems in certain locations across the country and specifically in rural areas. This is the most up to date illustration available at this time.



**Figure 2.11: Concentration of Septic Tank Systems in Ireland**



Source: CSO (2006)

#### 2.4.4 Comparative Analysis of Statistics for Wastewater Disposal

The 2006 census of population indicated that around 40% of the population of Ireland lived outside of main cities and towns. Unlike other more urbanised European countries, around a third of Ireland lives in the open countryside in individual dwellings that are not connected to a public sewer. The wastewater from such dwellings needs to be treated at or near the dwelling by treatment systems often called ‘on-site systems’ (GSI 2009).

It is estimated that in Ireland 50 million gallons of effluent from over 1.2 million people is produced from on-site systems daily. This effluent is disposed of in the ground (Daly, 2003). While septic tanks and other on-site wastewater treatment systems are used in other countries their numbers appear to be much lower. For example, according to the Irish Census of Population (2006) there are some 418,033 on-site systems in Ireland representing 28% of the overall housing stock compared to an estimated 800,000 in England and 100,000 in Scotland (Gormley 2009). The above comparison with England and Scotland is quite startling when you consider that Ireland has nearly half as many systems as England and Scotland combined but less than 20% of the combined population. Daly (2003) suggests that for many houses in rural areas, private wells and on-site systems are (or for future houses will be) on the same site or nearby. In other words, drinking water is obtained from a point just a few metres away from where we dispose of our faeces and urine. The location of a private drinking well and an on-site wastewater system on the one site is inherently risky, unless the ground conditions are suitable, particularly with regard to the depth to bedrock.

## **2.5 Sources of Legislation & Guidance for Wastewater Disposal**

The legislation that governs wastewater treatment and disposal is quite broad and a plethora of various regulations have been enacted in relation to water quality. EU legislation through the WFD has already been discussed in detail in sections 2.3.5 to 2.3.7. This section will look primarily at the domestic legislation that is relevant to the research topic. The most relevant extracts from this legislation and guidance will be examined in brief detail to determine the objectives that are set down by the Irish government, state agencies such as the EPA and also from local authorities such as County Cavan in the north-west of Ireland. These bye-laws form a major component of this research with valuable lessons having been learned since their inception. Some critical analysis of this legislation will inform the research on how County Cavan has addressed the issue of contamination of drinking water from on-site wastewater treatment systems.

The recent Water Services Act 2007 and the Water Services (Amendment) Act 2012 will be examined also in this section.

### **2.5.1 Overview of Irish legislation**

Statutory Instrument No. 313 of 1952 enacted the Housing (Private Water Supply and Sewerage Facilities) Regulations of 1952. These regulations provided some guidance for property owners on how to locate and construct an on-site wastewater treatment system. The regulations were enacted to administer a grant scheme that was made available to homeowners to provide water and sanitary facilities where no public connections were available. The following is an extract from the regulations in this regard;

Schedule 1(5) – ‘Where a septic tank is provided it shall be situated if possible on the lowest part of the site and on the down-wind side of the house and shall be not less than 60 feet distant from any dwelling house or public roadway. The tank shall be watertight and the walls shall be constructed of concrete and of not less than 9 inches thickness. The minimum dimensions shall be 6 feet by 2 feet with an average liquid depth of 4 feet. The tank shall be provided with inlet and outlet T. pieces. The floor of the tank shall slope towards the inlet end. The tank shall be covered with concrete slabs which shall be arranged as to give ample ventilation and to permit of easy removal for cleansing purposes. The effluent from the septic tank shall be discharged through un-jointed pipes laid in the adjacent subsoil, if suitable for percolation, or otherwise disposed of by shallow sub-surface irrigation. The drain from the house to the septic tank shall be at least 4 inches in diameter laid with a minimum cover of 2 feet and at a gradient of approximately 1/48 and shall include a manhole for cleansing purposes. Satisfactory arrangements for disposing of the effluent from the septic tank shall be made including provision to ensure that there is no risk of contaminating a water supply’.

There were no planning laws operative in Ireland at the time so it was therefore at the discretion of the homeowner to build a home on whatever site they chose. This meant that the house and on-site wastewater system could be constructed no matter what the prevailing ground conditions were.

Statutory Instrument No. 23 of 1957 enacted the Housing (Private Water Supply and Sewerage Facilities) Regulations of 1957. Once again these regulations provided guidance to homeowners who were seeking grant assistance for the provision of a water supply and on-site wastewater treatment system. There were some modifications in these regulations from the 1952 regulations and the following is the relevant extract thereto;

Second Schedule Part II – Standards of Constructional Requirements in Respect of the Provision & Installation of Private Sewerage Facilities:

(3) ‘Where a septic tank is to be provided- the tank is to be situated, if possible, on the downhill part of the site and is not to be less than 60 feet distant from any dwelling house or public roadway; the tank is to have walls and floor of 9 inch thick mass concrete and be watertight and is to have a minimum average liquid depth of 4 feet and a minimum liquid capacity of 450 gallons; the width of the tank is to be the smallest practicable, normally 2 foot 6 inches and it is to be provided with an inspection chamber at the inlet end and with inlet and outlet T pieces dipped not less than 1 foot 3 inches in the tank liquid; the floor of the tank is to slope towards the inlet end; a baffle wall of concrete with a 12 inch deep opening for its full length adjoining the floor of the tank is to be provided; it is to have a cover consisting of concrete slabs suitably reinforced and capable of removal for cleaning purposes; ventilation holes with grids are to be provided in the roof over the T pieces; the effluent is to be discharged through un-jointed land drain pipes laid end to end to form an even gradient of approximately 1/180 over a drain filled with fine gravel; the bottom of the drain is to be flat, to be achieved if necessary by benching; the drain from the house to the septic tank is to be at least 4 inches in diameter, laid with a minimum cover of 2 feet at a gradient of approximately 1/48m and is to include a manhole for cleansing purposes;

atisfactory arrangements for the disposal of effluent from the septic tank are to be made, including provision for to ensure that there is no risk of contaminating any water supply.’

The introduction of the baffle wall in the regulations highlights an awareness of the necessity to have a 2 chamber septic tank system for settlement and segregation of solids in the system. Furthermore, it is notable also that there is more emphasis place on the percolation of effluent from the septic tank into pipes over fine gravel to better distribute the discharge.

### **2.5.2 Local Government Planning & Development Act 1963**

This was a landmark piece of legislation for on-site wastewater treatment systems and the provisions of dwelling houses as a whole. This Act came into force on the 1<sup>st</sup> October, 1964 under Statutory Instrument No. 211 of 1964 and for the first time it was now necessary to obtain planning permission to construct a house and an associated on-site sewage treatment facility. Nowlan (1999) outlines that this was an act to make provision, in the interests of the common good, for the proper planning and development of cities, towns and other areas, whether urban or rural including the preservation and improvement of the amenities thereof. Now the DoEHLG had made provision for local authorities to have discretion over how and whether development such as on-site wastewater treatment systems could be constructed. This would revolutionise the built environment in Ireland and offered some opportunity to prevent pollution from on-site wastewater treatment systems.

### **2.5.3 The Local Government (Water Pollution) Acts 1977 – 1990**

The Local Government (Water Pollution) Acts 1977 – 1990 sets out that a polluter is liable under common law for any damage to persons or property caused by pollution. However, Sec. 20 of the 1990 Act provides a new statutory liability for water pollution in addition to that provided by common law. This section provides that damages are recoverable in some circumstances when trade or sewage

effluents or other polluting matter enter waters and cause “injury, loss or damage to a person or the property of a person”. The persons liable to pay these damages are:

1. The occupier of any premises from which the effluent or polluting matter originated unless the entry to waters was caused by an act of God or an act or omission of a third party over whose conduct such occupier had no control, being an act or omission that such an occupier could not reasonably have foreseen and guarded against;
2. Any persons whose act or omission occasioned the entry of polluting matter to the waters where the act or omission, in the opinion of the court, constitutes a contravention by the person of a provision of the 1977 or 1990 Acts.

Where it appears to a local authority that it is “necessary” to do so in order to prevent or control water pollution, it may serve a written notice under Section 12 of the 1977 Act, as amended by Sec. 9 of the 1990 Act, on any person having custody or control of any polluting matter on premises in its functional area requiring action to be taken to prevent water pollution. Section 12(2) provides that the notice shall;

- a) specify the measures which appear to the local authority to be necessary to prevent polluting matters entering waters
- b) direct the person served to take specified measures; and
- c) specify a period within which such measures must be taken

Section 12(2A) provides that the notice may, either in addition to, or in lieu of complying with S.12(2)

- a) regulate or restrict in such manner and to such extent and for such period as may be specified in the notice or make subject to specified conditions the

carrying on of any activity, practice or use of premises that, in the opinion of the local authority concerned, could result in the entry of polluting matter to waters;

and;

b) requires the provision, relocation or alteration of facilities for the collection or storage of polluting matter

The Local Government (Water Pollution) Regulations 1978 made provision for the need to secure a licence to discharge waste, including waste water to ground and surface waters. There was a key exemption in these regulations and that was to exempt:

i) Domestic Discharges – domestic sewage not exceeding in volume 5 cubic metres in any 24 hour period which is discharged to an aquifer from a septic tank or any other disposal unit by means of a percolation area, soakage pit or any other method

The exemption of 5 cubic metres resulted in domestic houses automatically being exempt and homeowners were indemnified from having to licence their discharges from septic tanks and on-site wastewater treatment systems.

#### **2.5.4 The Environmental Protection Agency (EPA)**

The EPA is an independent public body that was established in July 1993 in Ireland. The Agency was formed under the Environmental Protection Act, 1992 sponsored by the Department of the Environment, Heritage and Local Government. Section 7 of the EPA Act, 1992 authorises the EPA to prepare and publish codes of practice for the purposes of providing guidance, with respect to compliance with any enactment or otherwise, for the purposes of environmental protection (EPA, 2010). The EPA is the competent authority appointed by Ireland for reporting to the EU and co-ordinating certain activities and for other tasks

assigned in the 2003 Water Policy Regulations. In relation to River Basin Management Plans which form a major component of the WFD, the EPA's particular responsibilities include assigning status, monitoring programmes and the review of the plans. Under Section 63 of the Environmental Protection Agency Act (no. 7 of 1992) as amended by the Protection of the Environment Act (No. 27 of 2003) the EPA is authorised to supervise the performance of all public authorities with statutory functions in relation to environmental protection (SERBD, 2009).

In March 2007 new Drinking Water Regulations were published by the DoEHLG which significantly changed the role of the EPA in relation to drinking water. The new powers that were assigned to the EPA were the following;

- Ensure local authorities are taking appropriate action to ensure that public water supplies comply with the relevant quality standards
- Review the actions taken by local authorities in public water supplies where there has been a breach of a standard or any other risk to human health
- Review and approve monitoring programmes to ensure that adequate monitoring is carried out by local authorities
- Audit local authority water treatment plants
- Publish guidance on how local authorities are to implement the regulations

While it is currently the responsibility of local authorities to ensure compliance with legislation such as the Building Regulations, the EPA are poised to become more involved as they will be charged with providing the regulations relating to on-site wastewater treatment systems.



### **2.5.5 Building Regulations 1997 - 2010**

The Building Control Act 1990 initiated a formal legislative basis for construction standards for all times of building and development works in Ireland for the first time. This Act mandated that specific Technical Guidance Documents be prepared for all aspects of construction and Technical Guidance Document H relates to Drainage and Wastewater Disposal and refers to on-site wastewater treatment systems. These regulations specify the acceptable materials, methods of construction, standards and other specifications such as on-going maintenance and repair of OSWTS's. The DoEHLG (1997) who have published these regulations promote the technology and guidance as set out by the National Standards Authority of Ireland (NSAI) in what is referred to in section 2.5.1 as S.R.6 (1991). A revision to Technical Guidance Document H in 2010 stipulated that the contents of the EPA Code of Conduct for Wastewater Treatment and Disposal Systems Serving Single Houses (2010) were to be treated as mandatory standards. Consequently the Building Regulations for the very first time provided a legal basis for the mandatory maintenance of OSWTS's in accordance with the EPA Code of Practice (2010).

### **2.5.6 Planning & Development Acts 2000 - 2002**

The Planning & Development Act 2000 made provision for the Planning & Development Regulations of 2001. Under these Planning & Development Regulations 2001, maps accompanying planning applications must show septic tanks and percolation areas, bored wells and other features in the vicinity of the structure or land to which the application relates (as amended by the Planning & Development Regulations 2002 - S.I. No.70 of 2002). Compliance with the Regulations intended to facilitate planning authorities taking measures required under the WFD to protect the quality of groundwater and to take account of the obligation to protect groundwater sources from direct and indirect discharges of harmful substances. Furthermore, the reference to adjoining bore-wells was intended to prevent harmful discharges near water supplies.

This legislation has been bolstered by the implementation of the Water Services Act, 2007 which will be discussed later in the chapter. Local Authorities who are also planning authorities have power to make provision for waste water services and other matters relevant to water management in development plans, to control - though their development plans and otherwise - the location of developments likely to cause water pollution or inimical to water management objectives, and to refuse permission for, or to permit subject to appropriate controlling conditions, development which may cause water pollution or impair water management objectives.

Under Article 22(2)(C) of the Planning & Development Regulations 2006, which take legal effect from the Planning & Development Act 2002; where it is proposed to dispose of wastewater other than to a public sewer from a development proposed as part of a planning application to a planning authority, the planning applicant must submit information on the type of on-site treatment system proposed and evidence as to the suitability of the site for the system proposed as part of that planning application (EPA 2009). Local Authorities have adopted groundwater protection schemes in development plans and have regard to the need for groundwater protection in their decision making under the Act. Groundwater schemes subdivide regions into three zones corresponding to regionally important aquifers (zone 2), locally important aquifers (zone 3) and poor aquifers (zone 4). A code of practice lists the generally acceptable and unacceptable activities in each zone. This will be discussed in further detail in section 2.6.2.

### **2.5.7 The Cavan Bye-Laws 2004**

The Local Government Code of 2001 confers on local authorities the option of making bye-laws which are mandatory in a limited locality. Within that framework and after the study in 2002, County Cavan adopted the Water Pollution Bye-Laws (2004) which implement a complete system of management of wastewater from all on-site wastewater treatment systems, old and new. The

introduction to the County Cavan Bye-Laws (2004) outlined that ‘Cavan has a dispersed, rural population which results in the majority of domestic sewage being treated by wastewater treatment systems for single houses. In recognition of this and the problems associated with inadequate systems, Cavan County Council has adopted the Water Pollution (Wastewater Treatment Systems for Single Houses) Bye-Laws 2004’. The Bye-Laws came into effect on the 1<sup>st</sup> July 2004 and the following are the main provisions of the Bye-Laws;

- The Bye-Laws shall not apply to persons that have an adequate connection to a public sewer or have a valid discharge licence.
- All persons required to do so shall provide an approved and properly functioning wastewater treatment system.
- All persons required to do so shall submit an assessment, by a competent person, of his/her wastewater treatment system by 31<sup>st</sup> December, 2005.
- Where no or an unapproved treatment system exists then the assessment shall be accompanied by a programme of measures to eliminate environmental pollution.
- Where faults exist the local authority shall be informed within 7 days of the assessment along with a programme for repair.
- Septic tanks and proprietary treatment systems shall be desludged at specified or recommended frequencies.
- An approved and properly functioning treatment system shall be installed by 31<sup>st</sup> December 2005.
- Unless otherwise agreed by the local authority, all houses whose boundaries lie within 100 metres of a public sewer shall connect to the said sewer.

- Newly installed systems shall be located so as to be accessible to servicing vehicles and so that the nuisance or hazard from any accidental spillage is minimised.
- Wastewater treatment systems must be properly maintained.
- Wastewater treatment system sludges must be removed routinely and disposed of properly.
- Wastewater treatment systems must be inspected at least every seven years. A certificate shall be given in proof of each inspection.
- Up to date records of inspections and maintenance must be maintained and these shall be available for inspection by local authority staff.

These Bye-Laws are unique to County Cavan and have attracted positive comment from the European Court of Justice (2009) and also from Irish commentators such as Nix (2010) and SWAN (2007). The prosecution of Ireland by the European Court of Justice as outlined in section 2.7.10 specifically excluded County Cavan because they had adopted these Bye-Laws. This provides some independent adjudication as to the merit and benefits brought to on-site wastewater treatment in County Cavan through the adoption of this local legislation.

### **2.5.8 The Water Services Act 2007**

The DoEHLG (2007) emphasises that this Act sets down a comprehensive modern legislative code governing functions, standards, obligations and practice in relation to the planning, management, and delivery of water supply and waste water collection and treatment services. To this end it both consolidates and modernises the legislative code governing water services. The Act places a duty of care on the occupiers of property to ensure that their on-site systems do not

cause a risk to human health or the environment, or nuisance through odour (South East River Basin District, 2009). The EPA (2010) outlines that Section 70 of the Act is specifically relevant to on-site wastewater treatment systems and as it refers to the general duties of an owner or occupier of property and that Section 70(2) specifically states that “the owner of a premises shall ensure that all drains, manholes, gulley-traps and storage and treatment systems for waste water, including related accessories, not in charge of a water service provider, which serve that premises are kept so as not to;

“cause, or be likely to cause, a risk to human health or the environment, including to waters, the atmosphere, land, soil, plants or animals, or create a nuisance through odours”

As of the current date there has been no prosecutions brought forward against the owners or occupiers of properties that are serviced by on-site wastewater treatment systems. Nevertheless, the legislation makes provision for such prosecution and provides a clear framework for same.

### **2.5.9 Water Services (Amendment) Act 2012**

The Water Services (Amendment) Act 2012 provides for the introduction of a registration and inspection system for domestic wastewater treatment systems, including septic tanks and similar systems. It has been introduced to address the European Court of Justice ruling against Ireland in October 2009 and even more importantly, to protect ground and surface water quality (particularly drinking water sources) from the risks posed by malfunctioning on-site wastewater treatment systems (DoEHLG, 2012). For the first time in Ireland owners of domestic wastewater treatment systems are required to register their systems in accordance with the Domestic Waste Water Treatment Systems (Registration) Regulations 2012 which were published to implement the Water Services (Amendment) Act 2012. Section 70 of the Water Services Act 2007 as discussed in section 2.5.8 already places a duty of care on the owner of a household to

ensure that their OSWTS does not cause a risk to human health or the environment or create a nuisance through odours. The new legislation is intended to augment the existing duty of care provisions. The Water Services Acts 2007 and 2012 (Domestic Waste Water Treatment Systems) Regulations 2012 set out the performance standards that treatment systems must comply with. The basic standard to be met by all domestic OSWTS's is that they do not cause a risk to human health or the environment as stipulated in the ECJ (2009) 188/08 ruling. The regulations also provide for the operation and maintenance of treatment systems and set out de-sludging requirements. Inspections of OSWTS's commenced in mid 2013 to determine if the inspected systems are working properly and are being maintained in accordance with Part H of the Building Regulations (2010) as discussed in section 2.5.5.

## **2.6 The On-Site Wastewater Assessment Process**

The review of existing literature has demonstrated that the EPA has been very active since 1993 in seeking to improve the process of on-site wastewater treatment and specifically in relation to the assessment of individual sites for suitability. Prior to the establishment of the EPA in 1993 there were systems in place for assessing whether sites were suitable of on-site wastewater treatment systems. There was also some basic design criteria for the location of systems in relation to drinking wells and water supplies which dated back to the 1950's. This section will examine the early guidance and legislation for on-site wastewater assessment and will move on to look at the assessment procedures developed by the EPA in 2000. This new method of assessment for sites will be examined in some detail and an extensive amount of independent comment will be analysed to illustrate how the procedure changed the landscape for on-site systems and prevention of groundwater pollution. Moving on from there the most recent EPA Code of Conduct (2010) will be discussed and the main changes from the 2000 guidelines will be identified. This new code has the potential to have a major impact on wastewater treatment from on-site systems and the larger doctoral research that is being undertaken needs to acknowledge this. This section will

conclude with an evaluation of how the new code is to be introduced into legislation as a mandatory provision rather than just a guidance document. A clear understanding of the assessment process for on-site systems will help the reader when moving into the final sections of this chapter which reflect upon existing research that has been carried out for on-site wastewater treatment systems at specific locations around Ireland.

### **2.6.1 S.R.6: (1991)**

S.R.6. was produced by the National Standards Association of Ireland (NSAI) in 1991 and the formal title of the document is ‘Septic Tank System – Recommendations for Domestic Effluent Treatment & Disposal from a Single Dwelling House’. These standards replaced and updated the 1975 edition and introduced the concept of a site assessment to determine whether a site was suitable for an on-site wastewater treatment system and to provide design and installation criteria thereto. This was revolutionary in Ireland as prior to this assessment you could effectively apply for planning permission without having carried out any intrusive survey of ground conditions. Daly et al (1993) refer to the SR6 process and suggest that a critical aspect of proper septic tank system location is the assessment of the site suitability, in particular the geological and hydrological factors. The assessment of site suitability is based on;

- a trial hole test
- a percolation test
- a visual inspection of the site

The suitability of a site depends on factors such as soil, subsoil, and groundwater characteristics. The main function of soil and subsoil is to treat and dispose of the effluent in an environmentally safe manner. The subsoil percolation rate must be high enough to allow the effluent to pass through it without ponding at the surface

but low enough to allow purification of effluent by filtration of harmful micro-organisms and to allow favourable chemical reactions. Thus the subsoil characteristics are vital in assessing pollution risks and site suitability (NSAI, 1991). SR6 also established some important deficiencies in the design of on-site wastewater treatment systems that had gone before. Section 2.5.1 emphasised that soakpits were not a satisfactory alternative to percolation areas. It also emphasised the fact that storm-water from drains around the house should not be piped into the effluent percolation area. The minimum distance between the house and the septic tank was significantly reduced from the 1952 and 1957 Regulations. Those regulations required that the minimum distance was to be 60 feet (20 metres). In SR6: 2001 this was reduced to 7 metres between the house and the septic tank that it served. This would result in smaller sites being necessary to build a house in un-sewered locations.

There were also very detailed specifications provided for the design of percolation areas as well as specifications on the materials to be used therein. Indicative measurements were provided for depths, widths and the numbers of people that percolation systems could accommodate. There was also provision for ‘reserve’ percolation areas which were effectively a contingency if the primary percolation area failed. Clear guidance was offered on the maintenance and de-sludging of septic tanks as well as an overview on the maintenance regime for the percolation areas. No reference is made however to any mandatory supervision of installation or maintenance.

### **2.6.2 Groundwater Protection Schemes (1999)**

The EPA (1999) suggests that a Groundwater Protection Scheme aims to maintain the quantity and quality of groundwater and in some cases improve it, by applying a risk assessment-based approach to groundwater protection and sustainable development. These protection schemes should help public authorities to meet their responsibility to protect groundwater. This would include planning

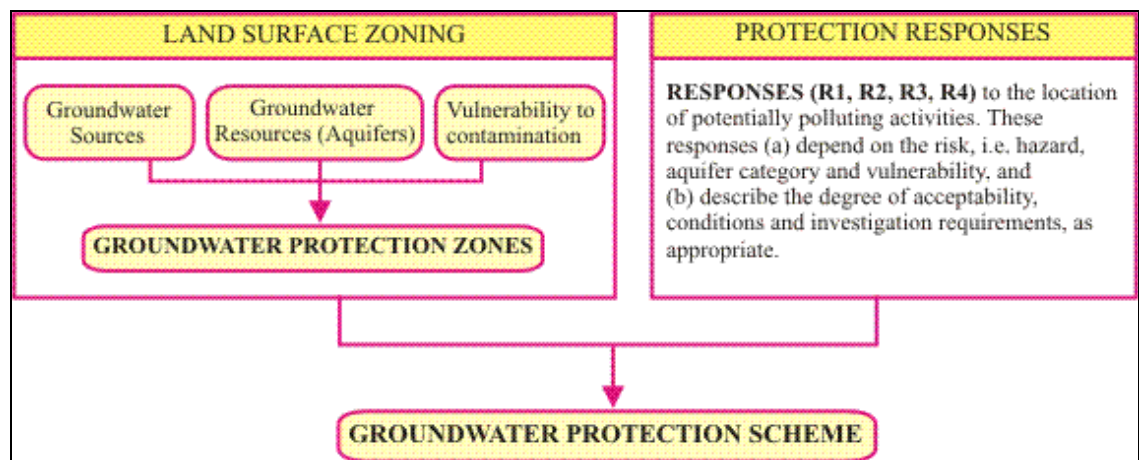


authorities which have a major function in the development and control of land use and the built environment. The GSI (1999) affirm this point by outlining that these schemes indicate the degree of risk or threat to groundwater from a human activity and therefore provide a powerful tool for environmental protection.

There are two main components that are integrated to produce a groundwater protection scheme and are highlighted in Figure 2.12;

- A land use zoning or objective
- A groundwater protection response for potentially polluting activities such as on-site wastewater treatment systems

**Figure 2.12: Components of a Groundwater Protection Scheme**



Source: EPA (1999)

The EPA produced a Groundwater Protection Schemes document in 1999 which outlined some key baseline issues as follows;

- Groundwater is an important source of water for industry, agriculture and drinking water

- Groundwater may be difficult to clean up, even when sources of pollution are removed
- Human activities are posing increasing risks to groundwater quality
- EU and national regulation require that pollution must be prevented as part of sustainable groundwater quality management

According to the EPA (1999) some local authorities in Ireland had been utilising groundwater protection schemes since the mid 1980's and it was now time to implement a national framework for all local authorities. This national framework would become part of the planning process and anticipated the forthcoming publication of the EPA Wastewater Manual (2000) which was in development. The DoEHLG (1997) referred to a number of key principles such as the 'Precautionary Principle' and the 'Polluter Pays Principle' and these were adopted by the EPA in the preparation of groundwater protection schemes. Therefore the imperative was placed on preventing groundwater pollution, whilst mandating those responsible for such pollution to be liable for the remediation of polluted groundwater. The EPA (1999) acknowledges that a significant problem has been the fact that groundwater is an underground resource and that for many people it is "out of sight and out of mind". The application of the above principles in the planning system would help to give the groundwater resource more exposure through the planning system. Groundwater protection schemes provide maps and categorisation of the vulnerability of groundwater resources across Ireland. The degree of vulnerability is determined by considering a number of factors such as;

- The sub-soils that overlie groundwater
- The type of recharge and source of proposed discharge to the groundwater
- The thickness of unsaturated zone through which the proposed contaminant will move before reaching groundwater

- The vulnerability of groundwater is classified under the groundwater responses scheme as; Extreme (E), High (H), Moderate (M) or Low (L). Figure 2.13 offers an insight into how planning authorities could see from a desk study areas where groundwater would be at risk from contamination by on-site wastewater treatment systems.

**Figure 2.13: Vulnerability Classification**

| Vulnerability Rating  | Hydrogeological Conditions                |  |  |                             |                |
|---|---|--|--|-----------------------------|----------------|
|   | Subsoil Permeability (Type) and Thickness |  |  | Unsaturated Zone            | Karst Features |
|   | High permeability (sand/gravel)           | Moderate permeability (e.g. Sandy subsoil) | Low permeability (e.g. Clayey subsoil, clay, peat) | (Sand/gravel aquifers only) | (<30 m radius) |
| <b>Extreme (E)</b>  | 0 - 3.0m                                  | 0 - 3.0m                                   | 0 - 3.0m   | 0 - 3.0m                    | -              |
| <b>High (H)</b>   | > 3.0m                                    | 3.0 - 10.0m                                | 3.0 - 5.0m   | > 3.0m                      | N/A            |
| <b>Moderate (M)</b>   | N/A                                       | > 10.0m                                    | 5.0 - 10.0m  | N/A                         | N/A            |
| <b>Low (L)</b>  | N/A                                       | N/A  | > 10.0m  | N/A                         | N/A            |
| Notes: (1) N/A = not applicable.<br>(2) Precise permeability values cannot be given at present.<br>(3) Release point of contaminants is assumed to be 1-2 m below ground surface. |   |  |  |                             |                |

Source: EPA (1999)

The Geological Survey of Ireland (GSI, 1999) have compiled maps for large portions of Ireland which are accessible digitally and the vulnerability rating for proposed development sites can be determined. This procedure became part of the on-site wastewater assessment procedure whereby the Site Characterisation Form required the vulnerability rating to be documented. In circumstances where a groundwater protection scheme had not been mapped by the GSI then the procedure set down by the EPA was to assume the area had an extreme (E) vulnerability classification.

Microbiological problems are also observed in the more vulnerable aquifers because they have little natural protection from organic wastes, such as septic tank effluent or farmyard manure (Daly & Craig, 2009). The EPA (1999) set out a response matrix to assist in the determination of the suitability of sites as follows;

Figure 2.14: Response Matrix for On-site Treatment Systems

| VULNERABILITY RATING | SOURCE PROTECTION AREA * |                 | RESOURCE PROTECTION<br>Aquifer Category |                 |                   |                 |                 |                 |
|----------------------|--------------------------|-----------------|---|-----------------|-------------------|-----------------|-----------------|-----------------|
|                      |                          |                 | Regionally Important                    |                 | Locally Important |                 | Poor Aquifers   |                 |
|                      | Inner (SI)               | Outer (SO)      | Rk                                      | Rf/Rg           | Lm/Lg             | L1              | Pl              | Pu              |
| <b>Extreme (E)</b>   | R3 <sup>2</sup>          | R3 <sup>1</sup> | R2 <sup>2</sup>                         | R2 <sup>2</sup> | R2 <sup>1</sup>   | R2 <sup>1</sup> | R2 <sup>1</sup> | R2 <sup>1</sup> |
| <b>High (H)</b>      | R2 <sup>4</sup>          | R2 <sup>3</sup> | R2 <sup>1</sup>                         | R1              | R1                | R1              | R1              | R1              |
| <b>Moderate (M)</b>  | R2 <sup>4</sup>          | R2 <sup>3</sup> | R1                                      | R1              | R1                | R1              | R1              | R1              |
| <b>Low (L)</b>       | R2 <sup>4</sup>          | R1              | R1                                      | R1              | R1                | R1              | R1              | R1              |

|                 |  |
|-----------------|--|
| R1              | Acceptable subject to normal good practice (i.e. system selection, construction, operation and maintenance in accordance with EPA (2000)).   |
| R2 <sup>1</sup> | Acceptable subject to normal good practice. Where domestic water supplies are located nearby, particular attention should be given to the depth of subsoil over bedrock such that the minimum depths required (EPA, 2000) are met and that the likelihood of microbial pollution is minimized.   |
| R2 <sup>2</sup> | Acceptable subject to normal good practice and the following additional condition:<br><br>1) There is a minimum thickness of 2 m unsaturated soil/subsoil beneath the invert of the percolation trench of a conventional septic tank system;<br><b>OR</b><br><br>1) A treatment system other than a conventional septic tank system as described in EPA (2000) is installed, with a minimum thickness of 0.6 m unsaturated soil/subsoil with P/T values 1 from 1 to 50 (in addition to the polishing filter which should be a minimum depth of 0.6 m), beneath the invert of the polishing filter (i.e. 1.2 m in total for a soil polishing filter). |
| R2 <sup>3</sup> | Acceptable subject to normal good practice, condition 1 above and the following additional condition:<br><br>2) The authority must be satisfied that, on the evidence of the groundwater quality of the source and the number of existing houses, the accumulation of significant nitrate and/or microbiological contamination is unlikely.  |
| R2 <sup>4</sup> | Acceptable subject to normal good practice, conditions 1 and 2 above and the following additional condition:   |

|                 |   |
|-----------------|---|
|                 | 3) No on-site treatment system should be located within 60 m of the public, group scheme or industrial water supply source.   |
| R3 <sup>1</sup> | <p>Not generally acceptable, unless:</p> <p>A conventional septic tank system is installed with a minimum thickness of 2 m unsaturated soil/subsoil beneath the invert of the percolation trench (i.e. an increase of 0.8 m from the EPA manual);</p> <p><b>OR</b></p> <p>A treatment system other than a conventional septic tank system, as described in EPA (2000), is installed with a minimum thickness of 0.6 m unsaturated soil/subsoil with P/T values from 1 to 50 (in addition to the polishing filter which should be a minimum depth of 0.6 m), beneath the invert of the polishing filter (i.e. 1.2m in total for a soil polishing filter);</p> <p>AND subject to the following conditions: 1)The authority must be satisfied that, on the evidence of the groundwater quality of the source and the number of existing houses, the accumulation of significant nitrate and/or microbiological contamination is unlikely. 2)No on-site treatment system should be located within 60 m of the public, group scheme or industrial water supply source. 3) A management and maintenance agreement is completed with the systems supplier.</p> |
| R3 <sup>2</sup> | <p>Not generally acceptable unless:</p> <p>A treatment system other than a conventional septic tank system, as described in EPA (2000), is installed with a minimum thickness of 1.2 m unsaturated soil/subsoil with P/T values from 1 to 50, (in addition to the polishing filter which should be a minimum depth of 0.6 m) beneath the invert of the polishing filter (i.e. 1.8m in total for a soil polishing filter);</p> <p><b>AND</b></p> <p>subject to the following conditions:</p> <p>1)The authority must be satisfied that, on the evidence of the groundwater quality of the source and the number of existing houses, the accumulation of significant nitrate and/or microbiological contamination is unlikely.</p> <p>2) No on-site treatment system should be located within 60 m of the public, group scheme or industrial water supply source.</p> <p>3) A management and maintenance agreement is completed with the systems supplier.</p>  |

Source: EPA (1999)

This groundwater response matrix provided a major advancement in the consideration of groundwater for local authorities and provided an early indication of the suitability of sites for an on-site wastewater treatment system. A significant indicator in the determination of vulnerability is the aquifer type that underlies the ground. From Figure 2.12 there is reference to regionally important, locally important and poor aquifers. The regionally important aquifer suggests that there is a high provision of drinking water derived from this productive source. At the other end of the scale, poor aquifers are unproductive and therefore it is unlikely that a significant amount of drinking water can be derived from this source. If there is a high concentration of inappropriate on-site wastewater treatment systems in the location of a regionally productive aquifer, then there is an extreme risk of drinking water contamination. Figure 2.6 demonstrates this scenario specifically in the north-west of Ireland. It is notable from the red dots that there is a high incidence of faecal contamination in excess of 100 per 100ml of water in an area highlighted as having a regionally important aquifer. This information is invaluable and demonstrates how the Groundwater Protection Responses could identify where drinking water supplies are most at risk.

### **2.6.3 EPA Wastewater Manual (2000)**

This EPA Wastewater Manual was published by the EPA in 2000 to “provide guidance on the design, operation and maintenance of on-site wastewater treatment systems for a single house”. Reference is made in the manual to the NSAI and their standard recommendations of 1975 and 1991 for the design, construction and maintenance of septic tank drainage systems. The EPA (2000) outline though that the 2000 manual “has been prepared to having regard to the above and will *inter alia* assist planning authorities, developers, system manufacturers, system designers and system operators to deal with the complexities of on-site systems”. The manual was prepared following completion of a research study that was completed under the direction of the EPA in the period 1995 to 1997. The study was co-ordinated by the Department of Civil Engineering at the National University of Ireland in Galway as part of the

Operational Programme for Environmental Services (1994 – 1999) implemented by the DoEHLG. This research concluded that S.R.6 (1991) was outdated and that improvements were required to the legislation. Duffy (2010) identified that a significant problem though for the EPA Manual (2000) was that it is a guidance document only and that there is not an onus on Local Authorities to implement the manual. From a legal perspective, Part H (Drainage & Waste Water Disposal) of the Irish Building Regulations 1997 still refers to S.R.6. (1991) as the legislation which governs on-site wastewater treatment systems. Therefore both the EPA Manual (2000) and the Groundwater Protection Responses (1999) were merely advisory documents without legal foundation. As outlined later in Section 5.4, the recent ECJ ruling (C-188/08) of Ireland found that the standards in Building Control Standard S.R.6 of 1991 (referred to in Technical Guidance Document H) are not suited to the geological and soil characteristics generally found in Ireland.

It therefore determined that planning permissions granted on the basis of these standards did not ensure a level of environmental and human health protection that is required under EU law (IPA, 2009). The ECJ (2009) cited the example of County Cavan in Ireland where Bye-Laws were introduced in 2004 as discussed in section 2.5.7 making the EPA Manual (2000) mandatory for both new and existing on-site wastewater treatment systems. The ECJ confirmed that these Bye-Laws in Cavan constituted an adequate legal mechanism for complying with EU legislation. Duffy (2010) complements this opinion and suggests that the EPA Manual (2000) was an excellent document and that if all on-site wastewater treatment systems were designed and constructed in accordance with the manual since its publication then we would have a much easier task today in rectifying the issue of groundwater pollution. Construct Ireland (2003) outlined that the EPA Manual (2000) and the Groundwater Protection Responses (1999) set out a robust framework for locating on-site systems in a way that minimises the impact on the environment and human health. They significantly upgrade the building regulations (S.R.6. 1991) and take greater account of both the need for a comprehensive site characterisation as a basis for decision making. According to Limerick County Council (2005) the EPA Manual (2000) provides detailed guidance in how sites should be assessed and how systems should be designed so

as to improve the level of protection afforded to both the aquatic environment and human health. They outline that the S.R.6. (1991) standards date back to the mid 1970's and considers it to be outdated in that it only dealt with septic tank systems and does not give guidance on more modern systems of wastewater treatment. Limerick and some other counties in Ireland did adopt the EPA Manual (2000) in the later part of the last decade as the 'rule of thumb' for new development, but made no effort to address the issue of existing systems. Critically however and as identified by the EU Commission (2009) the legislative basis for on-site systems which is Part H (Drainage & Waste Water Disposal) of the Irish Building Regulations 1997 refers to the outdated S.R.6 (1991) standards which are inappropriate for the approximately 500,000 on-site treatment systems in Ireland currently (CSO, 2012). Furthermore, the DoEHLG (2010) outlines that the ECJ in Ruling (C-188/08) were concerned that it was not a legal requirement for local planning authorities to use the EPA Manual (2000).

#### **2.6.4 The On-Site Assessment Procedure**

Due to the ever increasing pressure on the planning authorities to develop more rural sites, a rigorous site assessment procedure was introduced by the EPA Wastewater Manual (2000). This procedure consists of a desk study followed by an on-site assessment which aims to determine the vulnerability of local groundwater resources. The publication of the guidance manual is aimed at protecting groundwater resources from contamination by domestic wastewater effluent by defining acceptable site suitability criteria (Gill et al., 2005). This concept of a thorough site assessment was revolutionary according to the GSI (1999). The three stages of the on-site assessment are introduced below and incorporate the trial-hole test, the percolation test and the visual inspection of the site. The following is a description some detail as to the procedures at each stage;



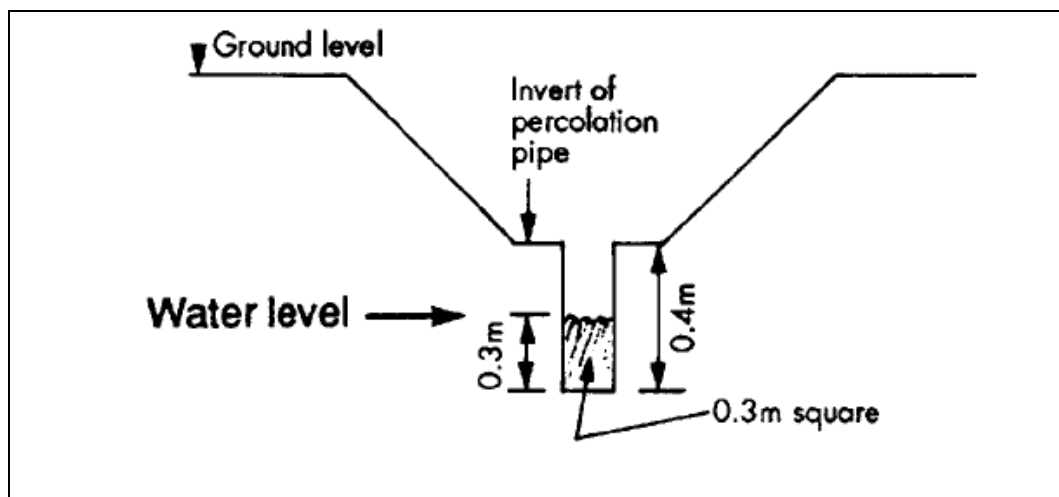
### Stage 1 - The Trial Hole Test:

A trial hole shall be dug to a minimum of 1 metre square and to a depth of 2 metres. Alternatively the depth can be adjusted to 1.5 metres below the depth of the invert level of the lowest percolation pipe (the level at where effluent discharges from the percolation pipework into the ground). The hole shall be covered and left for not less than 48 hours and at thereafter the depth of water in the hole should be measured. Daly et al (1993) further point out that the trial hole test will identify the depth from ground surface to bedrock, if any. In cases where bedrock is identified in the trial hole, where the site is in excess of 4,000 square metres or where there is a slope in excess of 1:20 a second trial hole should be excavated.

### Stage 2 - The Percolation Test:

The percolation test procedure involves the excavation of four holes at dimensions of 0.3 metres squared to a depth of 0.4 metres. Figure 2.15 is an illustration of how these holes should look;

**Figure 2.15: Cross Section of Percolation Test Hole**



Source: NSAI (1991)

Water to a depth of 0.3 metres is added to the holes and additional water shall be added to maintain this depth until the subsoil has become swollen and saturated. This saturation is required to replicate the environment in the percolation trenches. Once saturated the required time for water to recede in the hole by 0.1 metres shall be measured. This time in minutes is divided by 4 to determine the percolation rate for 0.025 metres and the result is expressed as the 'T' value. Daly et al. (1993) suggest that the percolation test enables the determination of the percolation properties or drainage characteristics of the subsoil. It involves the addition of water to a carefully prepared test hole and measurement of the drop in water level. The results of the percolation test can then be used to decide if the site is suitable or unsuitable for the development of an on-site wastewater treatment system. Furthermore, if deemed suitable, the T test result will determine the size and scale of the percolation area that will be required.

**Figure 2.16: Relationship Between 'T Test' Result and Percolation Area Requirements**

| <b>Table 1. Percolation Areas</b> |                              |
|-----------------------------------|------------------------------|
| <b>Value of 'T' Distribution</b>  | <b>Length of piping in m</b> |
| From 5* up to 10                  | 30                           |
| Above 10 up to 15                 | 36                           |
| Above 15 up to 30                 | 48                           |
| Above 30** up to 60               | 96                           |

\*'T' values < 5 may indicate a percolation rate that is too fast, possibly leading to pollution of the groundwater.

\*\*'T' values > 30 may indicate a percolation rate that is too slow, possibly leading to ponding of effluent at the site of the percolation area.

Source: NSAI (1991)

### Stage 3 - The Visual Inspection:

The visual inspection requires the 'common sense' of the person undertaking the test to be applied. Sites which are on depressions, or at the bottom or on concave of slopes are likely to be problematic.

Consideration should be given to issues which could point to poor percolation such as a high density of streams, water sensitive vegetation and poor soil texture.

The texture of the soil can be determined by following the procedures set out by NSAI (1991) in Figure 2.17;

**Figure 2.17: Soil Texture Characteristics**

|   |   |
|---|---|
| (i) When the subsoil is moist, take a sample and rub it between the palms of the hands. For each of the subsoil materials the result will be as shown |   |
| <u>Subsoil Materials</u>  | <u>Result</u>   |
| 1. Clean gravel   | Leaves no residue on hands; friable.  |
| 2. Sandy gravel, sand   | Leaves some grains on hands; friable.   |
| 3. Silt   | Leaves a thin dirty film; can also be detected by rubbing between the fingers.  |
| 4. Clay   | Sticky on hands, tenacious. If rolled in the palm of the hand, a moist sediment will form a ball which can be rolled into a narrow string; the thinner the string that can be made without crumbling the higher the clay content. |
| (ii) When the subsoil is dry, take a sample and rub it between the palms of the hands. For each of the subsoil materials the result will be as shown: |   |
| <u>Subsoil Materials</u>  | <u>Result</u>   |
| 1. Clean Gravel )   | Clods (if formed) can be crushed readily in the hand.   |
| 2. Sandy gravel, )  |   |
| 3. Clay, silty clay   | Clods will be formed which will be difficult to crush.  |

Source: NSAI (1991)

Daly et al. (1993) also recommend that the practitioner have regard to existing drinking wells in the vicinity as well as the density of on-site systems nearby. These are of critical importance in ensuring the preservation of water quality and preventing the contamination of drinking water supplies from domestic effluent. The Sustainable Water Network (SWAN, 2007) highlights some concerns about this site test process and specifically that there is totally inadequate monitoring of the test being undertaken with results varying by the time of year that tests are completed and the prevailing weather conditions. They express further concern that those who carry out on-site assessments are not unbiased and that the tests should be carried out by independent person appointed by the local authority.

### **2.6.5 EPA Code of Practice 2010**

The EPA Code of Practice for Wastewater Treatment Systems and Disposal Systems Serving Single Houses was published in October 2010. This new Code of Practice updates the earlier manual published in 2000 that was discussed in section 2.6.3. This revised code sets standards for new developments. According to the DoEHLG (2010) the code requires a new set of percolation tests to be administered to assess the ability of the soil to absorb water. New limits have been set to determine if sites are suitable for development of an on-site wastewater treatment system.

The EPA (2010) outlines that the new Code is in two sections;

1. Details the requirements and standards to be achieved in wastewater treatment for single houses
2. Contains further guidance on how to achieve compliance with the Code

They go on to identify that the key messages from the Code of Conduct (2010) are as follows;

- The importance of proper site assessment taking account of local conditions and of wider experience in the area, development plans and other policies
- The need for design of on-site wastewater treatment systems specific to local conditions
- The need for follow through by the builder / homeowner / supervisory authority i.e. installation, commissioning and maintenance as per design and planning conditions

- Specifically the EPA (2010) outline that the new Code of Practice will make no difference unless the following issues are adhered to;
- Competent / professional assessors, installers and maintenance contractors are used and provide documented evidence of assessment, installation, operation and maintenance
- Homeowners / builders accept responsibility to ensure that wastewater treatment systems are “kept so as not to... cause, or be likely to cause, a risk to human health or the environment, including to waters, the atmosphere, land, soil, plants or animals, or create a nuisance through odours”
- Acceptance that not all sites are suitable for discharge of treated wastewater to ground and that sites will fail
- Packaged treatment systems will not work in all and every case
- Effective enforcement is essential

From a planning perspective, the publication of the new Code of Practice is a very significant step forward in ensuring environmentally sustainable rural development in line with the statutory planning guidelines on Sustainable Rural Housing (2005) which has recently been published by the DoEHLG (IPI, 2010). The GSI (2009) outline that the new Code of Practice sets out the following;

- An assessment methodology for the determination of site suitability for an on-site wastewater treatment system and identification of the minimum environmental protection requirements
- A methodology for the selection of a suitable on-site wastewater treatment system for sites in unsewered rural areas

- Information on the design and installation of conventional septic tank systems, filter systems and mechanical aeration systems
- Information on tertiary treatment systems
- Maintenance requirements for all systems

In learning from the legislative mistakes outlined by the ECJ in case (C-188/08), the DoEHLG (2010) has revised Part H of the Building Regulations so that the EPA Manual (2010) becomes the standards that are applied from a legal perspective as discussed in section 2.5.5. This inclusion is in response to the ECJ (2009) where they expressed concern that it is not a legal requirement for planning authorities to use the Code of Practice issued by the EPA. SWAN (2007) previously highlighted this concern and stated that “guidance on best practice will be broadly ineffective since it is not in itself a ‘control’ unless it is translated into enforceable regulations”. On the 22<sup>nd</sup> April, 2010 the Minister for the Environment commented in the Irish Parliament that “implementation of the Code of practice is a key step in addressing a recent ECJ judgement (C-188/08) which found that Ireland was in breach of Article 4 of the EU Waste Directive 2006/12/EC which requires all EU Member States to take measures to ensure that waste, which includes wastewater from septic tanks and proprietary waste systems, is recovered and disposed of without endangering human health and without using processes that could harm the environment. In this regard the EPA Code of Practice lays down the technical standards to comply with Ireland’s duty of care under Article 4 of the Waste Directive, but in particular to ensure that the disposal of waste water systems for single dwellings does not give rise to public nuisance, health risk or damage to the natural environment”.

A shortcoming in the adoption of the Code of Practice (2010) into the Building Regulations has been identified though by the DoEHLG (2009). This shortcoming relates to existing development and specifically it states that “in general Building Regulations apply to the construction of new buildings and extensions and material alterations to buildings. In addition, certain parts of the regulations apply

to existing buildings where a material change of use takes place. Otherwise, Building Regulations do not apply to buildings constructed prior to 1<sup>st</sup> June, 1992”. Nix (2010) affirms this by stating that the Irish Government will soon start a public consultation process on the rules for new buildings but what about all the existing systems? It is clear that the EPA Code of Practice (2010) as adopted into Building Regulations is powerless in relation to existing on-site wastewater treatment systems that are problematic. Consequently, the Joint Oireachtas Committee on the Environment, Heritage and Local Government (2010) published a report on the EPA Code of Practice and made suggestions and representations on how best to address both existing and new systems in the Building Regulations.

## **2.7 Critical Review of OSWTS's**

The term on-site wastewater treatment system (OSWTS) has been established to refer to a system which treats domestic effluent from a residential dwelling that is not served by a municipal wastewater treatment facility. There are many different types of OSWTS however and the applicability of a system to the site it is situated on can have a huge influence on its performance (IOWA, 2013). This section will examine in some detail the different types of OSWTS that are prevalent in Ireland.

### **2.7.1 The Conventional Septic Tank**

The septic tank is according to the Irish On-Site Wastewater Association (2010) the most common form of on-site wastewater treatment system in Ireland, making up some 90% of all systems. Kahn et al (2000) offer a broad definition of the traditional septic tank system and suggest that “the gravity powered septic tank is a wonder of technology – past and present. Its operation is so quiet, natural and energy free that we tend to forget the vital function it serves. Sewage is carried from the house to the tank via gravity – no motors, no fossil fuel energy consumption and no noise.

Wastewater goes from the tank to the drainfield – also via gravity – where micro-organisms in the soil digest and purify bacteria and viruses.” Woodson (2003) defines a septic tank as “a tank that separates sewage into solids and liquids by the processes of sedimentation, flotation and bacterial action. The liquid is then discharged into a soil absorption system”. Sewage flows by gravity from the house to the tank. Occasionally sewage must be mechanically pumped upward into a tank at a higher level. There the sewage stands for the time needed for anaerobic bacteria to break down the solids. Incoming sewage displaces a like quantity of liquid, which flows from the tank outlet by gravity or by pumping if necessary. This displaced fluid is called ‘effluent’. Gill et al (2005) suggest that a recommended septic tank treatment process involves domestic wastewater, excluding roof and storm water drainage, flowing into a chambered tank in which primary sedimentation occurs and also some anaerobic digestion. The effluent then overflows into a suitable subsoil percolation area where further physical, chemical and biological treatment processes occur. Conventional septic tank systems produce an effluent that poses a significant threat to both human health and the environment, particularly in terms of microbial pathogens, nitrogen and phosphorous (Daly, 2003). Nevertheless, Daly (2001) does identify that “where the subsoil is free draining and sufficiently thick, conventional septic tank systems are a sustainable, least cost option”. The National Centre for Freshwater Studies at the Dundalk Institute of Technology (2008) suggests that on-site wastewater systems can be divided into two broad categories, septic tanks and secondary treatment systems or proprietary systems.

A conventional septic tank system comprises a tank, which is designed for the removal of solids followed by a soil percolation area. Most of the treatment of effluent takes place in the subsoil as it passes through the percolation area. Various physical, chemical and biological interactions occur in the subsoil which removes bacteria and other pollutants and renders the wastewater suitable for discharge. According to DETA Ireland (2010) a conventional septic tank processes wastewater by anaerobic activity and solids settlement only. A conventional septic tank is totally dependent on the soil disposal system to treat the wastewater prior to entry to groundwater. Soil and subsoil can provide an



excellent and cost effective media for the treatment and attenuation of contaminants from domestic wastewater provided that the hydrogeological conditions are suitable (EPA, 2000). Daly (2003) refers to the conditions described by the EPA as the basis for the successful use of conventional septic tank systems worldwide. There is no doubt according to Daly (2003) though that there are large areas of Ireland with suitable subsoil conditions where a properly installed system will use the ground to adequately treat the effluent from the on-site wastewater system so that the risk to the environment and human health is minimal. A notable point to mention here is the reference to ‘properly installed’ systems. It is also relevant to mention that Daly (2001) indicates that up to 50% of national territory might be unsuitable for conventional septic tank systems. The operation of the septic tank system is natural and requires no input from electricity and there are no moving parts or wearing components. According to Daly (2003) “in this era where the sustainable development principle is part of our environmental policy, the septic tank is the most sustainable of all the available systems”. Septic tanks are primarily sedimentation basins, although a minor degree of solids destruction may occur as a result of anaerobic activity. Units are ordinarily sized to provide a 24 hour retention time at average daily flow. Modern septic tanks are manufactured of both concrete and fibreglass. The inlet and outlet pipes are baffled in order that floating material and grease will be retained. Heavy solids, including most organic solids settle to the bottom where some biological activity may occur. (McGhee, 1991). The EPA (2000) suggests that septic tank systems are the simplest and most basic of the systems allowed. They are based on gravity flow and use the available natural site conditions to carry out the following;

- treat the contaminants from the domestic wastewater
- dispose of the effluent
- prevent environmental and health impact

A septic tank has one or two chambers and domestic wastewater or sewage enters the first chamber where most of the solids either settle or float leaving the clearer liquid top pass out of the tank or on to the next chamber for further settlement. The incoming wastewater displaces the water already in the tank in the same way that a bath would overflow if the tap was left running. When water is displaced from the final chamber, most of the gross solids and about one third to one half of the organic load has been retained as sludge and floating crust. This sludge or crust must be removed periodically so that the system continues to operate effectively (Grant et al, 2000).

### **2.7.2 Disadvantages of Conventional Septic Tank Systems**

According to Daly (2001) there can be no doubt that groundwater has been contaminated from conventional septic tank systems. He outlines that septic tank systems are one of the main sources of bacteriological pollution of private drinking wells in Ireland. This situation is reflective more of inadequate construction and location of systems however, rather than the system itself. Septic tanks only provide primary treatment and so should be followed by a percolation area or secondary treatment system before the effluent is discharged to surface or groundwater (Grant et al, 2000). The concern of Daly (2001) is that not all septic tank systems have provision for secondary treatment. According to EPA (2000) a septic tank is well suited to the breakdown of human excrement, and a well designed, properly used and maintained system is one of the best choices for waste disposal. However, there are many potential problems with septic tanks. One such problem is that people put a lot more than human waste down their drains. Even simple food items such as too much grease, cooking oil or fat may greatly reduce the efficiency of the system. Household cleaners, paints and other substances are toxic to the bacteria which make the system operate properly. Excesses of these chemicals may cause a severe disruption to the septic tank system. Moore (2005) suggests that in Ireland a significant number of septic tank systems do not function properly for one of three reasons;

- Located in areas with unsuitable subsoil
- Poorly designed, constructed, installed and maintained
- Use of soak-aways rather than percolation areas

It is notable from the issues identified by Moore (2005) that they are human faults rather than the fault of the septic tank system itself. Human error and misjudgement give rise to all three points. Tebbutt (1998) outlines that effluent from septic tanks will probably be high in organic content and possess large numbers of micro-organisms and therefore the indiscriminate release to the environment of such effluent would create health hazards. Nix (2010) suggests that septic tanks at coastal holiday homes are the worst offenders. This is due to the fact that they are used intermittently and the 'shock loading' of occasional use does not permit bacteria to break down the solids and adequately separate the effluent. These systems tend to break down more often and were inappropriately designed in the first place.

### **2.7.3 Secondary & Tertiary Treatment Systems (Advanced Systems)**

In situations where a septic tank installation is not suitable, some form of secondary treatment system such as a mechanically aerated system or filter system (Tertiary System) may be installed to improve the quality of the effluent before discharge to the subsoil, if ground conditions allow (Gill et al., 2005). Secondary and Tertiary Treatment Systems are systems that undertake more advanced treatment of domestic wastewater than conventional septic tanks. This is why they are sometimes referred to as 'advanced systems'. According to Daly (2003) advanced systems provide additional treatment of wastewater, particularly in reducing BOD, COD and pathogens but do not reduce the quantity of effluent generated. The most important benefits identified by Daly for advanced systems are:

- a) They are certified by the Irish Agreement Board.
- b) They are constructed and installed under the supervision of professional staff.
- c) They reduce pollutant loading, relative to conventional septic tank systems.
- d) They can be used in areas that are not suitable for conventional septic tank systems.

The Sustainable Water Network (SWAN, 2004) outlines that many modern wastewater treatment systems such as secondary and tertiary systems require an electric pump to operate effectively. They refer to evidence that often these pumps are not connected to the electricity supply or are not switched on. This evidence that SWAN refers to does reflect the findings of the National Source Protection Pilot Project (NSPPP) which will be discussed in section 2.6.6 whereby over 40% of systems were simply not switched on. Consequently, these systems that are not switched on are merely storage tanks for untreated effluent and provide little or no protection to the environment.

#### **2.7.4 Existing Research on OSWTS's**

According to Daly (2003) “the issue of so called ‘one-off’ housing is controversial at present. Tens of thousands of new houses will be built in un-sewered areas in the coming years. However, effluent from on-site wastewater treatment systems in these areas poses threats to human health (from microbial pathogens in particular) and the environment (mainly from nitrogen and phosphorus)”. Moore (2005) suggests that there will be approximately 20,000 new homes built annually that will be serviced by on-site wastewater treatment systems and that one-third of the national population live in rural areas. Grimes (2010), outlines that construction activity in rural areas has varied in recent years but that 15,000 to 20,000 un-

sewered homes are built in rural areas each year. The IOWA (2010) have suggested more recently however that 3,000 – 5,000 on-site wastewater treatment systems are being installed annually to reflect the demise of the overall construction industry in Ireland. Nevertheless, this is still a significant figure of new systems. The DoEHLG (2010) admits that there is no national performance standard or monitoring arrangements for the 440,000 existing on-site wastewater treatment systems in Ireland. It suggests that in order to address the ECJ (C-188/08) ruling it will be necessary to develop such performance standards and establish monitoring arrangements for the existing stock of systems. They specifically point out though that establishing such standards is not straightforward. There has been localised research undertaken on the performance of on-site systems in certain locations and these will be examined later in this chapter. The EPA (2010) have suggested though that from unpublished work completed for the River Basin Management Plans as part of the EU Water Directive that approximately 25,000 on-site wastewater treatment systems are considered to pose a risk to groundwater with a much larger number of approximately 120,000 posing a risk to surface water. These systems will require remediation and possible replacement, especially those located in areas of high vulnerability and poor permeability.

#### **2.7.5 National Source Protection Pilot Project (NSPPP)**

The National Rural Water Monitoring Committee has undertaken a research project titled the National Source Protection Pilot Project (NSPPP). The project was set up in 2005 and the research has identified that “very little definitive work has been undertaken on the impact of on-site wastewater treatment systems”. The committee refer to the importance of being able to quantify the effects of on-site wastewater treatment systems on water quality in order to improve management of our water resources and to meet the requirements of the WFD. The project was undertaken in the Milltown Lake Catchment area in County Monaghan and was set up to co-ordinate efforts to monitor and assess water quality in the catchment area and to identify reasons for the deterioration of the water in the area. The

committee outlined as an objective that “it is important to be able to quantify the effects of on-site wastewater treatment systems on water quality in order to improve management of our water resources and to meet the requirements of the WFD”. The project aimed to develop an understanding of on-site wastewater systems and to provide quantifiable data on their contribution to nutrient loading in the catchment area. On-site wastewater treatment systems were identified as a potential source of contamination and a total of 154 households in the area cooperated with the surveys undertaken with questionnaires and non-intrusive surveys completed during 2006.

The types of question asked of the participating homeowners are as follows:

- The age and type of on-site wastewater treatment system they had?
- The frequency that their system was de-sludged?
- The number of people resident in the house and the number of showers, baths and toilets in the house?

Of the 154 that cooperated, over 90% of the houses were identified to be using a conventional septic tank system. Of those surveyed, 27% had never de-sludged their systems which is imperative to ensure proper system performance. A subset of 42 systems were further inspected to determine the materials used in their construction, the type of effluent dispersal system and the overall condition of the site. Of these 42 systems, 83% were found to be conventional septic tanks with well over half being single chambered and hence substandard in line with current standards. All of the proprietary or advanced systems inspected had been installed within the previous ten years. All apart from one was still under maintenance contract but nevertheless it was found that 43% of these advanced systems were not operating properly or simply not switched on.

45% of the subset inspected were found to have a percolation area, 38% relied on a soak-away which offered little or no effluent treatment and 17% discharged

directly into a ditch or watercourse. Due to the very concerning nature of the results and the strong likelihood of pollution, five systems were then selected for intrusive survey at varying distances from a nearby water course contributing to the Milltown Lake. The systems selected were chosen also on the basis that there were no other potential sources of nutrient enrichment which could affect the result of the survey. A number of piezometers were installed down gradient of each system so that the effluent passing underground to the nearby watercourse could be captured.

Field collection of subsurface and surface water began on the 15<sup>th</sup> August, 2008 with samples of surface water also being taken both up and down stream of the on-site wastewater treatment systems on all sites. Samples were collected once every two weeks with the samples being analysed within 48 hours to ensure accuracy. Full site characterisations were completed in November 2008 to determine matters such as soil type, soil structure, percolation capabilities and the depths of water table and/or bedrock. These characterisations were completed in accordance with the EPA Wastewater Manual 2000 which was the relevant guidance document at the time. The assessments completed concluded the following on the on-site systems that were investigated;

- a) The on-site systems at all of the sites are either poorly maintained, non operational or poorly installed
- b) One system has broken pipe-work at the septic tank and is leaking
- c) The majority of sites are unsuitable for conventional septic tanks
- d) 3 of the 5 sites researched have perched water tables and are unlikely to be suitable for a mechanical aeration system with discharge to the ground
- e) In 4 of the 5 sites the percolation area had been by-passed and the effluent was discharging directly into open streams and trenches

In relation to conclusion e) above it is fair to assume that the perched or high water table posed problems for the on-site wastewater systems. Perhaps the effluent had to by-pass the percolation area so that the wastewater did not flood in the house. Gill et al. (2005) suggest that groundwater is especially at risk where sub-soils of high permeability underlie the site, and where the water table is close to the surface. These startling findings come as no surprise to Gray (2004) whereby he states that “it would seem that in many cases there was no intention of maintenance of the newly installed septic tank system or realisation that any attention was necessary”. He points out that “unfortunately this responsibility is not always taken seriously, with the attitude ‘out of sight out of mind’.”

#### **2.7.6 EPA Research of Performance of OSWTS's**

This research was a 3 year study funded by the EPA under the Environmental Research Technological Development and Innovation (ERTDI) Programme as part of the National Development Plan 2000 – 2006 in Ireland. The research brief was to establish the effectiveness of both septic tank and secondary treatment of on-site wastewater treatment systems on four sites which were to be designed according to the Treatment Systems for Single Houses Guidelines (EPA, 2000). The aim of the research project was to carry out a series of rigorous on-site trials in order to enhance the understanding of the processes involved and the performance of different subsoils in the wastewater treatment of typical domestic effluent from septic tanks and other small scale secondary treatment systems. The research involved the construction of 4 separate percolation areas and 2 stratified sand filters. According to EPA Report (2005) the project provided an interesting exposure to the existing practice of on-site wastewater system installation amongst practitioners in Ireland and also the practicality of using the EPA guidelines. While it is acknowledged by the EPA Report (2005) that the research involved just 4 sites, the following are some key findings from the research undertaken;



- a) A major weakness for the implantation of the guidelines is the question of how to achieve an even distribution of effluent between the percolation trenches when constructing the percolation area
- b) The septic tank and percolation system provided a comparable treatment performance with respect to groundwater protection as the secondary system and without the need for on-going maintenance or energy consumption
- c) The septic tank effluent has achieved an equivalent quality to the secondary treatment after percolating through 0.6m depth of unsaturated subsoil. The additional 0.6m required (total 1.2m) can thus be considered a buffer.
- d) The majority of treatment of septic tank effluent took place in the distribution gravel and first 0.3m of subsoil.
- e) The current distribution boxes available in Ireland do not distribute the effluent effectively in the percolation area.
- f) There was a better removal of nitrogen from the effluent by the septic tank system through the development of a biomat in the percolation area. This biomat did not form as successfully from the secondary effluent and therefore some retrofitting of a de-nitrification process to secondary systems would be advisable.

There were also some conclusions drawn by the researchers in relation to this research as well as from their experience of on-site wastewater treatment systems. Firstly, the installation of on-site wastewater treatment systems needs to be regulated since there is no guarantee that after a thorough site investigation that the system specified will actually be installed as it was designed.

Secondly, according to the researchers it seems to be common practice for builders to divert at least some of the storm water drains into the septic tank, presumably because this saves on expense and time involved in laying extra pipework. Although this did not seem to significantly affect the hydraulic loading

rates on the sites chosen for this project which was under the constant scrutiny of a research team, the practice would probably be much more acute in the normal situation where builders are effectively unsupervised.

Thirdly, the researchers expressed the opinion that on-site experience demonstrated that the correct distribution of effluent did not appear to be an issue that was of particular concern during the installation of on-site wastewater treatment systems by some builders even though it should be considered fundamental to the whole principle of on-site wastewater treatment and disposal.

### **2.7.7 County Cavan Study 2002**

Cavan County Council undertook a study in 2002 in response to large number of complaints received about groundwater contamination. According to the IOWA (2010) these complaints in Cavan made up 30% of the total national environmental complaints for 2002. The key findings of the research were the following;

- a) 36% of on-site wastewater treatment systems in the study were defective and causing pollution
- b) Most systems inspected were poorly maintained, not de-sludged and were poorly designed and installed
- c) In some instances, effluent was by-passing percolation systems and entering watercourses directly

It was as a result of the shocking findings and level of complaints registered in County Cavan that the Cavan Bye-Laws (2004) as set out in section 2.4.7 were introduced.

### **2.7.8 Synopsis of Problems Identified from Existing Research**

“There is much to be said for failure. It is much more interesting than success”

(Max Beerbohm, 1948)

Failure in relation to on-site wastewater systems may be an interesting topic to research but it is a very serious issue with potentially serious consequences. When on-site systems fail to operate satisfactorily they threaten public health and water quality. When domestic wastewater is not absorbed by the soil it can form stagnant pools on the ground surface. In such failures, humans can come into contact with the wastewater and be exposed to pathogens; also foul odours can be generated. In addition, inadequately treated wastewater through poor siting, design and/or construction may lead to contamination of our groundwaters and surface waters, which in many areas are also used as drinking water supplies (EPA 2009). According to Daly (2003) “the management of these threats is a crucial issue for land use planning and needs to be given a higher priority”. The “out of sight, out of mind” problem is suggested by Lenning (1996) whereby homeowners don’t seem concerned by what happens to the effluent once it leaves the house. There has been rising concern into the pollution caused by septic tanks and other on-site wastewater treatment systems in Ireland over the last few years, particularly due to the well publicised, burgeoning number of one-off developments in un-sewered rural areas (Gill et al, 2005). From international practice it is suggested by Beal et al (2004) that “there is much evidence suggesting that on-site systems may be a significant and underestimated source of nutrient input to water bodies in rural catchments”.

Carroll et al (2005) identifies though that “contamination of ground and surface water resources by effluent discharged by on-site wastewater treatment systems is of critical concern owing to the potential health risks, and the degradation of recreational and drinking water resources as a consequence of increased nutrient inputs”. As suggested by Scannell (2006) one cannot but sometimes think that ‘progress’ associated with the Celtic Tiger economy has been achieved at a very

heavy cost, not only to traditional ways of life in Ireland, but also in terms of the damage wrought on our environment.

### **2.7.9 Construction, Installation & Operation of OSWTS's**

According to the EPA (2009) under no circumstances should rainwater, surface water or run-off from paved areas be discharged to on-site treatment systems. This is to prevent excessive in-flows of water into the treatment system which may result in flooding and ineffective operation. There is evidence however that a substantial number of systems are designed in this way. In reality, many houses have illegal storm water connections and it is common to find roof gutters illegally connected to the wastewater system, significantly increasing the hydraulic load to the percolation areas (Gill et al, 2005). Common installation problems identified in on-site wastewater systems include too few and/or too short percolation trenches for the premises being served, an uneven distribution of effluent between percolation pipes, land drain pipe being used instead of proper percolation pipes and poor pipe-work connections into and out of the septic tank resulting in effluent not reaching the percolation area. It is clear therefore that all too often the installation stage of on-site wastewater treatment leaves a lot to be desired, a problem that urgently needs to be addressed (Gill et al, 2005).

According to Yates (1985) “there is increasing concern that failing or improperly installed and maintained on-site waste water treatment systems can cause contamination of ground and surface waters with pathogens, nutrients and biologically active compounds”. Also Daly (1993) outlined that “on-site wastewater treatment systems are considered to be one of the principal sources of groundwater pollution in rural Ireland”.

On-site wastewater treatment systems, both conventional septic tanks and advanced systems, should be installed under the supervision of a competent person and certified by that person. Both types of system will give problems if not properly installed and maintained. All efforts in evaluating a site is totally wasted

if the system is not installed as designed (Daly, 2003). Even though Daly was calling for such supervision as far back as 1993, the EPA Code of Conduct (2009) still had no framework to make such supervision mandatory. This was a damning indictment on the legislature and one which appears to have led to significant groundwater pollution (Daly et al 1993, Daly 2003, EPA 2003, Gill et al 2005 & Vaury 2003). Historically there is evidence from abroad that predates the assertions of Daly (2003) regarding supervision and monitoring. The Commission for Health Services (1981) undertook a study which was carried out in North Carolina in the United States on the installation and maintenance standards found a failure rate of 10.9% for systems that were constructed without supervision and that were not regularly monitored. Analysis of this data by Grayson et al (1982) outlined that “preventative maintenance was not being practiced and the majority of households waited until something went wrong before pumping the system”. There was less than a 1% failure rate however for systems that were constructed under supervision and where regular monitoring took place. A further study on the performance of septic tank systems was conducted by the same Commission in the same area in 1988. This study concluded that 25% of systems were malfunctioning and a further 9% showed signs of past failure. Hoover & Amoozegar (1989) concluded that these problems were due largely to improper maintenance and installation.

#### **2.7.10 European Court Justice Case C-188/08 (29/10/2009)**

On the 29<sup>th</sup> October 2009 the European Court of Justice declared that “by failing to adopt, save in County Cavan, all the laws, regulations and administrative provisions necessary to comply with Articles 4 & 8 of Council Directive 75/442/EEC of the 15<sup>th</sup> July 1975 on waste, as amended by Council Directive 91/156/EEC of 18<sup>th</sup> March 1991, as regards domestic waste waters disposed of in the countryside through septic tanks and other individual waste water treatment systems, Ireland has failed to fulfil its obligations under the directive”. Article 4 of Directive 75/442 requires that ‘member states shall take the necessary measures to ensure that waste is recovered or disposed of without endangering human

health and without using processes or methods which could harm the environment, and in particular:

- without risk to water, air, soil, plants and animals
- without causing a nuisance through noise or odours
- without adversely affecting the countryside or places of special interest
- Member states also take the necessary measures to prohibit the abandonment, dumping or uncontrolled disposal of waste’.
- Article 8 of Directive 75/442 further requires that ‘member states shall take the necessary measures to ensure that any holder of waste has it handled by a private or public waste collector or by an undertaking which carries out the operations listed in Annex II A or B, or
- recovers or disposes of it himself in accordance with the provisions of this Directive’

In effect, the ECJ ruled that Ireland has failed to make adequate provision for dealing with wastewater from on-site treatment systems. There was reference made to County Cavan which is the only local authority area in Ireland which has brought forward such legislation in the form of the County Cavan Bye-Laws 2004. These Bye-Laws are outlined and discussed in section 2.5.7 earlier. With the exception of County Cavan, the landmark judgement against Ireland condemned the existence of serious shortcomings such as incorrect construction, unsuitable siting, insufficient capacities, maintenance and inspection and the inactivity of the competent authorities regarding septic tanks.

Since 2003 the European Commission has been in repeated contact with the DoEHLG seeking a proper system of inspection and maintenance, and the ECJ found that the laws, guidelines and policy circulars in place in Ireland didn’t have the “indisputable binding force necessary” for the effective application of EU laws

to protect human health and the environment (Nix, 2010). Previous Irish experience of implementing EU environmental legislation has been disappointing (Scannell, 1990, OECD, 2000 & Flynn & Kroger, 2003). Nix (2010) goes on to outline that of the 30 or so European environmental actions in train against Ireland, the highest per capita in the EU, the on-site wastewater issue possible has the greatest impact on human health.

The Minister for the Environment in Ireland at the time Mr. John Gormley (2009) commented on the ruling by stating that “we know that in far too many instances septic tanks or on-site sewage treatment systems are causing pollution. The absence of a licensing and inspection system is a major weakness in our overall environmental management structures and needs to be addressed” The South East River Basin District (2010) have commented that in relation to existing unsewered properties, improvements are required regarding the operational performance, maintenance and monitoring arrangements of septic tanks and other on-site wastewater treatment systems serving such properties. In response, the Minister for the Environment, Heritage and Local Government intends to bring forward and consult on proposals for legislation during 2010. It is intended that this legislation will be in place by quarter three of 2010. The proposed legislation will provide standards for the performance, operation and maintenance of septic tanks and similar on-site wastewater treatment systems. It will also provide for monitoring and inspection of the performance of such treatment systems and will set out the responsibilities of households served by those systems, including requirements to carry out remedial actions where necessary. While the above are still objectives that have to be achieved, there is at least an acceptance that the regulation of new systems will not solve the groundwater contamination problem. The 500,000 existing systems in the country already (CSO, 2012) will also need to be surveyed, documented, maintained and possible replaced or upgraded.

### **2.6.11 National Inspection Plan**

The review of existing literature in Chapter Two identified that there is limited knowledge on individual OSWTSs in Ireland but where research has taken place these are very poor standards of construction, operation, maintenance and knowledge surrounding these OSWTS's (O'Suilebhan, 2004 & Gray, 2005). Results from the first official inspections under the National Inspection Plan (EPA, 2013) of OSWTS's in rural Ireland are shocking. More than half or 53% (EPA, 2014) of the small number of household units checked by local authorities failed basic maintenance standards while a significant number posed a threat to public health because of leaks and discharges to rivers and streams. That outcome reflects decades of official neglect and of government unwillingness to protect the quality of drinking water (IOWA, 2014). Of the 53% of OSWTS's that have been inspected and failed some 27% of these failed due to a lack of regular de-sludging and 26% of failures were due to a lack of simple operation and maintenance (EPA, 2014). Many of the OSWTS's that are failing could easily have passed if homeowners had taken small steps in the area of de-sludging and maintenance (DoEHLG, 2014 & EPA, 2014). The review of the literature also identified that the substantial changes taking place in the legislation that governs OSWTS's made little or no attempt to communicate these changes to homeowners (GSI, 2012 & IOWA, 2012).

### **2.7.12 Impact of Worldwide Recession on House Construction in Ireland**

The financial crisis that engulfed the worldwide economy in the middle part of the last decade was experienced in Ireland and had a significant impact on house constructions and the development of OSWTS's. The water quality statistics published by the EPA over the period 2005 – 2010 and referenced in many of the tables in this chapter are the most up to date data that is available. The fall off in the number of new rural dwellings being constructed has led to stagnation in



research by the EPA on water quality and Figure 2.18 confirms the magnitude of the drop in construction numbers;

**Figure 2.18: New House Completion Statistics**

| <b>Year</b> | <b>No. of New House Completions</b> |
|-------------|-------------------------------------|
| 2005        | 80,957                              |
| 2006        | 93,419                              |
| 2007        | 78,027                              |
| 2008        | 51,724                              |
| 2009        | 26,420                              |
| 2010        | 14,602                              |
| 2011        | 10,480                              |
| 2012        | 8,488                               |
| 2013        | 8,301                               |
| 2014        | 11,016                              |

Source: DoEHLG (2016)

### **2.6.13 Summary**

This section has examined on-site wastewater treatments from the traditional septic tank up to the more modern secondary and tertiary treatment system. The shortcomings of the traditional septic tank have been identified, whilst acknowledging that human error in the design and construction phase remains a major component in these shortcomings.

The lack of a national monitoring programme has been identified for on-site wastewater treatment systems for un-sewered properties and there is consensus from the existing research that only localised analysis of the performance of such systems has taken place. Clearly the results of the research that has taken place identifies poorly designed, constructed and maintained on-site systems that are a significant contributor to groundwater degradation and a risk to human health. Lessons from the US demonstrate that on-site wastewater system failure is closely

linked to improper monitoring and maintenance. The culmination of inadequate policy implementation, poor monitoring and regulation and a lack of emphasis on performance led to Ireland's prosecution by the ECJ. This prosecution has been identified as one of many that are facing Ireland for failure to adequately protect groundwater resources. Furthermore, the target date for achievement of 'good status' for all waters as part of the WFD is fast approaching but at this point the Building Regulations in Ireland still refer to 1991 standards. Clearly the shortcomings referred to by the ECJ and others for on-site wastewater treatment in Ireland must be addressed and addressed as a matter of urgency.

## CHAPTER THREE – MODELLING

### 3.0 Introduction

The previous chapters of this thesis have outlined in quite some detail the rationale and requirement for this research. The criticisms of Ireland and the subsequent prosecutions by the ECJ (2009) have demonstrated that there is an urgent need to improve the on-site wastewater treatment process on a national scale. The potential health risks associated with the excessively high levels of contamination in groundwater emanating from OSWTS's (Gray 1994; Daly, 2001; Flynn & Kroger, 2003; Gray, 2004; Gill *et al*, 2005; EPA, 2008; Daly & Craig, 2009 & Gormley, 2009, Kelly, 2013 & GSI, 2014) needs to be urgently addressed. The enactment of the Water Services (Amendment) Act 2012 and specifically Section 70 of the Act now directs that homeowners and the occupiers of residential property are responsible for the operation, maintenance and performance of their OSWTS. Chapter Two has demonstrated however the very fragmented nature of the regulations and legislation that governs on-site wastewater treatment in Ireland and the failure of the Irish Government to make codes of practice produced by the EPA mandatory in the current Building Regulations. Since the enactment of the Water Services Act 2007 and the Water Services (Amendment) Act 2012 there has been no practical advice offered to homeowners in relation to their OSWTS or to the potential legal consequences of having a poorly constructed, managed or maintained system (IOWA, 2014). The plethora of information contained in the various regulations and guidance documents relating to on-site wastewater treatment is poorly communicated and has been observed to be completely overlooked by homeowners and the competent authorities. The aim of this chapter is to review the use of modelling techniques which could help to inform and educate homeowners on how to improve and change their behaviour and to understand the necessity of properly managing their OSWTS's. The use of models in this subject area is not novel and according to Irvine (2005) the EPA in Ireland have previously used models to assist in the understanding of hydrological and groundwater issues.

DeYoung (1993) suggests that changing behaviour is a complex process but is worth the effort as one's sense of moral obligation is capable of creating powerful feelings of remorse and awaken the conscience, thus affecting and influencing future behaviour. The hypothesis for the use of models as part of this research is that they provide increased visibility and understanding (Lee, 2011). Chapin (1971) has identified that an exchange of information that is laborious, involved or tortuous usually breaks down in practice and this provides the argument for the development of something other than reams of text in Acts provided by the legislature. On reflection of these information exchange pitfalls, the development of a knowledge model may provide the solution for homeowners in better understanding and managing their OSWTS's. Modelling can encompass the use of graphics and according to Harris (1999) information graphics for operational purposes are used by millions of people on a daily basis for such things as improving their efficiency and effectiveness, improving quality, solving problems, planning, teaching, training, monitoring processes etc. With the need to cope with increased amounts of data and at the same time improve some operation purpose, charts, graphs and maps are being used more and more in operational situations. Fortunately as a result of developments in computer software, most of the popular charts and graphs used on a daily basis can be generated rapidly, easily, and with little or no special training. In order to develop a model for homeowners and their OSWTS it is important to first define some of the key concepts relevant to the modelling process. The chapter will provide detailed definitions for information, knowledge and process modelling as well as providing a broad overview of what modelling actually is. A selection of modelling techniques will then be introduced and analysed and the applicability of these techniques to the on-site wastewater treatment process will be considered. The modelling techniques chosen for analysis have been selected on the basis of an assumed applicability to environmental scenarios such as wastewater treatment and from examples of where they have been used in real world situations. The selection of the most popular sample of modelling techniques for analysis is necessitated due to the vast array of modelling techniques and the fact that an entire thesis could be dedicated to the analysis of such techniques. The sample of modelling techniques to be analysed have been selected by researching models that have been developed for

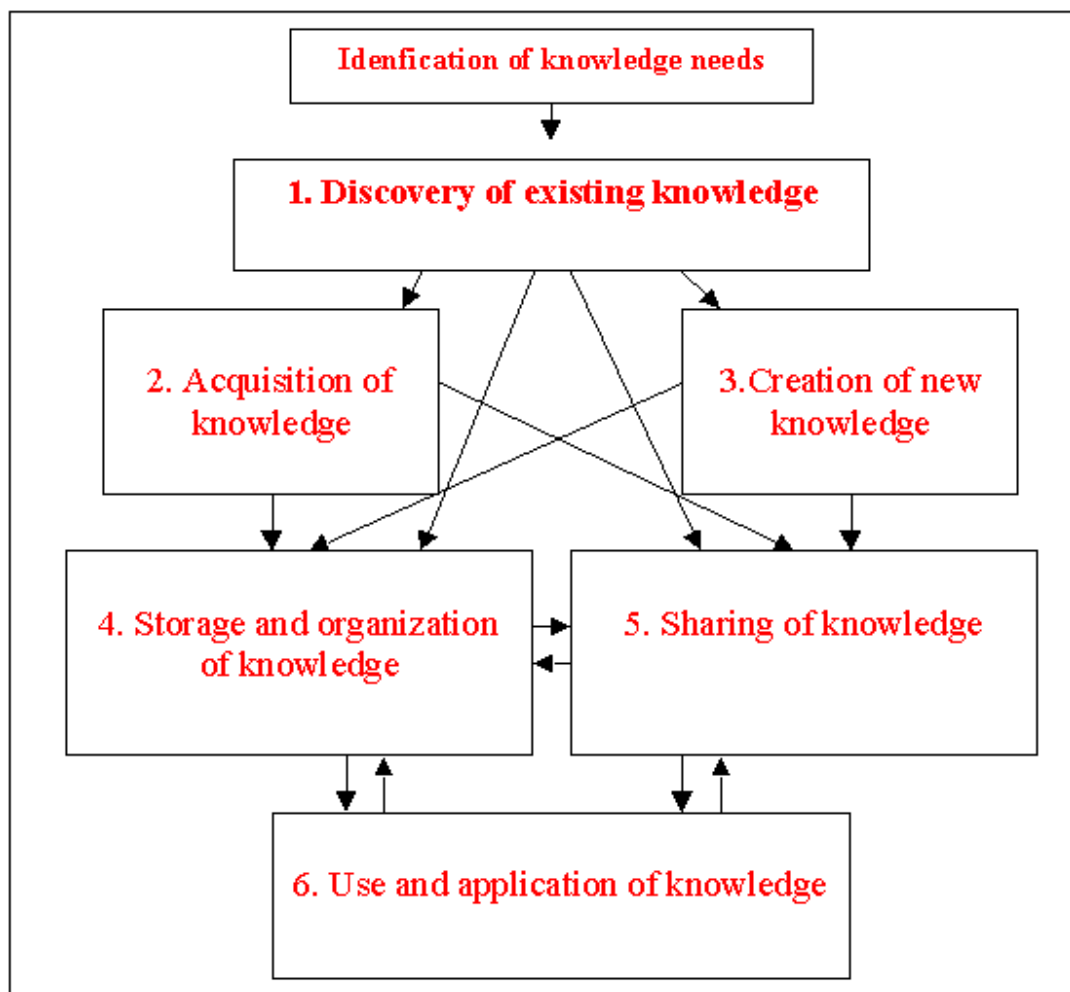
similar scenarios such as the OSWTS problem in Ireland. That is, situations where a lack of information or knowledge about an existing process was leading to difficulties or problems in that subject area. The strengths and weaknesses of the chosen sample of models can provide an invaluable insight into how the knowledge model can be formulated for OSWTS's and their owners.

### **3.1 Information & Knowledge Defined**

According to Foskett (1962) knowledge is what I know and information is what we know. Information is produced by assigning meaning to data relevant to mental objects. Mental objects in the case of on-site wastewater treatment could relate to the correct way in which an OSWTS should be constructed, operated, maintained or managed. Effectively the actions of construction, operation, maintenance and management are the objects. Wiig (1999) defines information as facts and data organized to characterise a particular situation and knowledge as a set of truths and beliefs, perspectives and concepts, judgments and expectations, methodologies and know-how. Therefore, information can be seen as data made meaningful by being put into a context and knowledge as data made meaningful through a set of beliefs about the causal relationships between actions and their probable consequences, gained through either inference or experience (Mitchell, 2000). Knowledge differs from information in that it is predictive and can be used to guide action while information merely is data in context. Knowledge is the subjective interpretation of information and approach to act upon in the mind of perceiver. Meadow et al (2000) purport that information has no universally accepted meaning, but generally it carries the connotation of evaluated, validated or useful data. Knowledge on the other hand involves a higher degree of certainty or validity than information and has the characteristic of information shared and agreed upon within a community. Knowledge is information combined with experience, context, interpretation, and reflection. It is a high-value form of information that is ready to apply to decisions and actions (Davenport et al., 1998). Knowledge is human expertise stored in a person's mind, gained through experience, and interaction with the person's environment (Sunasee and Sewery, 2002). Knowledge is information evaluated and organized by the human mind so

that it can be used purposefully, e.g., conclusions or explanations (Rousa, 2002). Martensson (2000) outlines in Figure 1 how knowledge can be managed, from the initial identification of a need for knowledge through to how this can be obtained from existing knowledge resources and from the creation of new knowledge. The model then moves to look at how these knowledge resources both new and existing and can be stored, presented, shared and applied;

**Figure 3.1 – Knowledge Management Processes**



(Source: Martensson, 2000)

As outlined in Figure 3.1 the management of knowledge and information is undertaken in the concept of a process. Arguably therefore the transfer and

application of knowledge to homeowners is part of a process and the applicability of the knowledge model for homeowners should be seen in the context of a “process”. This process should provide decision support (Bohanec, 2001) and according to Simon (2008) decision support is a part of the decision making process whereby the decision is defined as the choice of one among a number of alternatives. The model for homeowners will help them to make more sustainable choices from the available alternatives. Clearly this interaction of homeowners and the on-site wastewater treatment process could benefit enormously from the harnessing of information into knowledge in a relevant medium where experience can be transferred to the homeowner, such as a knowledge model which provides relevant decision support.

### **3.2 Definition of the Process**

Lee (2011) suggests that in order to improve something it is necessary to know in advance what the current state is. Without knowledge of how the process looks and works today, it will be very difficult to know which improvement initiatives can be applied and the extent to which they will work. The modelling of a process involves producing a picture or map or a model which helps to make the process visible. Increased visibility improves communication and understanding, and provides a common frame of reference for those involved with the process; it should be the first step in any improvement activity. The modelling of a process is also a tool that provides a means of communicating complex functions in a form more easily understandable by people and enables the formalisation of processes which in turn allows people to operate in a standardised manner. Knowledge of how a process looks today will help in identifying the areas in which to focus process improvement initiatives and provide the basis to then identify the extent to which they are working once improved (Tah, 2004). The application of a model to the domestic on-site wastewater treatment process could be a very effective mechanism for informing and educating homeowners. The effluent discharged from a dwelling should undergo a treatment ‘process’ whereby the environmentally damaging contaminants are removed and the effluent is

transformed into an acceptable form that can be discharged to groundwater. Vonderembse & White (1996) identify that a process can simply be stated as having an input and an output, with the process receiving and subsequently transforming the input into the desired output.



| Author             | Definition   |
|--------------------|--|
| Davenport (1993)   | A process is simply a structured, measured set of activities designed to produce a specified output for a particular customer or market' and that they are 'the structure by 'which an organisation follows that is necessary to produce value for its customers'  |
| Cooper (1994)      | Provides the thinking and action for transforming an idea into a product, and it can either be tangible or intangible, functionally based or organisationally based  |
| Oakland (1995)     | The transformation of a set of inputs, which can include actions, methods and operations, into outputs that satisfy customer needs and expectations, in the form of products, information, services or – generally – results'  |
| Zairi (1997)       | 'A process is an approach for converting inputs into outputs. It is the way in which all the resources of an organisation are used in a reliable, repeatable and consistent way to achieve its goals'  |
| Bulletpoint (1996) | Suggests that regardless of the definition of the term process there are certain characteristics that this process should have the following: -<br>- Predictable and definable inputs<br>- A linear, logical sequence of flow<br>- A set of clearly definable tasks or activities<br>- A predictable and desired outcome or result |

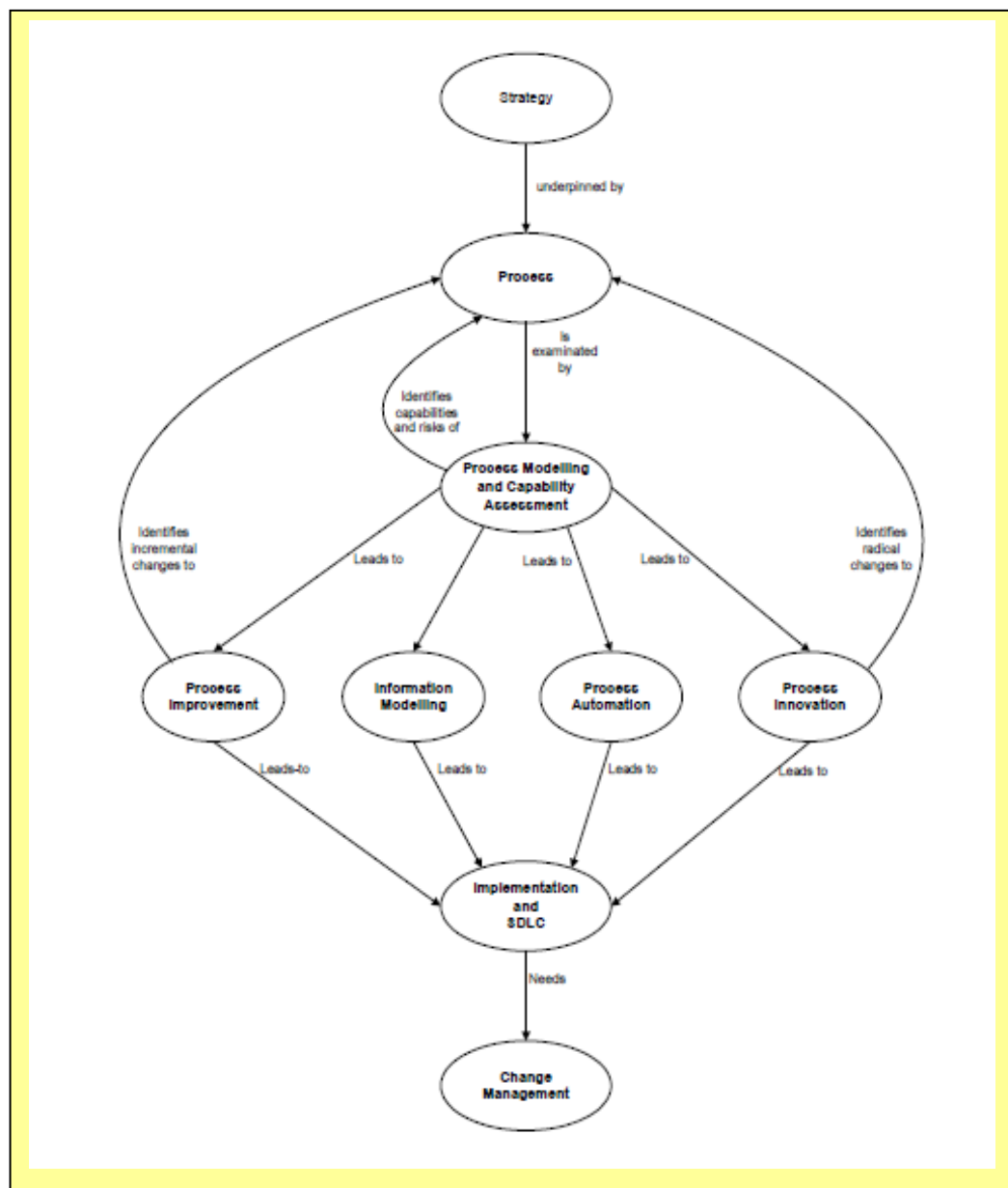
(Lee, 2011)

Once the relevant process has been understood, and in this case the on-site wastewater treatment, there are many different approaches to process improvement. These vary by industry, the nature of work being undertaken and by the nature of the environmental changes that need to be accommodated. Some changes only require modest improvements in existing processes while others require the complete redesign of an existing process or the creation of a new process, more commonly referred to as reengineering. Some focus on changes in the performance of people, while others involve the use of software applications



to automate a process. Thus, there are many different ways to improve or redesign processes. Once processes are identified that need changes, some kind of change effort must be initiated. The different options that can be used in combination include process improvement, innovation, or automation as outlined by Tah (2004) in Figure 3.2;

**Figure 3.2 Process Modelling**



(Source: Tah, 2004)

### 3.3 Concept of a Model

Some clear and concise definitions have been provided to explain the concepts of information, knowledge and process. Figure 3.1 outlined above and adapted from Martensson (2000) has illustrated at stage no. 5 that there is a need to consider how knowledge is to be shared in the knowledge process. Arguably this point is also relevant for information and the sharing of information. As outlined in section 3.0 above, the aim of this chapter is to review the use of knowledge models which could help to inform and educate homeowners on how to improve their behaviour, understanding and management of their on-site wastewater treatment systems. The review of knowledge and information has been provided and it is now necessary to gain an understanding of the concept of a modelling in order to ascertain the applicability of this technique for homeowners and the on-site wastewater treatment process.

The Collins English Dictionary (2011) defines a model as “a simplified representation or description of a system or complex entity, especially one designed to facilitate calculations and predictions”. Tah (2004) defines the model is a representation of a set of components of a system or subject area. The model is developed for understanding, analysis, improvement or replacement of the system. Systems are composed of interfacing or interdependent parts that work together to perform a useful function. System parts can be any combination of things, including people, information, software, processes, equipment, products, or raw materials. The model describes what a system does, what controls it, what things it works on, what means it uses to perform its functions, and what it produces. Modelling can be based on formal, informal or graphical techniques (Tah, 2004). Glassey (2009) suggests that “models are used to provide a framework to describe concepts and to reason about these concepts in order to create new knowledge. Modelling is a difficult area however because the process itself is a constructive problem solving activity for which no single “good” solution exists (Schreiber & Wielinga, 1998). Wierzbicki *et al* (2000) suggest that modelling is a partial truth about some selected part or phenomena of the surrounding world. It must be confined to a well-defined area of interest, it can

only be valid for a specific purpose, and real phenomena will always be only partially represented by the model. The model must avoid too much detail while preserving the essential features of the specific situation. Therefore, modelling remains and will remain an art. Models enable decision-makers to filter out the irrelevant complexities of the real world, so that efforts can be directed towards the most important parts of the system under study (Giaglis, 2001).

### **3.3.1 Process Modelling**

The concepts of the ‘process’ and the ‘model’ can be brought together in process modelling which is described by Tah (2004) as the production of process models or maps which help to make work visible. Increased visibility improves communication and understanding and provides a common frame of reference for those involved with the process. In the case of homeowners and the on-site wastewater treatment process, this common frame of reference could provide homeowners with an understanding of how they need to manage their respective OSWTS and provide for conformity in actions and decision making.

### **3.3.2 Information Modelling**

Information is knowledge acquired in any manner (Collins English Dictionary 2011). The term ‘information model’ is predominantly utilised for illustrating individual things, such as facilities, buildings, process plants, etc. According to Lee (1999) an information model is a representation of concepts, relationships, constraints, rules and operations to specify data semantics for a chosen domain or discourse. The advantage of using an information model is that it can provide sharable, stable, and organised structure of information requirements for the domain context. Mylopoulos (1998) asserts that information modelling is concerned with the construction of computer-based symbol structures which capture the meaning of information and organize it in ways that make it understandable and useful to people. There is a close relationship between processes and information and furthermore information plays an important role in

improving the innovating processes. Information models facilitate the development of a clear understanding of the information required to underpin a particular process. Information modelling allows us to develop a clear understanding of the information required to underpin processes and is a crucial step in the effective and efficient implementation of information systems to support the relevant process involved (Tah, 2004). In the case of domestic wastewater treatment, the homeowner could benefit enormously from accessing a model that illustrates the information that is critical to ensure the process operates effectively. Information modelling constitutes a cornerstone for any technique that claims to address the growing demand for more and better information services and management techniques. To use information, one needs to represent it, capturing its meaning and inherent structure. Such representations are important for communicating information between people, but also for building information systems which manage and exploit this information in the performance of useful tasks (Mylopoulos, 1998). According to Irvine (2005) models are, by nature, simplifications of reality. However, there are no universal models and the selection of appropriate models for specific tasks is critical. To properly use models there needs to be an appreciation of the strengths, weaknesses and uncertainties of individual models where used. Clearly therefore it can be argued that there is no one size that fits all in modelling and this must be considered in the adoption of a model for homeowners in relation to their OSWTS's.

### **3.3.3 Knowledge Modelling**

Many scientists argue that the main reason why humans have excelled as species is our ability to represent, reuse and transfer knowledge across time and space (Lillehagen & Krogstie, 2008). In recent years, knowledge sharing and reuse has become one of the primary goals of the knowledge-based systems research community. Knowledge modelling is a cross disciplinary approach to capturing and modelling knowledge. Knowledge Modelling packages combinations of data or information into a reusable format for the purpose of preserving, improving, sharing, aggregating and processing knowledge to simulate intelligence. The most

common applications of knowledge modelling are used for education, decision support, alerting and automation. Knowledge models are structured representations of knowledge using symbols to represent pieces of knowledge and relationships between them. Knowledge models include;

- Symbolic character-based languages, such as logic
- Diagrammatic representations, such as networks and ladders
- Tabular representations, such as matrices
- Structured text, such as hypertext

The generation of and modification of a knowledge model is an essential aspect of knowledge acquisition, as the model helps to clarify the language being used and quickly convey information for validation and modification where necessary. Thus the use of knowledge models is of great benefit during;

- Knowledge elicitation (from an expert)
- Validation (with the same expert)
- Cross-validation (with another expert)
- Knowledge publication

(Mylopoulos, 1998)

Knowledge modelling is a difficult process however and as suggested by Schreiber & Wielinga (1998) it is one where there is no single “good” solution. In the context of the on-site wastewater treatment process therefore it is likely that there will be a number of modelling options available and which will merit careful consideration.

### 3.4 Decision-Making Theory

The adoption of a knowledge model for homeowners in relation to the OSWTS's provides for better management and operation of the systems through better decision making. According to Wierzbicki *et al* (2000) there are three dominating aspects of decision-making;

- i) information about the current situation and history
- ii) the relation between basic processes and actions or decisions
- iii) the decision process

For each of these aspects there are cases where one aspect is more complicated than the other and therefore requires more attention. Nevertheless, there are many problems where all three aspects are essential. In highly complex decision situations one needs good tools for handling any of the three aspects and these tools should facilitate and integrated treatment of all three aspects. Andriole (1989) outlines that decision support tools should contain models of selected decision situations and they should support several phases of the decision process. Bonczek *et al* (1981) refer to early decision support systems as being primarily data orientated but it was soon acknowledged that there should be more possibilities of evaluating alternatives or decision options and even suggesting “best” decisions. Accordingly, model-based decision support was introduced. Wessels & Wierzbicki (1993) define a decision support system as a computerised system that supports it users in a rational organisation and conduct of a decision process (or its selected phases) and, besides a data base, also contains a pertinent knowledge representation in the form of decision situations as well as appropriate algorithms for using these models.

### 3.5 Model Based-Decision Support

Just as global environmental stresses are occurring with unprecedented rapidity, the resultant rate of behaviour change needs to thrive to mitigate the stresses.

Perhaps never before has so many individual behaviours had to change in such a short time. More challenging is that these behaviours, once changed, must stay changed. Such challenges have already put pressure on our limited environmental education and protection budgets. Consequently, one contribution that conservation behaviour researchers can make is to develop techniques that help change and maintain individual behaviour while minimising the need for repeated intervention (Young, 1993). Schultz (2002) suggests that education is often seen as the key to changing behaviour. Indeed, how can people engage in environmentally significant behaviours if they do not know about the impacts of their actions or about the details of how to engage in specific behaviour? Schultz (2002) queries whether education is sufficient to change behaviour and suggests that knowledge-based interventions such as modelling is an alternative educational approach that focuses on changing social norms. Cook & Berrenberg (1981) refer to persuasive communication techniques to change behaviour and specifically refer to the modelling of behaviour as an effective means of providing information that will facilitate effective change. Geller (1989) also purports a behaviourist perspective from an antecedent intervention of prompting, education and modelling. The alternative according to Geller is consequent interventions such as reinforcement and punishment. Geller's perspective can be compared to the 'carrot and the stick' whereby either you lead and empower behavioural change or you have no alternative to punish a lack of change. Katzev & Johnson (1987) identify the social benefits of persuasion rather than punishment through the medium of antecedent intervention techniques. The goal of intervention techniques such as model-based decision support is further discussed by DeYoung (1993) as helping people to understand the nature of the environmental problem that they are facing, the necessary behaviour needed to resolve the problem or the steps required to achieve improved behaviour. Model-based support will help homeowners to understand the on-site wastewater treatment process and how they need to change their behaviour. Figure 3.3 as adapted from DeYoung (1993) illustrates how modelling can influence behaviour.

Figure 3.3: Typology of Selected Behaviour Change Techniques

| <u>Source of Change</u>          | <u>Behaviour Change Techniques</u> |                            |                 |
|----------------------------------|------------------------------------|----------------------------|-----------------|
|                                  | <u>Information</u>                 | <u>Positive Motivation</u> | <u>Coercion</u> |
| Environment/Others<br>(Tangible) | Declarative knowledge              | Material incentive         | Fines           |
|                                  | Procedural knowledge               | Social support             | Social pressure |
|                                  | Feedback                           |                            | Prosecution     |
|                                  | <b>Modelling</b>                   |                            |                 |
|                                  | Prompting                          |                            |                 |

(Source: DeYoung, 1993)

Gray (1995) develops these points by suggesting that techniques such as models which successfully increase awareness about an environmental issue or that help an individual to gain specific knowledge about such an issue will alter the individual's attitudes and beliefs about the issue and ultimately cause the individual to take appropriate action. Both DeYoung (1988-1989) and Vining & Ebreo (1990) refer to the scenario whereby people are ready to act or change their behaviour in relation to an environmental topic but are uncertain as to the behaviour to adopt or how to proceed. Cook and Barrenberg (1981) identify that in this scenario the focus becomes one of helping the individual's attitude and to promote new behaviour as well as gaining the procedural knowledge to carry out the new behaviour. A further argument in favour of modeling is that individuals can see the importance of their actions in the process. Specifically in relation to on-site wastewater assessment the model can provide an opportunity for homeowners to see the consequences and benefits of their actions. Kaplan (1990) has suggested that when people perceive a role for themselves they have a sense that their contribution is not optional but a necessity and that a powerful behaviour change ensues. Folz (1991) develops this point by asserting that when people feel they are expected to play a role in a process that this can make them feel an obligation or responsibility to help and foster change. The model can also assist in providing homeowners with the knowledge on what actions they should take and will prevent confusion or uncertainty on what course of action to take.



According to Simon (1992) behaviour is dependent on knowledge and different people applying different knowledge to the same situation are likely to come up with a great variety of potential solutions. The model can provide homeowners with the knowledge necessary but also provide them with the protocol on how to better manage their on-site wastewater treatment systems. According to Young (1993) the reliability of the model can be tested by measuring the effect it has on an individual's or homeowner's behaviour the first time the model is used. As a further measure the model can be tested for reliability by measuring its effect after many presentations to the same individual. Young goes on to outline that the speed at which the model can effect behavioural change is also relevant to the reliability.

From the perspective of on-site wastewater treatment systems it is critical that the model is quickly understood and that the homeowner does not have to take a long time to understand it. The durability of the model refers to the notion that once behavioural change has been effected, can it be maintained without repeated intervention. Clearly the speed and reliability of the initial adoption of the model is important, however, given the scale of the environmental problem being faced and the number of on-site wastewater treatment systems in Ireland, it is important that the model has a lasting impact on homeowners. Oskamp et al (1991) suggest that changing the behaviour of a diverse population may call for the enlisting of creativity to enhance the individual's discovery process or to provide clear and firm guidance. The benefit of a model is that the 'picture can paint a thousand words' principle applies (Lee, 2011) and can make the knowledge / information transfer a more successful process. This chapter will now move on to discuss the use of decision support modeling tools for waste water and will observe some examples thereto. This will be followed by some consideration of key models that could be applicable for this research project.

### **3.6 Modelling and the Water Framework Directive**

Irvine (2005) has outlined that modelling has been used to help achieve the objectives of the Water Framework Directive. This subject area is closely related to the topic of this research and Ireland's compliance with the objectives of the WFD will be very much influenced by OSWTS's as outlined earlier in Chapter Two. Specifically the models referred to by Irvine (2005) relate to groundwater and hydrology and are both relevant to on-site wastewater treatment performance. While the WFD can be considered a macro issue in relation to its scale and complexity, the OSWTS issue for homeowners in one small EU state such as Ireland may be contrasted as micro. Nevertheless, Irvine affirms that groundwater models that have been developed to solve problems at widely different spatial scales, from local scale (e.g. one or two dimensional simulation) up to regional or catchment scale (three dimensional) simulations. This illustrates therefore that such models can be applied to both macro and micro environmental scenarios.

In the development of the models to support the WFD, consideration was given not only to the identification of appropriate models but also to the technical and end-user decision support mechanisms. These considerations will also be applied in this research project as mentioned earlier whereby the modelling process will ultimately inform the decision support tools to be used. The lessons of WFD model will be applied to the model to be adopted for homeowners in this research. The WFD models involved the integration of science within policy and enhanced methods of communication and understanding among scientists, decision-makers and stakeholders. The use of modelling for decision support includes forecasting the outcome of various scenarios and developing integrated frameworks for management. Such frameworks integrate the appropriate existing models, data and knowledge and are employed commonly. Irvine (2005) suggests that in a given scenario there are often a number of models that could be applied. Model choice should take account of factors such as applicability, data demands and cost. The further development of decision and user support models to include enhanced communication for the understanding and use of models and to promote dialogue among stakeholders is also noted as critically important.

He goes on to critique differing model options such as the hydromorphological modelling technique which is applicable to the WFD and affirms that simple management orientated models using functional or empirical relations can appear more feasible than complex models. The simpler models, however, generally lack the mechanistic detail of the process models and may provide less insight to the required, and targeted, solutions of any particular problem. The choice of simpler models over complex ones requires careful consideration, and there is no point in applying a simple model if it is inadequate to the task at hand. On the other hand, there is no guarantee that a complex model provides a better, or more reliable, outcome than a simple one in all circumstances.

### **3.7 Decision Support Models / Tools**

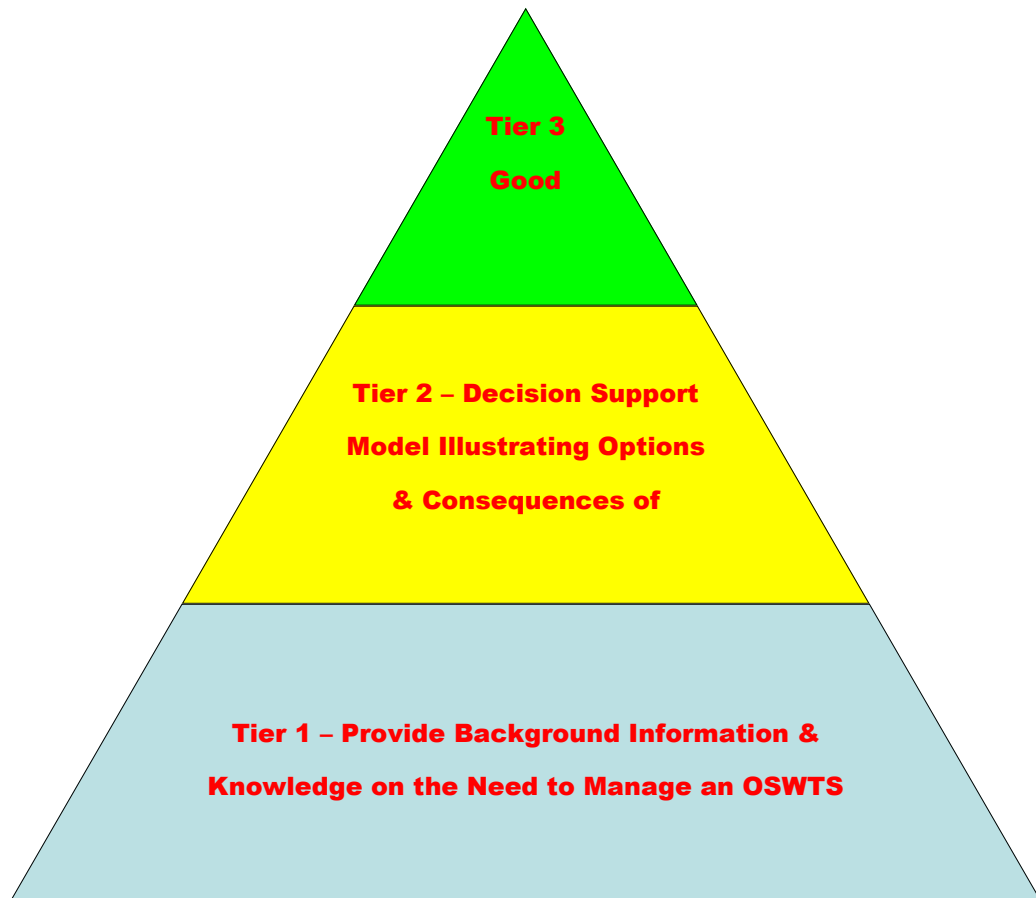
Why use decision support models / tools? The analysis of complex decisions with significant uncertainty can be confusing because;

1. The consequence that will result from selecting any specified decision alternative cannot be predicted with certainty
2. There are often a large number of different factors that must be taken into account when making a decision
3. It may be useful to consider the possibility of reducing the uncertainty in the decision by collecting additional information
4. A decision makers attitude towards risk taking can impact the relative desirability of different alternatives

(Kirkwood, 2002)

The development of a decision support model specifically designed for homeowners will help to educate and overcome their knowledge deficiencies that exist in relation to OSWTSs. The uncertainties arising from complex decision options as outlined by Kirkwood (2002) are relevant for homeowners in relation to their OSWTS, however there is evidence that there are even more fundamental deficiencies in knowledge amongst homeowners. Critically, the starting point for the development of a decision support model must consider the homeowner who does not even know that they ‘need’ to manage their OSWTS at all. Therefore, the decision support model for homeowners must be a tiered approach based on the initial need to provide information and knowledge on the subject before moving on to guide the homeowner on how to make the necessary decisions. The following Figure 3.4 presents the objectives of the decision support model in a tiered concept in hierarchical form from the initial baseline up to the end goal of well managed and maintained OSWTS;

**Figure 3.4 Tiered Objectives for Decision Support Models**



The next section of this chapter introduces some popular decision support models that have a foundation in information, knowledge or process modelling. A concise critical analysis of these decision support models will be presented and some of the key strengths and weaknesses will be observed. The homeowner model that is to be developed as part of this research will be informed by the critical analysis and a hybrid model can be developed based on the most suitable characteristics of the modelling techniques outlined.

### **3.7.1 Environmental Decision Support Systems (EDSSs)**

The complexity of environmental problems such as that posed by on-site wastewater treatment systems makes necessary the development and application of new tools capable of processing not only numerical aspects, but also experience

from experts and wide public participation, which are all needed in decision-making processes (Poch et al, 2003). Environmental decision support systems (EDSSs) are among the most promising approaches to confront this complexity with the capability to support learning and decision-making processes. Efforts to integrate new tools such as EDSSs are as a direct response to complex systems (Guariso & Werthner, 1989; Rizzoli & Young, 1997). According to Fox & Das (2000), a decision support system is a computer system that assists decision-makers in choosing between alternative beliefs or actions by applying knowledge about the decision domain to arrive at recommendations for various options. It incorporates an explicit decision procedure based on a set of theoretical principles that justify the rationality of this procedure. In the case of OSWTS, the homeowner is effectively the decision maker on how the system should be used, managed and maintained and therefore the EDSS may be a suitable decision support tool. This tool can harness experience from experts as well as information and knowledge from manufactures and other relevant stakeholders. The EDSS is an intelligent information system or model that reduces the time in which decisions are made in an environmental domain and improves the consistency and quality of decisions (Haagsma & Johanns 1994; Cortes et al 2001). Figure 3.5 illustrates the relevant components of an EDSS model and Figure 3.6 moves on to look the process of developing an EDSS model;

Figure 3.5 EDSS Conceptual Components

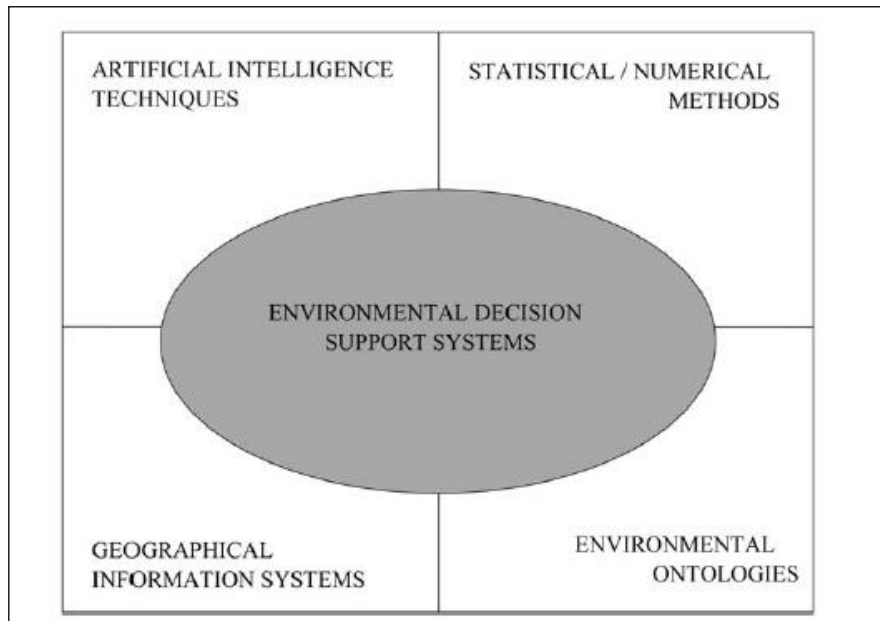
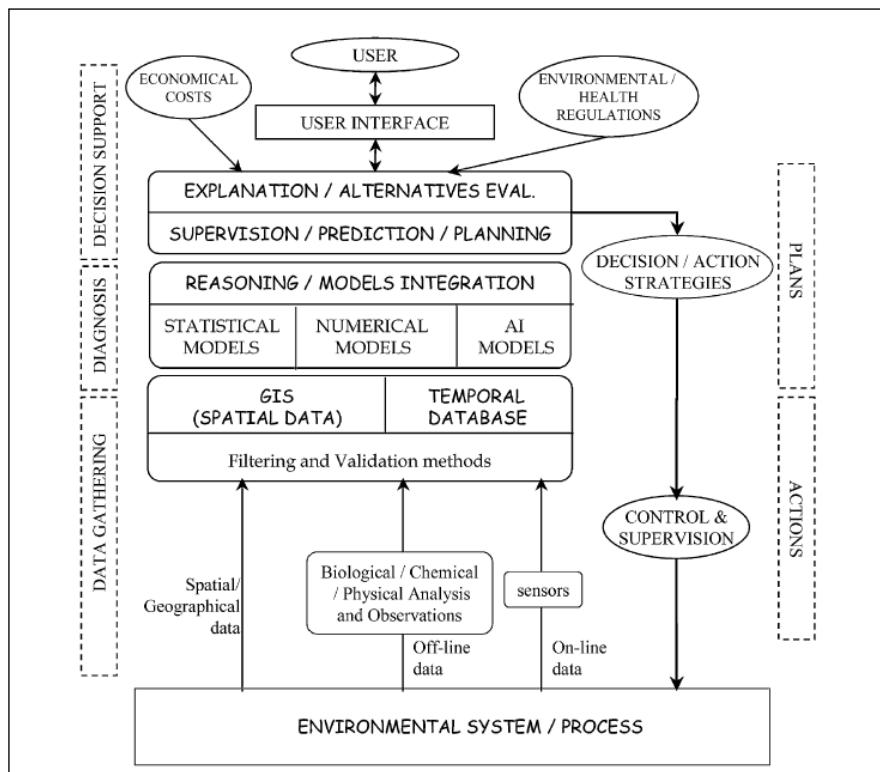
(Source: Poch *et al*, 2003)

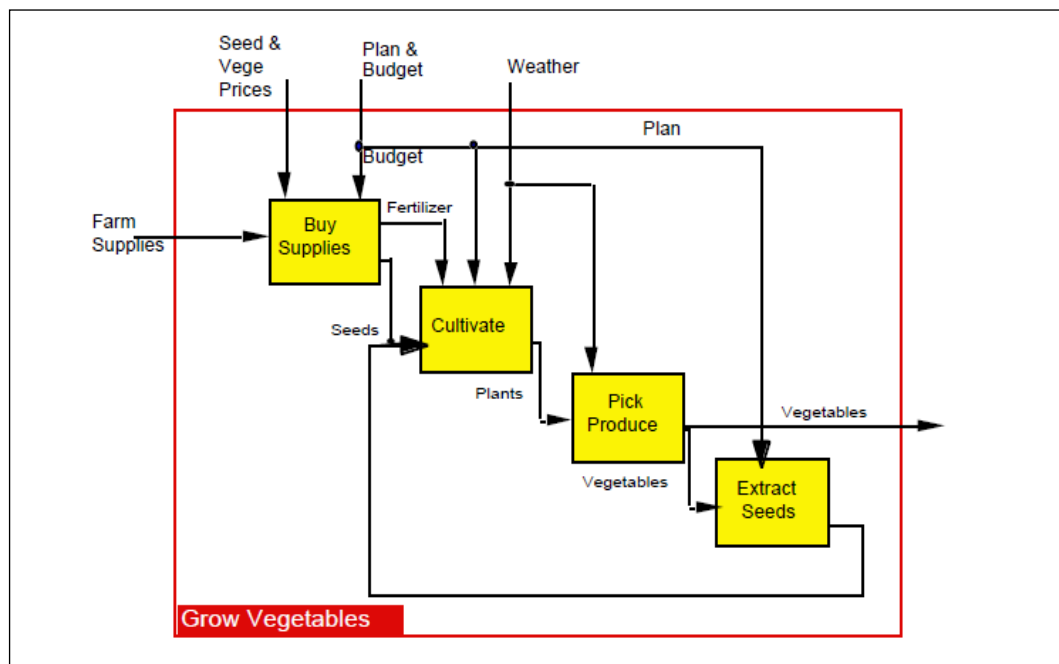
Figure 3.6 Flow Diagram for an EDSS

(Source: Poch *et al*, 2003)

### 3.7.2 The Structured Analysis & Design Technique (SADT)

Douglas Ross proposed in the mid-'70s the *Structured Analysis and Design Technique* (SADT™) as a “language for communicating ideas”. This technique is also referred to and more commonly known as IDEF. The technique was used by Softech, a Boston-based software company, in order to specify requirements for software systems. According to SADT / IDEF, the world consists of activities and data. Each activity consumes some data, represented through input arrows from left to right, produces some data, represented through output arrows from left to right, and also has some data that control the execution of the activity but are neither consumed nor produced. For instance, the Buy Supplies activity of figure 3.7 has input arrow Farm Supplies, output arrows Fertilizer and Seeds and control arrows Prices and Plan & Budget. Each activity may be defined through a diagram such as that shown in figure 3.7 in terms of sub-activities. Thus Growing Vegetables is defined in terms of the sub-activities Buy Supplies, Cultivate, Pick Produce and Extract Seeds.

Figure 3.7 SADT Activity Diagram



(Source: Ross, 1981)



One of the more elegant aspects of the SADT conceptual model is its duality: Data is described in terms of diagrams with input, output and control arrows too, but these now represent activities which can produce, consume or affect the state of a given datum.

### **3.7.3 Instructional Engineering**

Instructional engineering is a means for going beyond information management to knowledge management. It is an essential support for our transition from an information society to a knowledge society. The ultimate goal of instructional engineering is to empower people with new competencies. The vast, irreversible movement leading us toward a knowledge society gives new importance to human learning. Learning is the process by which information, scattered or structured in various domains, becomes knowledge and skills integrated in to the intellect of the individual (Paquette, 2004). Latham (1999) refers to instructional engineering as a means of combining instruction with technical procedures. This technique is grounded from a technological foundation and suggested by Liebman (2005) the “engineer uses the fruits of science to feed the appetite of technology”. Vargas (2007) suggests that the technique may not work well initially, but a scientific understanding facilitates finding out “why” and improving it. And if it works well, understanding of its principles expedites the next breakthrough. As referred to above, the ultimate goal of instructional engineering is to empower people with new competencies but the concern is that the technology may not work well initially as purported by Vargas (2007). Perhaps the complexity of this approach to decision support may be somewhat beyond the homeowner who has little or no understanding of OSWTS. Nevertheless, the use of technology in the decision support mechanism provides an opportunity for help and further clarification that may not be possible in non-technology based modelling.

### **3.7.4 Flow-charts**

Flowcharting is amongst the first graphical modelling techniques, dating back to the 1960s (Schriber 1969). The intellectual father of flowcharting is John von Neumann and he was the first to use this graphical aid systematically for the purpose of publishing information. Even though the details of flowcharting today differ considerably from what von Neumann advocated, the spirit, philosophy and rationale of flowcharting remain much as he presented them. The flowchart is a graphic technique specifically developed from existing graphic techniques for the purpose of representing processes or operations. It is fairly easily produced and relatively easily learned, having only a few relatively simple rules and few component parts. It can be used to represent operations and processes and because flowcharts are a graphic technique, it can be read at almost any level of detail. Because flowcharts meet the criteria of simplicity and ease of use well, people commonly use them for describing work done or to be done in a number of different circumstances. The flowchart is a diagram that visually displays interrelated information such as events, steps in a process, functions etc. in an organized fashion such as sequentially or chronologically (Chapin, 1971). Lee (2011) suggests that a flowchart is a graphic representation of the sequence of steps that make up a process. The use of flowcharts is really a reinforcement of the fact that it is easier to understand something presented graphically rather than when it is described and put simply “a picture is worth a thousand words”. Chapin (1971) goes on to suggest that a flowchart is a means of portraying, in graphic form, a sequence of specified operations performed on identified data. The graphic part of a flowchart is composed of symbols, outlines, or boxes of various shapes with connecting symbols, lines or arrows. The use of flowcharts is really a reinforcement of the fact that it is easier to understand something presented graphically rather than when it is described. Put simply: “A picture is worth a thousand words.” Tah (2004) suggests that a flowchart is a graphic representation of the sequence of steps that make up a process and affirms the benefit of the visual approach by stating that the use of flowcharts is really a reinforcement of the fact that it is easier to understand something presented graphically rather than when it is described.

The advantages of flowcharts centre on their ability to show the overall structure of a system, to trace the flow of information and work, to depict the physical media on which data are input, output and stored, and to highlight key processing and decision points (Jones 1986). Flowcharting was initially intended to provide computer program logic representation, but, due to its generic nature, it has been used in many other application areas as well, including business process modelling. Despite its advantages (namely familiarity and ease of use), flowcharting is no longer a dominant modelling technique because it can provide only basic facilities in representing processes. According to Doumeingts & Browne (1997) one of the main shortcomings of flowcharts is their ability to show a sequence of events in a single process. Nevertheless, there do exist some more sophisticated versions of flowcharts allowing multiple process threads. Therefore, flowcharts are nowadays typically used as a simple, graphic means of communication, intended to support narrative descriptions of processes when the latter become complicated and difficult to follow (Giaglis, 20xy). Lewis (1971) outlines the key features of flow charts and can be summarised as follows;

- Word descriptions of events, activities, steps, or functions are typically enclosed by symbols and connected by lines or arrows.
- Generally two-dimensional. Those that are three-dimensional are generally pictorial.
- Typically not hierarchical or quantitative.
- Typically plotted sequentially.
- Typically not plotted against a time scale.
- Can run vertically or horizontally. Large flow charts usually run horizontally because of space considerations.
- Normally proceed from top to bottom or from left to right.

- On very large programs, individual charts are made for each subprogram and all of them cross-referenced.
- The major information is conveyed by text: however, significant additional information can be encoded by symbols, lines, colours and images.
- Flow charts are applicable to large and small activities.

The reasons according to Lewis (1971) of using flowcharts are the following;

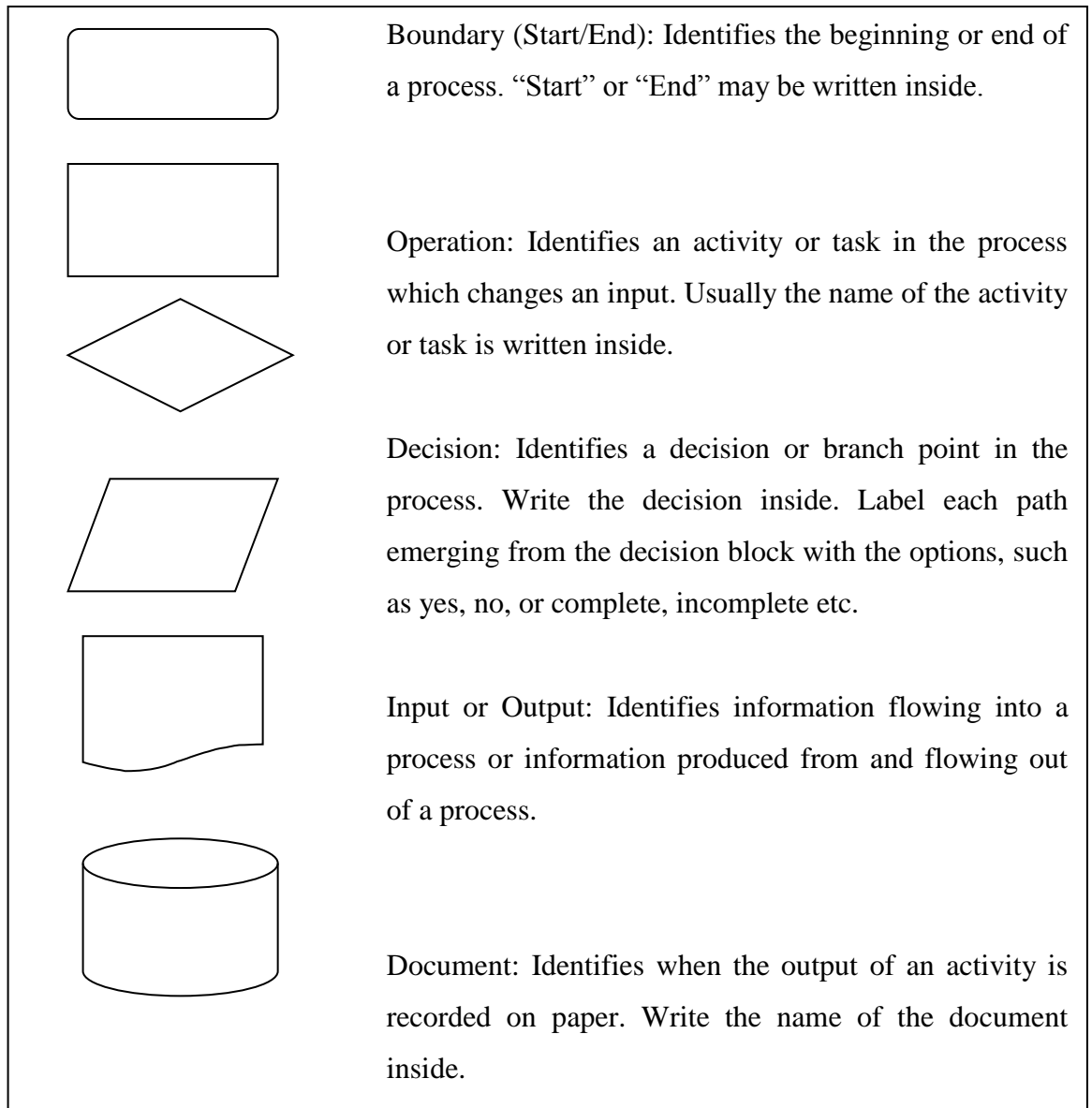
- Describes processes, ideas and networks etc. particularly complex and abstract ones.
- Defines, analyses and better explains processes, procedures and sequences etc.
- Improves communications.
- Helps to clarify ideas.
- Aid to trouble shooting.
- Serves as a tool in planning and forecasting.
- Reduces misunderstanding and conserves time.
- Simplifies training.
- It documents procedures.
- It illustrates cross-functional relationships and responsibilities.

There are a number of charts that are normally referred to by other names but may also be considered variations of flow charts (Wayne, 1973). Some of these are as follows;

| <b><u>Name of Chart</u></b>       | <b><u>What the Chart Displays</u></b>      |
|-----------------------------------|--|
| Organisation Chart                | Flow or authority of responsibility        |
| Decision Tree                     | Flow or sequence of decisions              |
| Time & Activity Charts            | Sequence or flow of events                 |
| “How to” Charts                   | Sequence of tasks to achieve an objective  |
| Conceptual Charts<br>and/or ideas | Flow of intellectual information           |
| Process Charts                    | Step by step description of a process      |
| Procedural Chart<br>goal          | Procedures to accomplish a particular goal |
| Flow diagram                      | Internal logic of a software system        |

Lee (2011) outlines that there are many ways of drawing flowcharts and that the most basic way is to simply use different symbols to represent activities, and arrows to illustrate the connection between activities. When it comes to the symbols that are used there are a number of different variants ranging from complex shapes to simple boxes and lines. Lee (2011) goes on to suggest that it is not viable to claim that one way is better than another, simply that the most important point is that users must share a common understanding of the symbols. Some of the commonly used symbols used in flowcharts are illustrated in Figure 3.8;

**Figure 3.8** illustrating key factors that influence OSWTS's performance



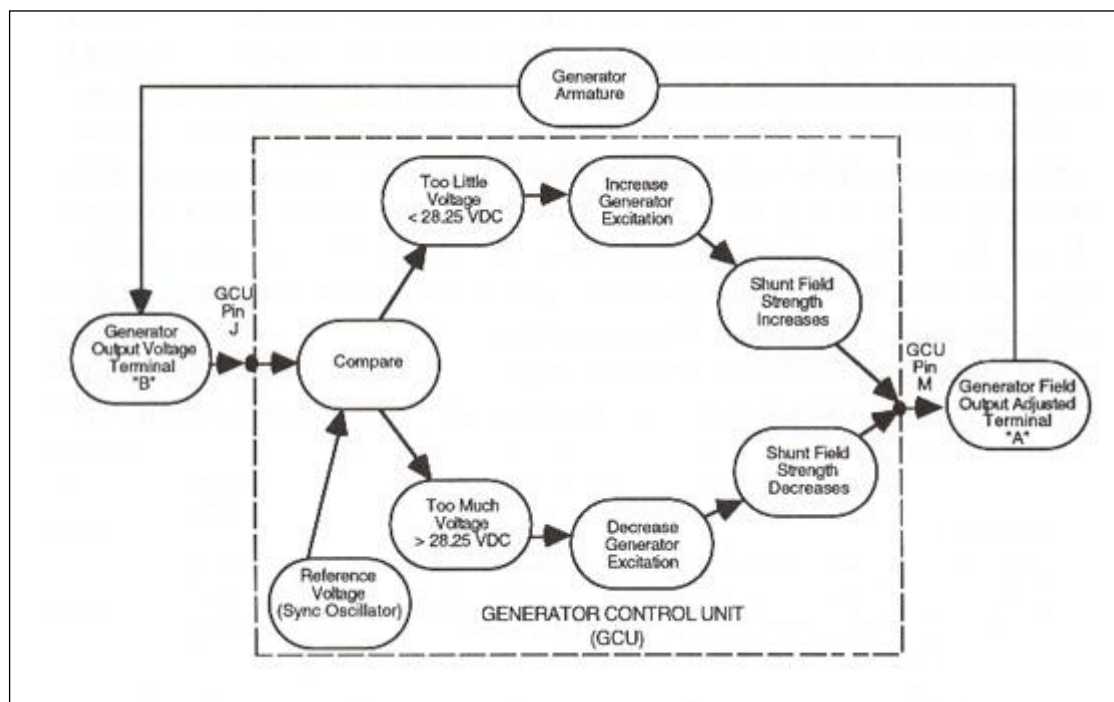
(Source: Lee, 2011)

### 3.7.5 Flow Diagrams

A flow diagram is a graphic representation of the physical route or flow of people, materials, paperwork, vehicles, or communications associated with a process, procedure, plan or investigation. A flow diagram is often the counterpart of a flow or process chart. The flow or process chart indicates the location of these activities

and how the physical flow of people, material, etc. occurs between them (Bohl, 1978). Process flow diagrams or data flow diagrams are another form of flow diagram and these are also sometimes referred to as decision tree diagrams. These have been most commonly used in the fields of electrical engineering or computer science to illustrate the logical flow of data through a system (Kolko, 1234). These diagrams assist in understanding the discrete rules, and their relationships to one another, to make up an activity. Figure 3.9 is an example of a flow diagram for an electrical operation and you can follow the process through the diagram;

**Figure 3.9** illustrating key factors that influence OSWTS's performance



(Source: Journal for Industrial Teacher Education, 2011)

### 3.7.6 Decision Trees

In decision theory and decision analysis decision-trees are graphs and/or models which depict the steps or stages involved in making decisions and their possible outcomes and are constructed to help with decision-making (Pemberton-Billing, 2010). Decision Trees not only show the decision-making route but also identify

thought processes, mind sets and decision-patterns whilst ensuring that each stage is tracked and progressed appropriately (Witten and Frank, 1999). Decision trees can break down a complex classifying/decision-making processes into a simple ones. The main advantage of decision trees is there interpretability and ease to turn them into 'if then' rules (Yang, 2006). All of the symptoms, facts procedures and relationships used for problem diagnosis can be cast into a set of decision trees (Sanchez-Marre *et al.*, 1996; Comas *et al.*, 2003). Decision trees can also be referred to as decision diagrams, decision charts or decision flow charts. Wayne (1978) refers to decision trees as a graphic representation of alternative decisions or actions that might be taken, plus potential outcomes resulting from those decisions or actions. The ability to see options and estimated outcomes before decisions are made is one of the main advantages of decisions trees. If each decision point on the diagram allows only one or two decisions then the chart is referred to as a binary decision tree. If more than two options are possible at decision points then it can be referred to as a multiple-choice decision tree. The following summarises the key characteristics of decision trees;

- A decision tree breaks down systematically the decision making process, showing all possible options.
- Identify the range of decisions, which have common input, processing or output.
- Relates each group of decisions to a specific user group.
- Identify decision-making inputs and outputs.
- Identify the decision rules which users use to make decisions.

The following Figure 3.10 extracted from Pemberton-Billing (2010) identifies some of the major advantages and disadvantages of decision-trees;



Figure 3.10 Critique of Decision Trees

|   |   |
|---|---|
| <b><i>Advantages of Decision-Trees</i></b>    | <ul style="list-style-type: none"> <li>• Can be easily created using a range of software</li> <li>• They provide a visual tool that can be easier to understand than pages of written text</li> <li>• Once created they can easily be analysed</li> <li>• Can be shared amongst a range of stakeholders to discuss current and future decision-making</li> <li>• Can hold huge amounts of data in 1 structure</li> <li>• Can be linked to other documents/data</li> </ul> |
| <b><i>Disadvantages of Decision-Trees</i></b> | <ul style="list-style-type: none"> <li>• Can take some time to create and can be complex diagrams which are difficult to interpret.</li> <li>• The decision-tree created is only as useful as the details used to create it if the data used to create the decision-tree is inaccurate the resulting tree will be miss-leading.</li> <li>• Can require user to have expert information system knowledge in order to create and/or manage</li> </ul>                       |

(Source: Pemberton-Billin, 2010)

Kaplan (2001) provides a critical appraisal of decision trees and affirms that they are not good at expressing sequences or procedures. This is best left to graphical techniques such as flowcharting. Multiple decision environments can quickly produce very large decision tables. These can be split into a number of smaller tables but inter-relating these tables can be difficult. Nevertheless, decision tables are a useful tool for the analyst throughout the systems development process.

### **3.7.7 Simulation**

The basic idea behind simulation is simple and according to Doran and Gilbert (1994) if we wish to acquire knowledge and reach some informed decisions regarding a real-world system. But the system is not easy to study directly. We therefore proceed indirectly by creating and studying another entity (the simulation model), which is sufficiently similar to the real-world system that we are confident that some of what we learn about the model will also be true of the system.

## **3.8 Critique of Model Technique to be Adopted**

Chapter Three has examined in detail various different modelling techniques and other forms of knowledge transfer media with examples of where they have and can be used in practice. There are strengths and weaknesses for each of the techniques that could be adopted and clearly there is a need to adopt the most suitable approach for the homeowner knowledge model. As discussed in detail in sections 3.7.4 & 3.7.5 the strengths of flow charts and flow diagrams are that they are easily understood and avoid the need for the extensive use of text (Chapin, 1971). The knowledge model for homeowners is intended to be an easy to understand and uncomplicated model and therefore the adoption of a flowchart / diagram offers a mechanism for information to be conveyed that once understood becomes knowledge. The knowledge required for a homeowner to properly manage and maintain their OSWTS centres on a range of different issues and considerations so therefore process modelling is not appropriate on this occasion. Decision support could be considered for the homeowner model but this could lead to the model being very detailed and therefore lose its effectiveness. Information modelling has been demonstrated to be very useful in digital environments but this is again not the media required for homeowners. The model for homeowners needs to be able to convey knowledge quickly, simply and in an easy to understand manner. The model must also be designed to be effective in the case of poorly literate homeowners as well as the better educated.

The adoption of a mixture of flow charts and flow diagrams in the homeowner knowledge model offers the best opportunity to improve the behaviour and understanding of OSWTS's as it is a basic and uncomplicated mechanism to convey knowledge to a broad audience.

### **3.9 Chapter Summary**

This chapter has introduced and described the concepts of information and knowledge whilst also observing the process of modelling and illustrating how models can be useful decision support tools. Information, knowledge and process modelling have been used in various industries and environments to enhance and improve decision making. Some examples of these models and industries have been provided and specifically in section 3.6 modelling in the WFD has been discussed. The WFD makes provision for ground and surface water resources and is very relevant to the topic of this research. The use of modelling in the WFD is a clear indication that this decision support mechanism is relevant to environmental issues such as OSWTS's. The use of decision support tools has been considered in this chapter also and a concise critical analysis of some popular modelling techniques is documented. The strengths and weaknesses of these support tools have helped to inform the design of the model for homeowners and their OSWTS. One of the key criteria identified in the research to date has been the need for the homeowner knowledge model to be simple and easy to understand and not a complicated document that replicates existing guidance such as that produced by the EPA. The next chapter will move on to prepare for the primary research that needs to be undertaken so as to establish the knowledge that needs to be provided to homeowners so that they can better manage their OSWTS's.

## CHAPTER FOUR – RESEARCH METHODOLOGY

### 4.0 Introduction

*“He who knows others is wise; he who knows himself is enlightened”*

*Lao Tzu*

Methodology is at the heart of any research project for it binds together the rationale for the research, as demonstrated in the previous chapters and in the findings to be discussed in the subsequent chapters (Chan, 2004). According to Creswell (1994) the guiding principle for developing any research methodology is that it must completely address the research question. Methodology means being aware of the way in which you do something and being able to justify why you did it that way (Trafford & Lesham, 2008). A very thorough illustration of the research problem has been provided in Chapters One to Three and this illustration has identified the very urgent need for an improvement in homeowner knowledge and behaviour towards OSWTS's. The preceding Chapters of this research have illustrated and introduced the precarious position that Ireland finds itself in regarding pollution from OSWTS's (Gray, 1994; Daly, 2001; Flynn & Kroger, 2003; Gray, 2004; Gill *et al*, 2005; EPA, 2008; Daly & Craig, 2009; Gormley, 2009; IOWA, 2013; Kelly, 2014 & GSI, 2014). From a homeowner's perspective there is evidence that there is a lack of knowledge and understanding in the subject area and that where homeowners are aware of their responsibilities to maintain and manage their OSWTSs, unfortunately this responsibility is not always taken seriously with the attitude 'out of sight out of mind' (Gray, 2004). This research will address these issues and provide a model that is motivated to improve homeowner knowledge and understanding of their OSWTS. Wiig (2003) argues in favour of this approach and states that it is generally accepted that good knowledge produces good performance and that better knowledge leads to even better performance. The research problem has necessitated the development of a pragmatic approach in the transfer of information and knowledge to homeowners regarding OSWTS's. This chapter will consider the most suitable research

methods to achieve the aim and objectives of the overall study. The chapter begins with an overview of the concept of ‘research methodology’ and will move on to examine the philosophical standpoint of the researcher for the research to be undertaken. The examination and identification of the philosophical standpoint of the researcher is an essential component in justifying the approach and methodology to be adopted in the research. The adoption of the multi-method research strategy for the research to be undertaken will be justified before the chapter concludes with an analysis of the data collection and analysis techniques to be adopted and the ethical procedures that need to be considered in the research.

#### **4.1 Definition of the Research Methodology**

Any substantial research investigation must be based on a rigorous scientific methodology, and although research is central to both business and academic activities, there is no consensus in the literature on how it should be defined. One reason for this is that research means different things to different people (Lee, 2002). Nevertheless, research can be considered to be an act of inquiry or finding out and is generally expected to involve a systematic process of investigation, that is, one which is carefully designed and executed with regard to relevant methodological principles. It is also expected to be aimed at advancing knowledge within the field of inquiry, and not just acquiring information that is new to the inquirer or needed for an immediate practical task (Griffiths, 2004). According to The Chambers Dictionary (2001), research is defined as a careful search or investigation; systematic investigation towards increasing the sum of knowledge. Williams and May (1996) offered a similar definition as they characterise research as a methodical investigation into a subject or problem, however, placing a greater emphasis on “methodical” as they maintained that to ‘research’ is to seek answers. Brew (2001) highlights a difficulty when defining the concept of research however and states that there is no one thing, nor even one set of things which research is. The research methodology is one of the most critical steps in the journey of doctoral level research. The core goal when considering the research

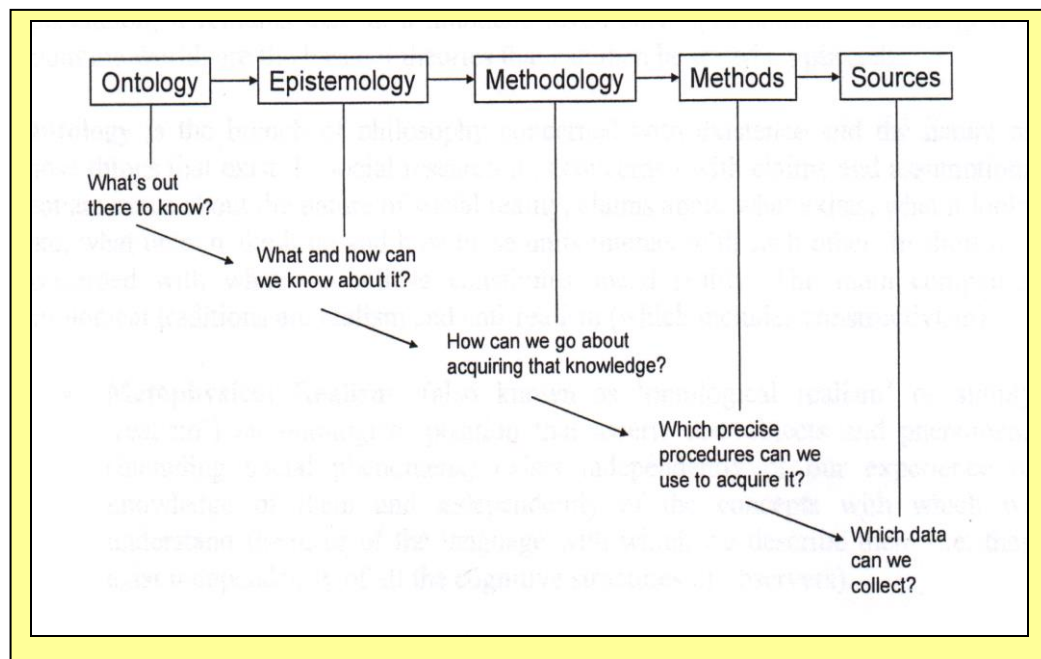
methodology is to avoid gross misfits – that is, when you are planning to use one type of method but another is really more advantageous (Yin, 2009). According to Howard (1985) one of the biggest challenges is deciding which research methodology to use and suggests that “research that tests the adequacy of research methods does not prove which technique is better, it simply provides evidence relating to the potential strengths and limitations of each approach”. The research methodology of the investigation has to be sympathetic to the issues being investigated, or rather, to suit the method to the problem and not the problem to the method (Linstone, 1978; Robson, 1993). The methodology should describe the path of the research, embodying a particular style and employing different methods, being dependent upon the type of questions posed, the extent of control the researcher has over actual behavioural events, the degree of focus on contemporary events and the nature of the enquiry (Yin, 1994).

## **4.2 The Philosophy of Research**

The assumptions that a researcher brings to the world or their ‘intersection of philosophy’ as proposed by Cresswell (2007) will provide an explicit ‘worldview’ or ‘paradigm’ illustrating the general views about the world and the nature of knowledge that the researcher holds. This intersection of philosophy provides the ‘worldview’ of the researcher’s beliefs which Guba (1990) goes on to define as “a basic set of beliefs that guide action”. This basic set of beliefs forms our in-built bias towards knowledge and knowledge production. Woolgar (1988) refers to this concept by outlining “how personal research bias affects the research process itself”. Bryman (1988) offers a definition of a paradigm as a “cluster of beliefs and dictates which for scientists in a particular discipline influence *what* should be studied, [and] *how* research should be done. Knight & Ruddock (2008) direct us that “understanding the influence that competing paradigms have on the way in which research is carried out is fundamental to understanding the contribution that it makes to knowledge”. Informing this decision should be the worldview assumptions the researcher brings to the study (intersection of philosophy); procedures of inquiry (called strategies); and specific methods of data collection, analysis and interpretation.

The selection of a research design is also based on the nature of the research problem or issue being addressed, the researcher's personal experiences and the audiences for the study. According to Easterby-Smith *et al.* (2002) a failure to consider the philosophical basis of any research can seriously affect the quality of the research. Philosophically, researchers make claims about what knowledge is (ontology), how we know it (epistemology) what values go into it (axiology), how we write about it (rhetoric) and the process of studying it (methodology) (Creswell, 1994). Knight & Ruddock (2008) suggest that research methods cannot be viewed in isolation from the ontological and epistemological position adopted by the researcher. Grix (2004) outlines that ontology and epistemology are to research what 'footings' are to a house; they form the foundations for the whole edifice. They are the assumptions which underpin the research and which will therefore influence our decisions about methodology, methods and sources. Figure 4.1 illustrates graphically the building blocks of research (Grix, 2004);

**Figure 4.1: The Building Blocks of Research**



(Source: Grix, 2004)

Biglan (1973) argues that the physical sciences are characterised by the existence of clearly defined paradigms that specify the appropriate problems for study and the appropriate methods to be used. The social sciences and non-science areas do not have such clearly delineated paradigms however. Easterby-Smith *et al.* (2002) do suggest though that two philosophical paradigms have dominated debate in the social sciences and these are;

- Positivism which suggests the use of quantitative and experimental methods to test hypothetical and deductive generalisations
- Interpretivism which suggests the uses of qualitative and naturalistic approaches to inductively and holistically understand and explain a phenomenon rather than search for external causes or fundamental laws.

Figure 4.2 illustrates the key difference in these paradigms arises from their different conceptions of human beings and how their behaviour can be understood (Easterby-Smith *et al.*, 2002)



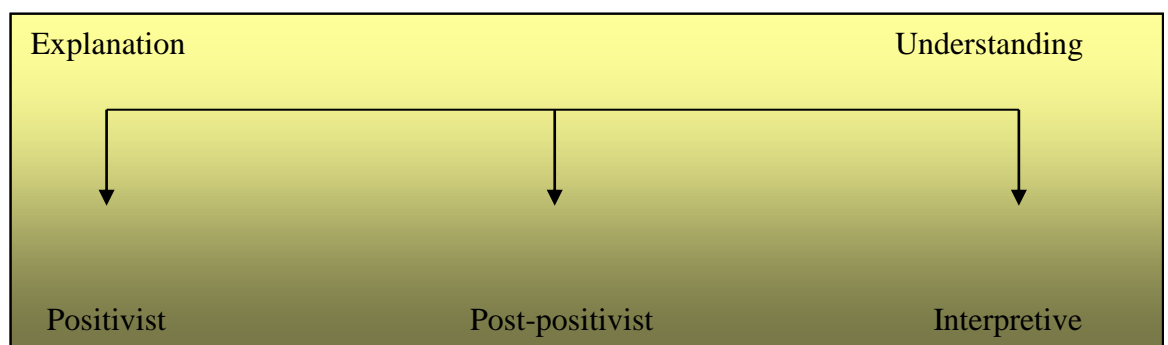
Figure 4.2: Contrasting Implications of Positivism &amp; Interpretivism

|                           | <b><u>Positivism</u></b>                                | <b><u>Interpretivism</u></b>                               |
|---------------------------|---|--|
| The Observer              | Must be independent                                     | Is part of what is being observed                          |
| Human Interest            | Should be irrelevant                                    | Is the main driver of the science                          |
| Explanations              | Must demonstrate causation                              | Aim to increase the general understanding of the situation |
| Research Progress Through | Hypothesis & deduction                                  | Gathering rich data from which ideas are induced           |
| Concepts                  | Need to be operationalised so that they can be measured | Should incorporate stakeholder perspectives                |
| Units of Analysis         | Should be reduced to the simplest terms                 | May include the complexity of the 'whole' situation        |
| Generalisation through    | Statistical probability                                 | Theoretical abstraction                                    |
| Sampling requires         | Large numbers selected randomly                         | Small number of cases chosen for specific reasons          |

(Source: Easterby-Smith *et al.*, 2002)

Grix (2004) further develops the paradigms suggested by Easterby-Smith *et al* (2002) and provides for a post-positivist approach which can be seen a ‘middle ground’ and is broadly based on a mixture of positivism and interpretivism. It can be considered as a mixture of the ‘how’ and ‘why’ and the concept hopes to bridge the gap between the two extremes. Figure 4.3 below illustrates where post-positivism sits in relation to positivism and interpretivism;

**Figure 4.3: Positivism, Interpretivism & Post-Positivism**



(Source: Grix, 2004)

Sutrisna (2010) affirms that the researcher needs to crystalise their philosophical standpoint before adopting a methodology. He goes on to refer to a “Continuum” as set out in Figure 4.4 to help the researcher identify their own individual philosophical perspective;

**Figure 4.4: The Philosophy Continuum**

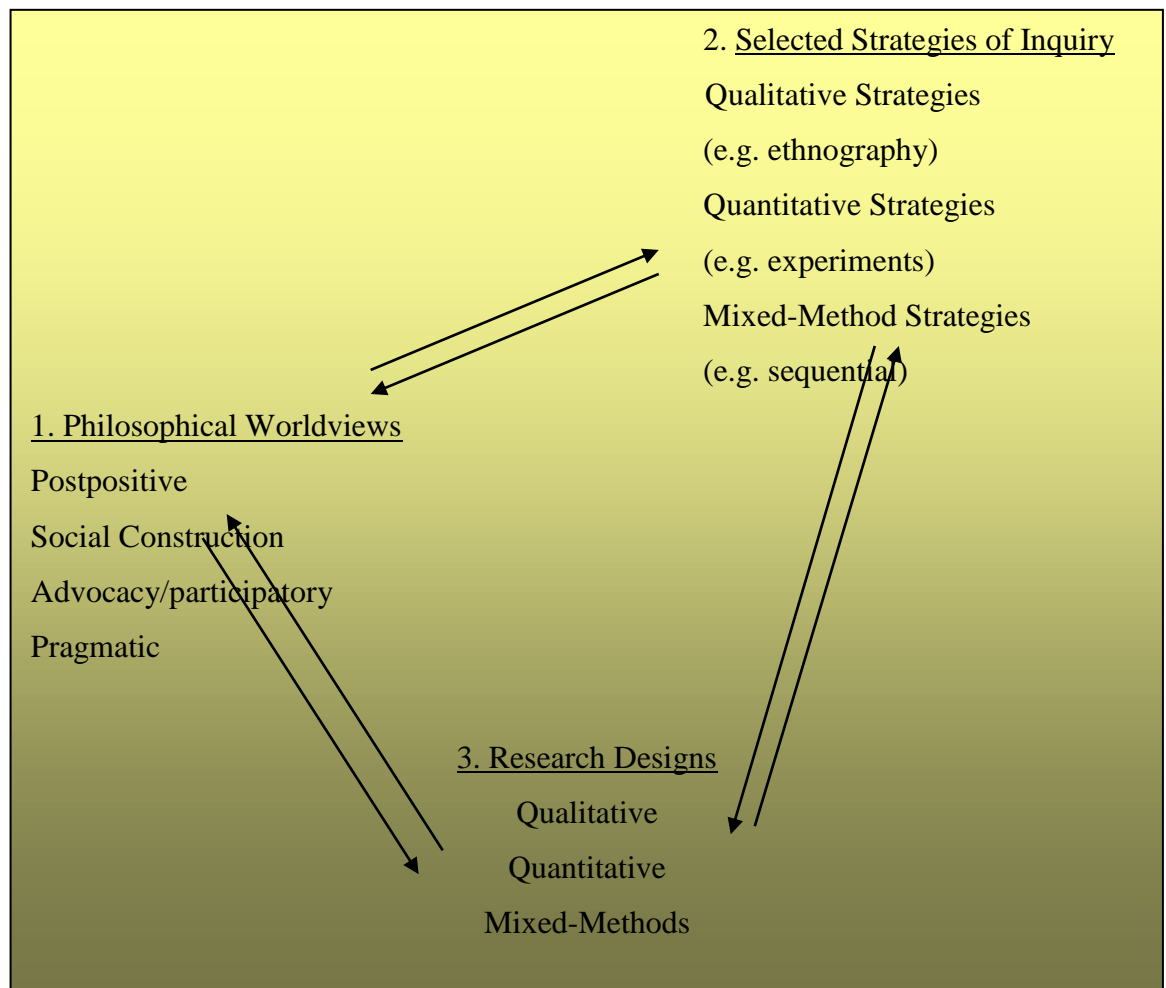


(Source: Sutrisna, 2010)

Cresswell (2008) identifies that a researcher’s paradigm is shaped by the disciplinary area and/or background of the student or researcher. The research

design which he refers to as the plan or proposal to conduct research, involves the intersection of philosophy, strategies of inquiry and specific methods. Figure 4.4 provides a framework to explain the intersection of these issues;

Figure 4.4: Interrelationship between the Building Blocks of Research.



(Source: Creswell 2007)

The researcher is aware of the difficulties and critique that this approach will invite, specifically in relation to the ‘paradigm incommensurability thesis.’ This according to Bryman & Bell (2003) encompasses the difficulties of epistemological commitments and the fact that quantitative and qualitative are underpinned by different assumptions and methods which are incompatible between paradigms. Newman & Benz (1998) discount the paradigm incommensurability thesis however and suggest that “qualitative and quantitative

approaches should not be viewed as polar opposites or dichotomies: instead, they represent different ends on a continuum”.

### **4.3 The Research Proposal**

The research design (proposal) according to Yin (2009) will provide a “logical plan getting from here to there, where ‘*here*’ may be defined as an initial set of questions to be answered, and ‘*there*’ is some set of conclusions (answers) about these questions”. This concept by Yin is also reflected by Philliber, Schwab & Samsloss (1980) where they state that “research design is a blueprint for your research, dealing with at least four problems;

1. What questions to study?
2. What data are relevant?
3. What data to collect?
4. How to analyse the results?

The motivation to prepare a research proposal is further developed by Lee (2009) and states that it is necessary that you settle on a project and spend time working up a detailed proposal. Colleagues, funders and supervisors will be concerned about a researcher who keeps changing their mind about a project, or who is reluctant to or cannot produce a proposal. This is a critical but difficult stage in the research process and Lee (2009) goes on to outline the difficult nature of developing such a proposal. The process of working up a research proposal takes time and is not necessarily comfortable, but it is always helpful in the longer run as it enables us to clarify aims and purposes and identify and iron out potential problems and unrealistic plans. The failure to adopt a clear research plan or proposal could lead to the rejection of the findings of the research as suggested by the Learn Higher Centre for Excellence in Teaching & Training unfortunately there are large numbers of small-scale research projects whose findings are

rejected because their methodology is not appropriate, their methods are flawed or lack rigour, or their conclusions are invalid. The concept of the research proposal is that it will provide a framework to ensure that the correct methodology and methods are applied and that any potential challenges to the validity to the research as addressed. Knight & Ruddock (2008) identify a problem for researchers in the field of the built environment however in that their field of study covers a vast range of subjects and approaches. In this sense, the built environment is clearly not a discrete discipline with its own standard approaches of philosophy". This difficulty is also expressed by Griffiths (2004) where he outlines that the built environment discipline is a very heterogeneous collection of fields of study and practice and that different paradigms exist therein. This undoubtedly poses difficulties for the research student in adopting a philosophical standpoint. Dainty's concern in Knight & Ruddock (2008) that an enduring adherence to the positivist paradigm will do little to enable construction management researchers to grasp the meaning of social action from the perspective of the actors involved and goes on to identify that no single methodology can ever provide a complete picture.

#### **4.4 The Research Strategy**

Bryman (2001) has defined research strategy as the way of going about research, embodying a particular style and employing different research methods, a way of collecting evidence that indicates the tools and techniques used for data collection. Saunders *et al* (2009) outlines that the research strategy is really important because it enables the researcher to answer the research question and meet the objectives of the research. Yin (2009) identifies three conditions which can be used to select an appropriate strategy for research;

- The type of research question
- The control of the researcher over behavioural events
- The degree of focus on contemporary as opposed to historical events

Robson (1993) has suggested that social science research strategy should adopt one of three methodologies; a survey, experiment or case study. As outlined from the Biglan Model (1973) this research is not confined to social science research as many different disciplines exist;

**Figure 4.5 The Biglan Model**

|                | Hard                |               | Soft                      |                      |
|----------------|---------------------|---------------|---------------------------|----------------------|
|                | Non-Life            | Life          | Non-Life                  | Life                 |
| <b>Pure</b>    | Astronomy           | Botany        | English                   | Anthropology         |
|                | Chemistry           | Entomology    | German                    | Political science    |
|                | Geology             | Microbiology  | History                   | Psychology           |
|                | Mathematics         | Physiology    | Philosophy                | Sociology            |
|                | Physics             | Zoology       | Russian<br>Communications |                      |
| <b>Applied</b> | Ceramic engineering | Agronomy      | Accounting                | Ed. administration   |
|                | Computer science    | Dairy science | Finance                   | Secondary education  |
|                | Mech. engineering   | Horticulture  | Economics                 | Special education    |
|                | Civil engineering   | Ag. economics |                           | Vocational Education |
|                | Nuclear engineering |               |                           |                      |

Source: Biglan (1973)

However and as suggested by Griffiths (2004) and Kinght & Rugddock (2008) the problem for the researcher in the built environment is that this is not a discrete discipline. Blismas (2001) takes account of this by recommending four possible strategies for research in the areas of social science and construction management which are experiment, survey, action research and case study. Sexton (2003) adds another strategy option which is ethnography while Yin (2009) lists five possible research strategy options being experiments, survey, archival analysis, history and case study. Saunders *et al* (2008) goes somewhat further by offering seven options for the research strategy and these are experiment, survey, case study, action research, grounded theory, ethnography and archival research. The philosophical standpoint of the researcher is critical in considering the research strategy as alluded to by Bryman (2001) whereby experiments and surveys tend to be used by those from a positivist research philosophy while action research, case study and

ethnography tend to be used by those adopting an interpretivist philosophy. The research strategy integrates the different components of the research project in a cohesive and coherent way. Rather than a “cookbook” from which you choose the best recipe, it is a means to structure the research project in order to address a defined set of questions (Trochim & Land, 1982). The methods adopted for this research which will shortly be discussed have been selected on the basis of a defined set of questions. These questions are centred on how best to inform and educate homeowners about the OSWTSSs.

Yin (2009) notes the importance of using the correct methods in a research project such as this so as to prevent against threats to the validity of the research findings and to maintain a “chain of evidence” for the research strategy. The choice of research topic guides the researcher into the selection of appropriate techniques or methods and the appropriate analysis procedures (Saunders *et al.*, 2009). The strategy adopted for this research has been guided by the three conditions set out by Yin (2009) and Table 4.6 has also influenced the research strategy to be adopted by reviewing the different strategy options with a focus on the relevance of each strategy for particular research problems. The post-positivist philosophical standpoint of this research reflects the fact that some of the research relates to human or social factors while on the other hand some of the research relates to technological factors. Ultimately this is how the nature of the problem to be investigated influences the research strategy (Yin, 2009) and the quantitative and qualitative components of the research require the adoption of a mixed methods approach on this occasion.

**Figure 4.6 Relevance of Different Research Strategies (Adapted from  
Nawi (2012))**

| Research Strategies    | Advantages  | Disadvantages  | Form of Research Question                 | Requires Control of Behavioural Events? | Focuses on Contemporary Events? |
|------------------------|---|--|---|---|---------------------------------|
| <i>Experiment</i>      | Clear possibility & answer; controlled context, replicable generable; safe time and resources; casual relationship        | Requires specific knowledge; artificial; ethical problem due to variable control; quantitative does not really explain | How, why                                  | Yes                                     | Yes                             |
| <i>Survey</i>          | Widely used; quantitative and qualitative; directive: affordability of large data; high predictability using              | Misplace findings; difficult to obtain truthfull data; and be applicable phenomenon studies                            | Who, what, where, how, how many, how much | No<br><br>less depth;                   | Yes<br><br>detail may not for   |
| <i>Case Study</i>      | In-depth, capture complexities, relationship; multiple data sources and methods; flexible time and space; less artificial | Problem of generalization; focus on natural situation; unpredictable; unacceptable for some course                     | How, why                                  | No                                      | Yes                             |
| <i>Action Research</i> | Collaborative; the researchers and context integrity; for practitioner  | Difficult for new exclusive; work setting influence;   | How                                       | Yes                                     | Yes<br>researcher;              |



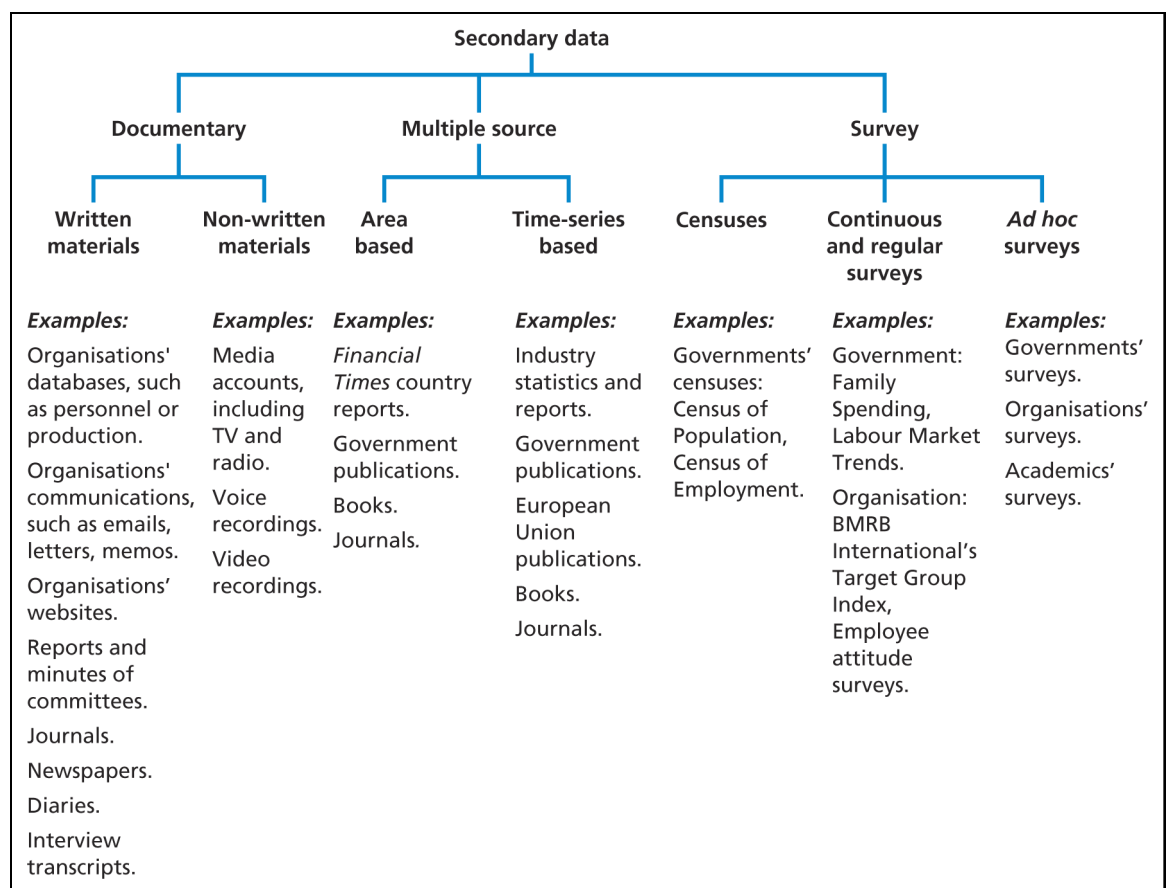
| Research Strategies                          | Advantages   | Disadvantages  | Form of Research Question                   | Requires Control of Behavioural Events? | Focuses on Contemporary Events? |
|--|--|--|---|---|---------------------------------|
| <i>Ethnography</i>                           | Feasible within the constrain of time and researches; direct observation; no specific data collection methods; rich data; deal with culture, inclusive | Difficult for new researcher; high skill needed; descriptive to explanative; ethical issues; limited accessibility problem of generalization | ‘Why’, to understand context and perception | No                                      | No                              |
| <i>Archival Research (documentary Study)</i> | Independent researcher; the researcher will not influence the quality of the documents; ca be reviewed repeatedly                                      | The documents might be produced for specific reason; lead to bias; can be difficult to find (irretrievability)                               | Who, what where, how many, how much         | No                                      | Yes / no                        |
| <i>History</i>                               | Applicable deal with ‘dead’ sources of evidence; can be reviewed repeatedly  | The data is limited in term of in-depth descriptions (not produced specific reason)  | How, why                                    | No                                      | No                              |

Sources: Sarantakos (2005), Robson (2007), Yin (2009), Saunders *et al.*, (2009), Grix (2010) & Setiawan (2011)

## 4.5 Data Collection Techniques

Churchill (1999) and Ghauri & Gronhaug (2005) have recommended that all research should start with secondary sources of data. Secondary data refers to any information or literature that has been collected and recently published (Nawi, 2012). Saunders *et al* (2009) have categorised data into three main groups as set out in Figure 4.wxy. These groups are documentary, multiple source and survey with examples of each in Figure 4.7;

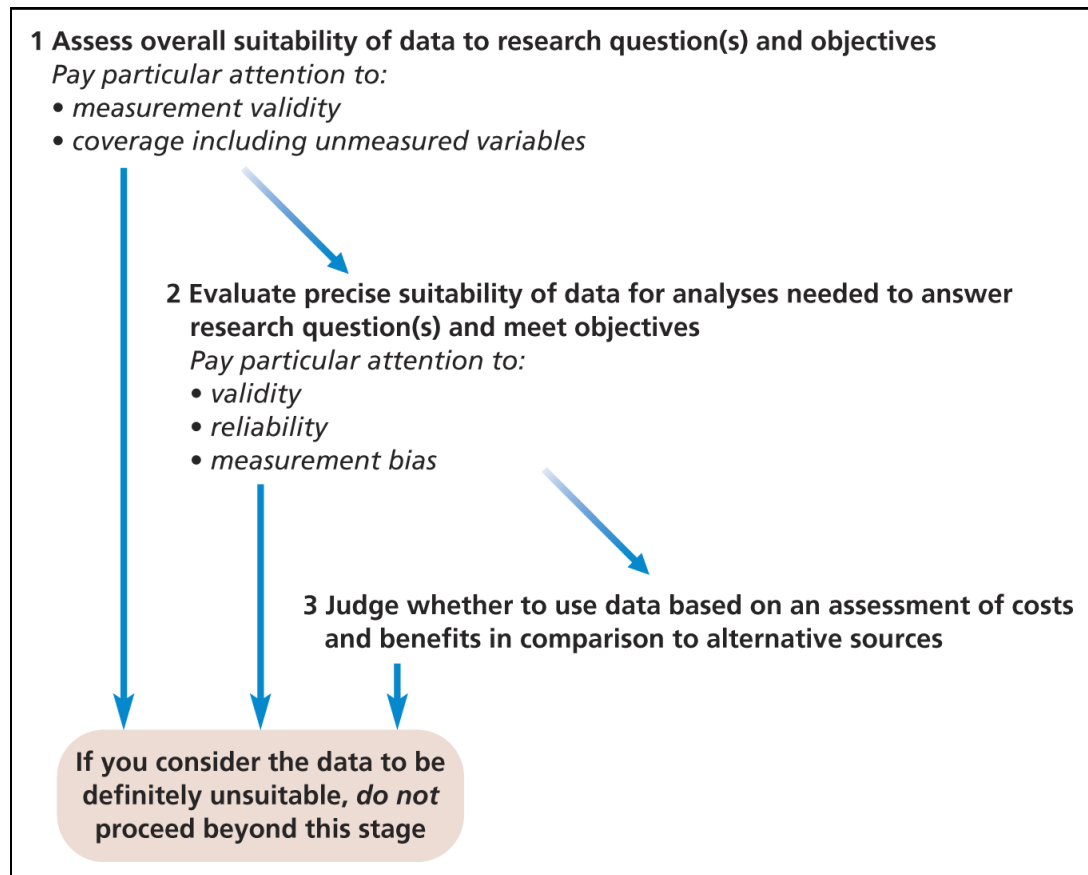
Figure 4.7: Types of Secondary Data



(Saunders *et al* (2009))

Once the secondary data has been identified and researched the suitability of this data must be considered in the context of the research aim and objectives. Saunders *et al* (2009) provide a systematic approach to determining suitability as set out in Figure 4.8;

Figure 4.8: Types of Secondary Data

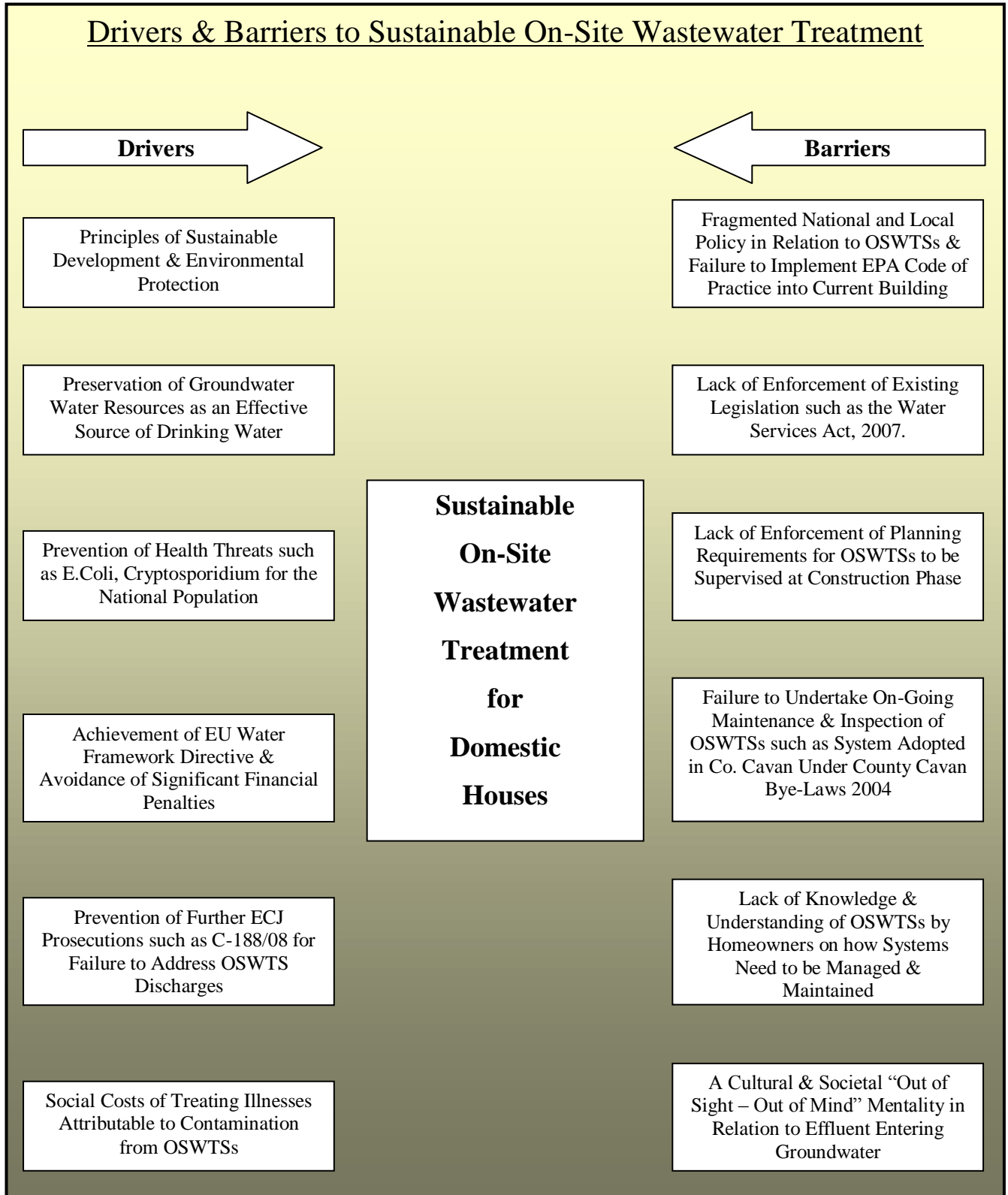
(Saunders *et al* (2009))

#### 4.5.1 The Literature Reviews

The review of existing literature is a vital component of any research project as it provides the researcher with an insight into the work that has already been undertaken in the subject area (Sckaran, 1996). Bryman (2001) suggests that the discovery of existing knowledge and research undertaken will prevent the duplication of efforts already expended by other investigators. This existing knowledge in the form of secondary data does have the potential to become out of date however (Bell, 1999) and this risk needs to be considered in the context of any particular research project. A good literature search demonstrates the ability to search, identify and select materials relevant to the topic and which need to be reviewed at a level appropriate to the project (Hart 2001).

The literature reviews that have been undertaken for this research project are presented in Chapters Two and Three and are cognisant of the time issue as referenced by Bell (1999). Accordingly, the literature review is being treated as an iterative process with regular updates from new and updated literature as it becomes available. During the course of the research process there will have been a number of amendments to the relevant Building Regulations pertaining to OSWTs as well the imposition of a new registration and inspection regime. There will also be results published for the most recent Census of Population 2011 carried out in Ireland and there will be a host of new information relevant to the research topic contained therein. The regular update of the literature review has ensured that the chapter remains relevant and accurate throughout the research. A significant portion of the knowledge base that is relevant to this research has been published in books, journals, practice guides and policy documents. Therefore, the literature review will focus mainly on explicit knowledge sources in these published forms. Nevertheless, there is also an element of tacit knowledge relevant to the research in the literature review and which is defined as being based on the experience of individuals, expressed in human actions in the forms of evaluation, attitudes, points of view, commitments and motivation (Nonaka et al 2000). The following illustration summarises the drivers for sustainable on-site wastewater treatment in Ireland that have been identified from the review of literature as well as the barriers that are currently preventing the achievement of sustainable OSWTs thus informing the aims and objectives of this thesis;

**Figure 4.9: Drivers & Barriers for Sustainable OSWTS Treatment Identified from Literature Review**



## **4.6 Research Methods**

In the development of the search strategy for the literature to be reviewed, the following issues have been considered;

1. What I need to know?
2. Consideration of the overall research aims and objectives
3. What I already know?
4. What literature do I currently have?
5. What information sources do I have access to?

The data collection techniques or methods that are to be implemented are a critical step in the research journey. Stanley and Wise (2008) refer to methods as the data collection tools used to generate data about our chosen subject. The collection of evidence can come from many sources of evidence: reviewing documentary and archival records, interviews, workshops, direct observation and participation-observation (Bryman, 2001). In research there is no single source of evidence or method that is better than all the others (Yin, 1994) while Crotty (1998) reminds us in the overall context of knowledge where methods are relevant to research;

- Epistemology: a theory of knowledge or what we think counts as knowledge about a topic
- Theoretical Perspective: the philosophical position that guides our research
- Methodology: an overall research design or approach that shapes the choice of methods
- Methods: the techniques, tools or procedures to generate knowledge

(Crotty, 2008)

The epistemological and theoretical perspectives of the researcher have been discussed in sections 4.1.& 4.2 above. It is now necessary to consider the data that will be gathered as part of this research so that the most appropriate methods can be adopted. As eluded to earlier in this Chapter, research may be categorised into two distinct types: quantitative and qualitative (Creswell, 1994). ‘Quantification means to measure on some numerical basis... whenever we count or categorise, we quantify... a qualitative approach by contrast emphasises meanings, experience, descriptions etc’ (Coolican, 1990). The data that is required to achieve the aim of developing a knowledge model for homeowners is both quantitative and qualitative in nature and therefore requires a mixed method approach to the research. According to Glaster & Backer (1973) this can make the quantification and summary of findings problematic and ambiguous. Nevertheless, the use of a variety of research methods in the research will help to achieve triangulation and the overlapping of data sources will ensure the validity of the research design (Creswell, 1994). Yin (1983) also supports the use of multiple sources of data and suggests that research that uses multiple sources are rated more highly than those that rely on only one single source of data. To Lee (2004) quantitative research grows out of a strong academic tradition that places considerable trust in numbers that represent opinions or concepts. In contrast, the qualitative approach concentrates on words and observations to express reality and attempts to describe people in natural situations. King (2004) provides a very useful analysis of the practical applications of both methods in the Table 4.10;

Figure 4.10: Features of quantitative and qualitative research methods

| <b><u>Quantitative</u></b>  | <b><u>Qualitative</u></b>  |
|---|--|
| Inquiry from the outside  | Inquiry from the inside  |
| Underpinned by a completely different set of epistemological foundations than in qualitative research | An attempt to take account of differences between people   |
| Involves the following of various states scientific research  | Aimed at flexibility and lack of of the structure in order to allow theory and concepts to proceed in tandem   |
| The results are said to be 'hard generalisable data'  | The results are said to be through theoretical generalisation, 'deep, rich and meaningful'   |
|   | Inductive – where propositions may develop not only from practice or literature, but also from ideas themselves  |
|   | An approach to the study of the social world, which seeks to describe and analyse the culture and behaviour of humans and their groups from the point of view of those being studied |

(Source: King, 1996)



#### **4.6.1 IOWA Committee Workshop**

The workshop technique is a useful and effective data collection approach that provides a conducive platform for making sense of various concepts (Krueger & Casey, 2000). The workshop is a highly efficient for qualitative data collection since the amount and range of data is increased by collecting it from several people at the same time (Robson, 2004). Krueger & Casey (2000) outline that a group of four to six participants sharing similar backgrounds, attitude and behavioural patterns is recommended for a workshop and the IOWA executive committee is made up of five members and thus is an ideal method for this research. The aim of the workshop is to enhance the review of existing literature as set out in Chapter Two by providing an insight into the perceptions and experience of the IOWA executive committee which is representative of practitioners in the OSWTS industry. This experience can therefore be regarded as practitioner based experience (PBE). The workshop serves as a platform for discussion on the issues raised in the literature review and to determine which, if any, are relevant to the knowledge model for homeowners for their OSWTS's. To achieve this objective the workshop adopted a semi-structured discussion approach which centred on the drivers and barriers to sustainable OSWTS's set out in Figure 4.8.

#### **4.6.2 Questionnaires at IOWA Conference 2013**

The questionnaires to the general IOWA membership were undertaken in the validation stage of the research with practitioners and stakeholders in the field of OSWTS and a copy of the Questionnaire is outlined in Appendix 1. These questionnaires were intended to confirm what knowledge needs to be conferred to homeowners in the knowledge model. These issues were identified in the literature review in Chapter Two and from the workshop session that was held with the committee of the IOWA that will be discussed in Chapter Five. This approach affirms the research need and confirms the areas for the research to be undertaken. The literature review which has been undertaken in Chapter Two has identified

many issues and problems pertaining to on-site wastewater treatment in Ireland and these issues will be challenged in the questionnaires undertaken with the wider IOWA membership. Each question in the questionnaire was designed to gather a specific piece of information or opinion on a certain aspect of the knowledge model and its content and structure. The questionnaires were presented and completed at the IOWA annual conference which attracted membership and attendance from professional groups such as on-site assessors, architects and engineers, legislators, academics, manufactures and system designers. The reason for undertaking the questionnaires at this event was that there would be an attendance from all over Ireland and the attendees all have a professional background in the subject area and are familiar with the wastewater treatment problems being experienced in Ireland as presented in Chapter Two.

A cover letter was presented with the questionnaire to the participants introducing the research being undertaken and briefly justifying the need for the research. This would also confirm that the responses would be confidential and that no individuals would be identified in the presentation of results. Finally the cover letter also provided directions for completing the questionnaire and confirmed how it would be collected and followed the guidelines of good questionnaire design as suggested by Hague (1994) and Oppenheim (1992). The format of the questionnaire was in three sections. The first section sought to identify the professional background of the participant and this information would be useful to cross reference opinions derived from the second section of the questionnaire. Section two of the questionnaire was designed to obtain the participant's perspective and opinion on the issues and problems identified in the literature review. The questions in this section of the questionnaire were based on a five point balanced Likert scale (1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree or 5 = strongly disagree) and this approach is commonly adopted in attitude assessment. The questions contained in the questionnaire form were developed from existing knowledge identified in the literature review and are industry specific to those who would be in attendance at the IOWA conference. Section three of the questionnaire provided for additional comments and suggestions from the participant in accordance with Oppenheim's (1992) theory

that the final section should be left free for the respondents to comment about the survey questionnaire, to add any additional points that were not included, or to reinforce any particular attitudes or perceptions questioned that could be used in the subsequent analysis. The adoption of the questionnaire method at the IOWA conference provided a unique opportunity to gather responses from a very wide spectrum of professionals in a concise timeframe. It would not have been possible to undertake individual interviews with this number of participants due to the limitations of time and resources available for this research project. The researcher also has the opportunity to introduce the research to the participants verbally and this assisted in the completion of almost 100 questionnaires on the day of the conference. This method ensured that the questionnaire phase of the research was regionally balanced, broad and comprehensive.

#### **4.5.1.0      Testing of the Questionnaires**

The format and validity of the questionnaire was measured by sending it to a sample number of professionals in a pilot test and comments were sought on issues such as clarity, terminology and consistency of the questions. According to Yin (2009) a pilot test will help to refine the data collection plans with respect to both the content of the data and the procedures to be followed. The pilot is not a pre-test, it is more formative and assists in developing relevant lines of questions, possibly even providing some conceptual clarification for the research design as well.

#### **4.5.1.1      Responses to Questionnaires at IOWA Conference 2013**

Table 4.10 illustrates the number and professional background of the participants who completed the questionnaires at the IOWA Conference in 2013;

Figure 4.11 illustrating key factors that influence OSWTS's performance

| Professional Background<br>Of Participant: | No. of<br>Responses | % of<br>Sample | No. of Unusable<br>Responses |
|--|---------------------|----------------|------------------------------|
| OSWTS Manufacturer /<br>Supplier           | 15                  | 16.86%         | 0                            |
| On-Site Assessor                           | 39                  | 43.82%         | 0                            |
| Local Authority Representative             | 12                  | 13.48%         | 0                            |
| EPA Representative                         | 0                   | 0%             | 0                            |
| Legislator /<br>DoEHLG Representative      | 3                   | 3.37%          | 0                            |

#### 4.6.3 Structured Interviews with IOWA Committee

A number of structured interviews also took place in the validation stage of the knowledge model and the participants comprised of the executive committee of the IOWA. The committee is made up of five members and therefore the adopted approach is limited to a maximum of five. The reason for adopting this approach is that the IOWA executive committee is elected to their position by members of the IOWA and their election is seen as an acknowledgment of expertise, knowledge and understanding of issues relating to on-site wastewater treatment in Ireland. This committee would be familiar with current and proposed legislation relevant to the research topic as well as having a thorough understanding of the problems identified in Chapter Two. The benefit of this approach over randomly selecting individuals to undertake the interviews is that the researcher could be assured of the interviewee being informed on the subject area. If the researcher had to inform the interviewee of issues relating to the subject there would of course be a risk of bias (Schon, 1983 & Jarvis, 1998) in the interview responses.

These structured interviews were undertaken to gauge opinion on the suitability of the knowledge model and to seek opinions any refinements that might be suggested. To mitigate the possibility of participants not having time to consider the draft model at the interview stage, it was proposed to circulate the draft model in advance of the interviews. These interviews tested the suitability of the model and all interviews were undertaken before the commencement of the questionnaire survey to homeowners. The structured nature of the interviews ensured that valuable time was not consumed discussing issues not specifically related to the knowledge model. The interviewees were afforded an opportunity in the workshops to raise the points that they felt were relevant and these points have been considered in the knowledge model design. A concern of adopting semi-structured or un-structured interviews at the validation stage would have been that the interviews would have drifted onto wider environmental matters and not be exclusively focused on the knowledge model that will be developed. The research flow chart at Figure 11 also illustrates where these interviews have taken place in relation to the wider research project.

#### **4.6.4 Structured Interviews with Homeowners**

The structured interviews with homeowners are undertaken in the validation stage of the research. These interviews adopt a three stage process to firstly determine the homeowner's existing knowledge on how to manage and maintain their OSWTS. This is done by asking a selection of questions that will be developed in Chapter Five and Six. The homeowners will then be provided with the knowledge model and then asked the same questions again. The homeowner will be free to refer to the knowledge model and the learning outcome will be measured by comparing the before and after responses. In order to ensure that the participants are randomly selected the interviews would take place at the "Self Build" property show. This show attracts visitors from all over the country and is typically directed at existing and perspective homeowners who live in locations not served by municipal sewerage facilities.

#### **4.7 Data Analysis Techniques for Research Undertaken**

There is no standardised approach to the analysis of qualitative data (Saunders *et al*, 2003). Nevertheless, the Template Analysis which has originated from King (2004) is considered to be the most suitable for the analysis of the qualitative data that will be gathered as part of this research. Template Analysis has also been referred to as ‘codebook analysis’ or ‘thematic analysis’ and it focuses on the textual content to describe a phenomenon (King, 2004). King (2004) goes on to suggest that this data analysis tool is used for making replicable and valid references from data to their context; to determine the beliefs, values and behaviour, attitudes and other elements of cultural influence through the systematic analysis of words and pictures and it concentrates on individual themes or subjects and patterns. The quantitative data derived from the questionnaires was analysed manually with statistical data presented in the form of percentages with discussion summaries.

#### **4.8 Ethical Procedure**

This research investigation is based on obtaining information from people and therefore it is a requirement that ethical approval be obtained prior to conducting research. According to Lee (2009) research conducted in any context requires that participants know why and how the research is to be undertaken. The ethical principles of informed consent and doing no harm ‘non-maleficence’ apply to this research and therefore all participants have been made aware of the exact nature of the enquiries made either in written or verbal form. Informed consent has been obtained in a variety of ways including the use of written information as well as by the use of verbal explanation whereby the nature of the research is explicitly defined. Miller and Boulton (2007) concur that informed consent is an important aspect of the relationship between those involved in research activities and participants. Robson (2002) states an even higher regard for informed consent than just important and adjudicates that it is unethical to involve people in

research without their knowledge and permission. The key ethical issues that have been considered in this research project are the following;

- Doing no harm or ‘non-maleficence’ in the research undertaken
- Confidentiality and anonymity for the safeguarding of those who do not wish to be named
- Consideration of mental capacity and the ability of participants to make individual decisions in the basis of information presented
- Data protection issues related to the storing and recording of information

A copy of the research proposal for this study was provided to the University of Huddersfield Ethics Committee prior to conducting the research and subsequently ethical approval was received.

## **4.9 Chapter Summary**

This research focuses on Irish homeowners that rely upon OSWTS’s and the urgent need to educate and inform these homeowners on how to operate and maintain these systems on a more sustainable basis than has currently been the case. The review of existing literature in Chapter Two has identified that there is limited knowledge on individual OSWTS’s in Ireland but where research has taken place these are very poor standards of construction, operation, maintenance and knowledge surrounding these OSWTS’s. The review of the literature also identified that there are very substantial changes taking place in the legislation that governs OSWTS’s and that little or no attempt has been made to communicate these changes to homeowners. The research strategy for this study which has been introduced in Section 4.4 has highlighted the need to adopt a pragmatic or post-positivist approach for this study. Knight & Ruddock (2008) have attested that the adherence to a positivist paradigm amongst construction

management researchers will prevent them grasping the meaning of social action from the perspective of the actors involved. The nature of the problem to be investigated in this research is a social one as it involves behaviour, knowledge and understanding of homeowners who rely upon OSWTS's. Nevertheless, there is also a technological aspect in relation to the development of the knowledge model for homeowners and this part of the research demonstrates a positivist worldview. In essence, there is a divide in this research between the need to understand and explain (Grix, 2004) and hence the adoption of the post-positivist approach.



## **CHAPTER FIVE – WORKSHOP & PBE**

### **5.0 Introduction**

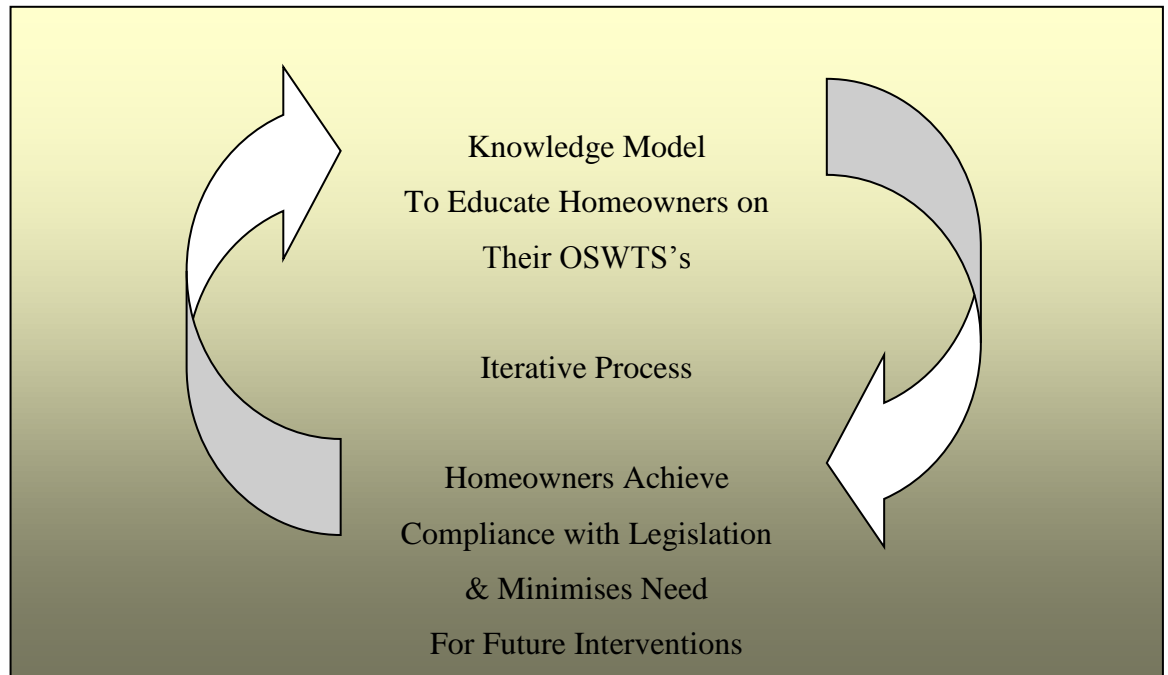
An introduction to this research investigation was described in Chapter One which outlined in detail the aim and objectives of the research. Chapter Two then moved on to outline the precarious position that Ireland finds itself in currently and its on-going prosecution for failures to implement EU policy (ECJ, 2009) specifically in relation to OSWTS's. In Chapter Three a thorough examination and critical review of modelling techniques was undertaken to consider the applicability of the concept of modelling to educate and inform homeowners on their legal responsibilities and how to better manage and maintain their OSWTS's. Chapter Three identified the many advantages of modelling as a technique to convey knowledge and the concept of graphic means of knowledge transfer critically analysed. Chapter Four identifies the philosophical standpoint of the author and from this philosophical worldview (Knight & Ruddock, 2008) a comprehensive research methodology is established and provides the justification for the research methods adopted in the thesis. This Chapter builds on the conclusions of the literature review in Chapter Two by reporting on the findings of the PBE which will develop the issues that are to be contained in the knowledge model for homeowners. This Chapter will then examine how these issues will be verified through the questionnaires to be undertaken with the wider IOWA membership.

### **5.1 Objective of the Knowledge Model**

The research to this point has focused on the existing literature that exists in the subject area and has been discussed in detail in Chapters Two and Three. An important milestone in the thesis has now been reached whereby the research moves from secondary sources to primary research. The research methodology that has been formulated in Chapter Four now requires the input of industry practitioners which will be the source of the PBE for the thesis. In order to

introduce the aim of the research to those industry practitioners a visual aid has been prepared and is set out in Figure 5.1;

**Figure 5.1** illustrating key factors that influence OSWTS's performance



## **5.2 Workshop Session with IOWA Executive Committee**

The justification for and explanation of the workshop session with the executive committee of the IOWA has been discussed in detail in Chapter Four. Chapter Four identified that a workshop is a useful and effective data collection forum as it provides a conducive platform for making sense of the various concepts relevant to the research (Krueger & Casey, 2000). Furthermore the workshop is a highly efficient technique for qualitative data collection since the amount and range of data is increased by collecting it from several people at the same time (Robson, 2004). The research design had to be cognisant of the fact that the literature review had identified shortcomings that exist in homeowner knowledge towards OSWTS's or in the case where homeowners did have an awareness of the need for maintenance of their systems that they choose to disregard this knowledge (Gray, 2005 & IOWA, 2012). The research needed to be mindful of the fact that there

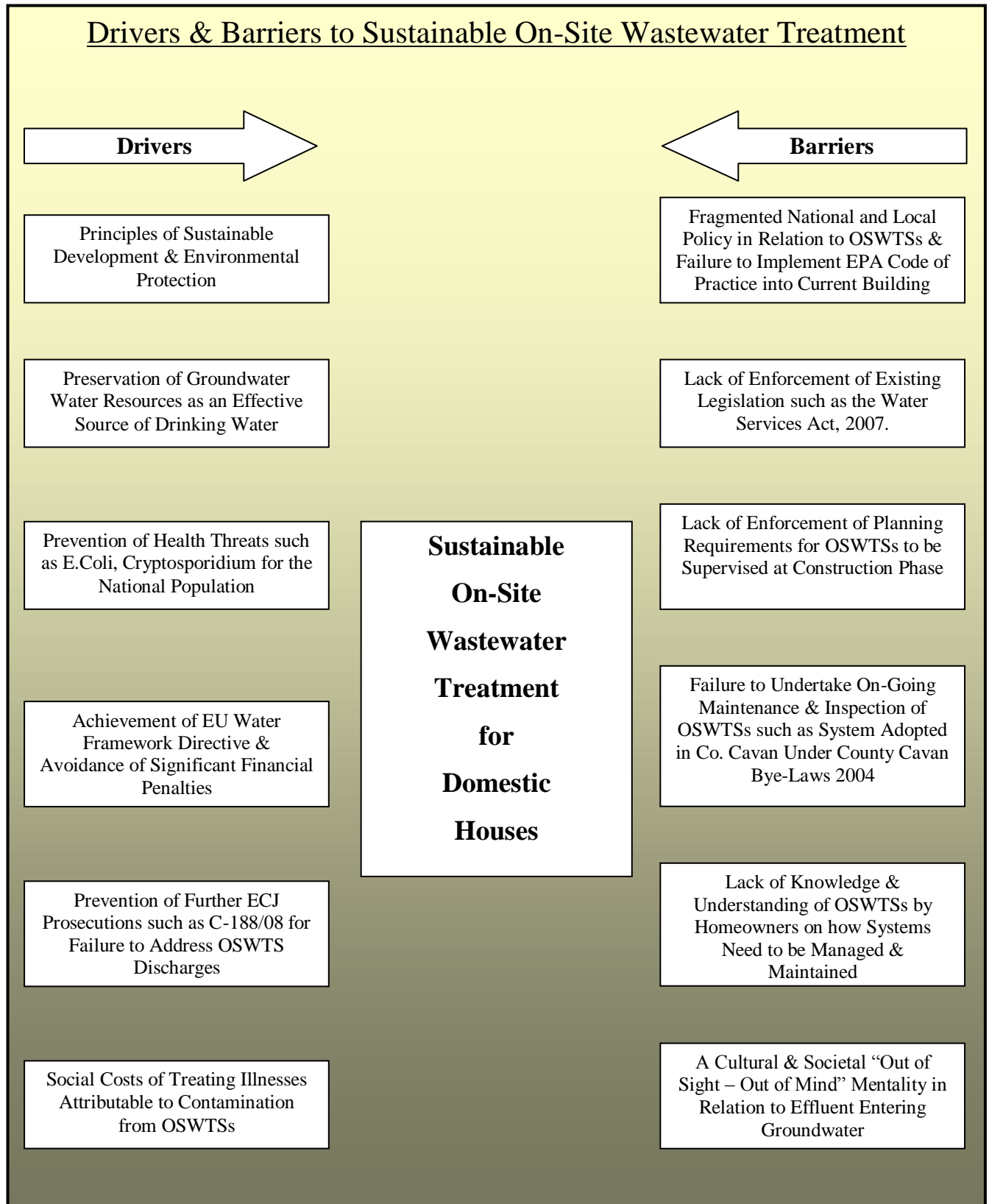
was little or no point asking a homeowner about what they needed to know in relation their OSWTS when a knowledge deficiency existed already. The research strategy therefore had to consider how the issues that needed to be contained in the knowledge model could be determined. Chapter Four has introduced and discussed the workshop as a method of data collection that assists in the revision and refinement of the literature review (Abukhzam, 2011). The IOWA have been introduced in Chapter Four as an association that represents professionals in the on-site wastewater industry and membership comprises a broad range of cross disciplines including tank manufacturers, system installers, site assessors, council staff, trainers and policy makers, industry manufacturers and suppliers, system designers, architects, operators and maintenance professionals (IOWA, 2011). The committee of the IOWA is made up of five members who are elected to their positions by the wider membership of the association and the election of the committee is seen as recognition of industry expertise (IOWA, 2012). The committee will be familiar with current and proposed legislation relevant to the research topic as identified in the literature review in Chapter Two. The IOWA executive committee meet periodically it was agreed that the workshop could be undertaken at the meeting times for the convenience of the participants.

## **5.2 Workshop Aim & Objectives**

The aim of the workshop is to enhance the literature review (Abukhzam, 2011) as set out in Chapter Two with the main objective to provide an insight into the perceptions and opinions from the practice based experience of the participants from the OSWTS industry. The workshop will focus on the findings of the literature view and specifically the drivers and barriers to achieving a sustainable on-site wastewater treatment in Ireland. In addition to this objective the workshop also provides a platform for the researcher to examine the acceptance of the knowledge modelling from the participants as well as gauging opinion on what issues the knowledge model should contain. The workshop adopted a semi-structured discussion approach with the discussion based on the drivers and

barriers to sustainable on-site wastewater treatment as outlined in Figure 5.2 overleaf was developed from the findings of the literature review at Chapter Two. Finally the analysis of the data from the workshop will be combined with the findings from the literature review and analysed using the methods outlined in Chapter Four.

**Figure 5.2 Drivers & Barriers to Sustainable On-Site Wastewater Treatment Identified from the Literature Review**



### 5.2.1 Workshop Participants

The workshop was organised with Smart Office Services who are a contract administration firm that are engaged by the IOWA. The workshop was attended by all members of the executive committee and Table 5.1 provides a profile for each participant;

**Table 5.1     Profile of Participants**

| <b>Name</b> | <b>Position Held</b>  | <b>Experience</b>                                      | <b>Discipline</b> | <b>Location</b> | <b>Gender</b> |
|-------------|-----------------------|--|-------------------|-----------------|---------------|
| P1          | OSWTS System Supplier | 20 years in Ireland and 15 in USA                      | Engineer          | Southern        | Male          |
| P2          | Scientist             | 13 years   | Local Authority   | South East      | Male          |
| P3          | On-site Assessor      | 17 years   | Engineer          | South           | Male          |
| P4          | Academic              | 35 years in Local Authority Role and 5 years lecturing | Engineer          | North West      | Male          |
| P5          | OSWTS Installer       | 26 years   | Construction      | Midlands        | Male          |

### **5.2.2 The Workshop Process (Practice Based Experience)**

The workshop was conducted on the 15<sup>th</sup> August 2012 in the business suite of the Heritage Hotel in County Laois, Ireland. The workshop was undertaken immediately after the IOWA executive committee had held their own meeting and the participants kindly gave almost two hours of their time for the workshop. The workshop commenced with the researcher introducing the research objectives as well as the ethical procedures which would protect the participants' anonymity and ensure confidentiality of responses.

A short presentation was given to provide an update on the research undertaken to date and agreement was obtained for the proceedings to be recorded on dictaphone so that the responses could be analysed after the workshop. This analysis as discussed in Chapter Four and the findings will be verified from the questionnaires that will be outlined later in this Chapter.

#### **5.2.2.1 Findings of Question 1 - Problems Associated with OSWTS's in Ireland**

The first question was quite general to stimulate the debate and was broad in scope:

*“What are the problems affecting OSWTS performance in Ireland and why have these occurred?”*

The debate commenced with very strong agreement that the problems that surround on-site wastewater treatment in Ireland come from a range of perspectives. All of the participants agreed that Ireland's current predicament is a combination of poor policy enforcement, a lack of regulation and a failure to take responsibility by homeowners for their OSWTS's. The key problem identified by (P2) was trying to remediate OSWTS's that have been so utterly neglected that

there is little hope for them into the future. This point was expanded by (P5) where he stated that;

*‘There are many OSWTS’s in Ireland that are not now and were never going to be fit for purpose. In many cases these systems are no more than cess-pits that are purely providing retention of wastewater before it finds its way to stream, rivers or groundwater. The problem as far as I can see is that there are so many of these scattered all over the countryside that the EPA and the government do not realize the scale and magnitude of the problem’.*

The researcher referred back to the original question and specifically the ‘why this had happened’ and (P4) responded to this jointly with (P5) and said;

*‘There has been a culture of people not considering their actions and not really caring about what happened with domestic wastewater. There was no regulation of these systems being constructed, builders had little concern for whether the systems were properly constructed and to be honest even if there was an acknowledgement of the right thing to do people preferred to spend their money on something other than a properly functioning OSWTS’.*

Participant (P1) referred to the drivers and barriers to sustainable on-site wastewater treatment that was presented and referred specifically to the issue of maintenance and repair and disagreed somewhat with the previous comments of (P4) & (P5) and stated;

*‘I agree that there are huge numbers of systems that are not fit for purpose but there are also a huge number that are (fit for purpose). We have supplied OSWTS’s all over the country and these are packaged wastewater treatment plants that are prefabricated and ready to operate once placed in the ground and the services connected to them. What we would be very concerned about is the fact that only a handful of the people that we have supplied these systems to have ever come back about having the systems serviced or maintained. In almost all cases the first occasion we hear back from a customer is when the system has*



*broken down and this can be 10, 12 or 15 years after the plant (OSWTS) has been sold. These breakdowns are more often than not a result of sheer neglect and would be avoided if components in the plant (OSWTS) were not flooded or choked up with sludge. We have tried to set up maintenance agreements as a source of business when we sell the plants (OSWTS's) and this is usually a requirement of planning permission anyway but we have had little success.'*

The points raised by (P1) stimulated a discussion on the type of maintenance that OSWTS's need and a general conversation began about de-sludging. The consensus amongst the participants was that de-sludging of OSWTS's is a very simple maintenance measure but one where there is also major problems in the industry. (P2) who is a scientist referred to the problem of unregistered and unregulated operators undertaking de-sludging and explained that;

*'Septic tanks (OSWTS's) contain highly contaminated substances that need to be safely treated and handled. At least when these substances are in the septic tank (OSWTS) they are out of harms way but we have a huge problem with contractors emptying the tanks (OSWTS's) and land spreading this material untreated. Birds, vermin and humans are then exposed to this and for instance when this (sludge) is spread in heavy rainfall the run-off from fields takes it straight into the water network. In my opinion if the material is not going to be properly dealt with then it is better left where it is as it's a lesser of two evils'.*

Once again the researcher prompted (P2) to say why this has happened and he explained;

*'There's a number of reasons no doubt but obviously the main one is the fact that operators have been doing this for years and not knowing or understanding the consequences of what they are doing. We have had no proper recording of what happens to sludge and therefore once it leaves a property there has been no follow up by anybody'.*

This point stimulated the debate about the National Inspection Plan (EPA, 2013) and the measures that are proposed.

(P4) referred to the requirement under the National Inspection Plan (EPA, 2013) for a record to be maintained by the homeowner of all and any de-sludging that had been undertaken on the OSWTS and that this would need to be provided to the inspector at the time of inspection. The consensus from the debate was summarized by (P5) where he stated;

*‘Time will tell whether the National Inspection Plan (EPA, 2013) resolves the de-sludging issue so we will have to wait and see on that point’.*

#### **5.2.2.2 Findings of Question 2 – Responsibility for OSWTS’s in Ireland**

The second question was more specific than question one and seeks to identify who is responsible for OSWTS’s: *“Who is ultimately responsible for the performance of individual OSWTS’s?”*

This question was framed so that participants were aware that it referred to individual OSWTS’s and not OSWTS’s in a national or cumulative context. The Water Services (Amendment) Act 2012 as outlined in Chapter Two makes homeowners legally responsible for their OSWTS’s and any consequent pollution. There was complete consensus amongst the participants that this was correct and that the homeowner be responsible and (P2) explained;

*‘Under the polluter pays principle the homeowner must take legal responsibility for their system (OSWTS) as there is no alternative to this either in law or otherwise. The situation would be implausible if a homeowner could not be prosecuted for instance if their system (OSWTS) is causing contamination and they could not be prosecuted for it’.*

The other participants agreed with this and consensus was therefore determined that the homeowner is responsible both in law and morally for their own system with (P4) summarising humorously;

*‘With the condition of many of the systems (OSWTS’s) in my area it’s every man for himself!!!)*

### **5.2.2.3 Findings of Question 3 – Issues to Achieve Sustainable On-site Wastewater Treatment**

This question returned to a more broad scope anticipating a more discussion type response than the previous question and was framed as follows;

*“What needs to change in order to achieve sustainable on-site wastewater treatment?”*

The responses to this question raised some very insightful responses and (P5) was the first to respond by explaining that;

*‘In simple terms the new legislation needs to be enforced and homeowners need to understand the gravity of the situation and the implications of allowing untreated effluent discharge from their property’.*

The researcher asked if all participants agreed with that assertion and all confirmed that they did. The next participant to respond was (P1) and furthered the point by stating that;

*‘There needs to be a complete change in mindset towards septic tanks (OSWTS’s) like we had some years ago with recycling. Poorly performing septic tanks (OSWTS’s) need to be frowned upon and people need to be educated from a*

*young age that a septic tank (OSWTS) is like a rubbish bin and that allowing it to fill up and flow over is not acceptable'.*

Participant (P2) immediately agreed with the comment of (P1) and referred to a 'cultural change' as being required from the top down and the bottom up. The fact that no prosecutions of individual homeowners have taken place for contamination from their OSWTS was identified by (P4) and he outlined that;

*'This problem (OSWTS) has been there for decades and neither the government, the EPA or anybody else thought it a matter of importance until Ireland was prosecuted by the EU. As soon as the fines and penalties were announced there was a new piece of legislation implemented in a matter of weeks that established the inspections (National Inspection Plan) and these inspections have now found that over half of systems (OSWTS's) are failing. If the same principle was applied to homeowners there would be a very swift change in mindset'.*

There was then an exchange of views between (P1) and (P4) with the former believing that the 'carrot and the stick' approach required that homeowners be given an opportunity to get things right before punishments were applied. (P4) argued that this would be too slow to solve the problems of poorly performing OSWTS's and that the stick would be more productive in the shorter term. There was a clear difference of opinion between the participants on this and the manner in which homeowner's behaviour could be changed.

Participant (P5) who is an OSWTS installer cited the problem of unregistered and untrained contractors undertaking works on behalf of homeowners to their OSWTS's. This he felt was something that needed to be addressed as he had come across situations where improvement works had been paid for by homeowners but not actually completed or undertaken properly. He explained;

*'I think on balance it needs to be accepted that not all systems are causing pollution and not all homeowners are ignoring their responsibilities. There is an urgent need however for some form of registration of contractors as there are*

*“cowboys” undertaking works that they are neither competent in nor concerned about. The difficulty with OSWTS is that they are in most cases underground and the homeowner cannot see what work, if any, has been undertaken. We have been called out to sites where remedial works have been paid for and all that has been carried out is the ground dug up and filled back in again. Something here needs to be done’.*

Participant (P1) agreed with the theory but suggested that the registration of builders / contractors was something that the wider construction sector needed and that it was unlikely in the short term that this would happen. (P5) responded by suggesting then at the very least homeowners needed to know what to look out for and all participants were in agreement with this. Participant (P3) also referred to the comment by (P5) on the matter that not all homeowners were seeking to avoid responsibility and suggested that;

*‘I agree with (P5) in relation to the people not actively trying to avoid their responsibilities or knowingly causing pollution. There are systems (OSWTS’s) out there that are the cause of contamination and their owners simply don’t realise it. That’s something that needs to change and to me it’s a case of educating homeowners on what to look out for like was mentioned for the de-sludging. Some people are having their systems de-sludged but just do not realise that they should be getting proper receipts and certificates from registered contractors’.*

#### **5.2.2.4 Findings of Question 4 – The Relevant Issues for Homeowners Regarding OSWTS’s and the Knowledge Model**

This question was designed to identify and summarise the issues that are relevant for homeowners in relation to their OSWTS’s and was as follows;

*“What does a homeowner need to know about in relation to their OSWTS and what issues should be contained in a knowledge model specifically designed for the homeowner?”*

This question was asked nearing the end of the workshop as it was anticipated that it would summarise the debate that had been undertaken so far. While the workshop was being recorded on Dictaphone for the benefit of the researcher the responses to this question were listed on a flip chart also which was intended to assist the participants in responding to the question. As the issues were raised the researcher listed the items on the flipchart and the following is a summary of how the list developed;

- They need to know about maintenance and de-sludging (P3)
- The National Inspection Plan (EPA, 2013) (P2)
- How to register (P5)
- What to do if their system (OSWTS) isn't functioning or if you fail inspection (P1)
- How to identify if their system is not functioning (group comment)
- If it needs repairs what to do and how to apply for grant (P3)
- The need to keep records for the inspection process (P4)
- What documents to get from a contractor if getting work done (P3)
- The need to check if planning permission is required for works (P4)
- The importance of a maintenance agreement (P1)
- The legal requirements and consequences of not complying with National Inspection Plan (P5)

- Explain to them what an OSWTS is as some people won't automatically know (P2)
- Who to contact if their system (OSWTS) is broken down (P1)
- What to do if they have been selected for inspection to get ready (P2)

When the list had been completed the researcher flipped back to the first page of the list (1 of 3) and read through the list again to offer an opportunity for further comment or in case participants felt they had overlooked any issues but they were satisfied that the list was comprehensive and contained all relevant issues for homeowners.

#### **5.2.2.5 Findings of Question 5 – The Use of Graphic Means to Educate Homeowners**

This question was designed to gauge participants' opinions on the use of graphic modelling as a means to educate homeowners on how to manage and maintain their OSWTS's;

*“How useful do you believe the use of graphic means would be in educating homeowners on how to manage and maintain their OSWTS's?”*

This final question removed participants from industry related questions to a theory based scenario whereby the education of homeowners would be framed using modelling. To commence this phase of the workshop and for context the researcher outlined to participants that the drivers and barriers to sustainable on-site wastewater treatment illustration that they had been provided with for the workshop was an example of where knowledge is conveyed visually rather than in a purely textual setting or document.

The reaction of the participants to this question was varied and somewhat divisive and there were clear differences in opinion. Participant (P1) was first to offer an opinion and explained;

*‘When I worked in the United States there were guidance documents for homeowners on how to maintain their systems (OSWTS’s) and these seemed to work fine. They covered the points that were relevant to the homeowner so have you not considered doing that here?’*

The response from (P1) returned a question to the researcher and in response the researcher referred to the literature review and the critique of modelling that had been undertaken. Reference was made to Chapin (1971) specifically and the researcher outlined that the research of existing literature had identified that modelling is used in many forms for education and knowledge transfer and that the aim of this research is to develop a knowledge model for homeowners to better understand, manage and maintain their OSWTS’s.

(P1) enquired what were the differences between a text based document and the model that was being proposed as part of this thesis and the researcher referred to flowcharts as an example compared to an instruction manual booklet. (P3) confirmed that he felt that this was a good idea and stated;

*‘I am familiar with the US (United States) version Homeowners Guide to Septic Tanks (OSWTS’s) and to be frank it would not be much use in Ireland in my opinion. It’s about 30 pages long and goes into far more detail than a homeowner needs to know on the treatment of wastewater etc. If the model you propose is concise and easy to use then I think it could be a success’.*

Participant (P4) commented that if the model could be formulated in a way so as to become a form of service document or recording system it could be very worthwhile;



*'If what you are creating (the model) is going to contain the issues raised today for the homeowner on things like what to do if your system (OSWTS) is going to be inspected or if the system (OSWTS) is broken down or not working then I think it would be very useful if you could record your documents in it. For example the certificate you get when you register your system (OSWTS) is valid for 5 years and many people will undoubtedly lose this as well as any receipts that they get for de-sludging and so on. I think you could solve a very real problem by combining what you are creating (model) into a folder that holds the necessary documents'.*

Participant (P5) was positive on the concept of modelling but was somewhat concerned that the use of a graphic means might be too restrictive and (P4) agreed while this comment was being made;

*'The use of graphic sounds good in practice but will you be able to fit all of the information into it (the model)? If you are going to cover all the issues raised today then you are going to have to produce something very large to fit in details about registration, repairs, maintenance, keeping receipts and so on. My concern is also that you might not be giving enough information in an attempt to squeeze everything into your model'.*

Participant (P2) who is a qualified scientist adopted a pragmatic and balanced view on the adoption of modelling for homeowners and was very conclusive on good and bad examples of modelling and explained;

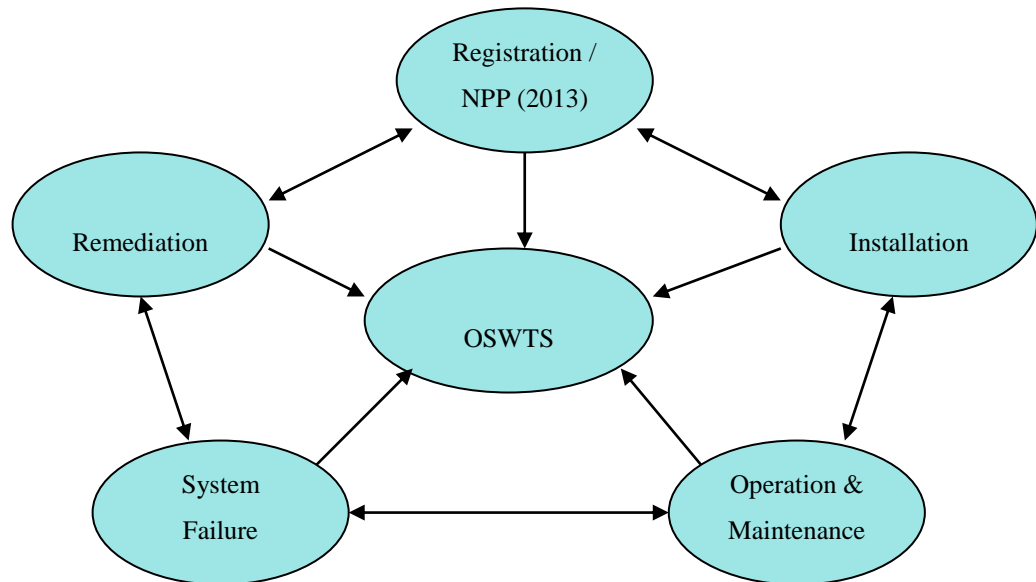
*'I am familiar with very good examples of graphical presentation where complex functions are well explained and easy to understand but I am also familiar with horrendously difficult graphical presentations of relatively simple functions like putting IKEA furniture together. In theory graphical presentations like Powerpoint © can be much more enjoyable than being given a document to read but the presentation of the graphics is fundamental. Much as the case with shoes I think you will find some people that will like one style and others than prefer to go barefoot. The problem for you (the researcher) as I see it is trying to make it (the*

*model) something that will appeal to the half a million householders (homeowners) that need to get their head around the new legislation’.*

### **5.3 Issues Raised from Workshop**

Section 5.2.6 lists the issues identified at the workshop that homeowners need to be aware of and this is what has directed the contents for the knowledge model. As referred to in section 5.2 the drivers and barriers to sustainable OSWTS were prepared from the findings of the comprehensive literature review in Chapter Two. To summarise and conclude the workshop the participants were asked in an open forum to distribute the issues raised into sub-headings that the knowledge model could present for homeowners. The participants listed the subheadings as outlined in Figure 5.3 overleaf and this is what has directed the sub-headings in the knowledge model. It was suggested by the participants in the workshop that the homeowner model would need to provide for cross-referencing between the sub-headings so that they could understand how actions and inactions had consequences on OSWTS performance. The progression of this discussion led to the suggestion from participant (P2) of colour referencing the sub-headings and tabulating the model so that the homeowner could navigate through the sub-headings in differing perspectives. The selection of proposed colours was not agreed at the workshop as the agreed time schedule had elapsed.

**Figure 5.3 Illustration of the key factors that influence OSWTS's performance from Workshop Session with IOWA Executive Committee**



## 5.4 Correlation of Issues Identified in Literature Review & Workshop

The following sections consider in detail each of the component issues identified in Figure 5.3 from the workshop and from the literature reviews in Chapter Two and Three.

### 5.4.1 National Inspection Plan

The Water Services (Amendment) Act 2012 was enacted in February 2012 by the Irish Government and a detailed outline of this legislation is set out in Section 2.4.9 of the literature review. This act was passed with the objective of bringing Ireland into compliance with the ruling of the ECJ (C188-08). This ECJ (2009) ruling as outlined in section 2.6.10 identified a number of issues in relation to OSWTS's that need to be addressed in order for Ireland to be deemed in

compliance with the ruling (C188-08). Table 5.2 cross-references the issues raised from the literature review with those identified from the brainstorming sessions with the IOWA to affirm what needs to be included in the knowledge model for homeowner.

**Table 5.2: Cross-referencing National Inspection Plan Issues from findings of the literature review and from practice-based experience**

| <i>National Inspection Plan Issues</i>               | <i>Literature</i> | <i>PBE</i> |
|--|-------------------|------------|
| <i>1. The need to register OSWTS's every 5 years</i> | <i>Yes</i>        | <i>Yes</i> |
| <i>2. Penalties for non-compliance</i>               | <i>Yes</i>        | <i>Yes</i> |
| <i>3. The need to undertake pre-inspection works</i> | <i>No</i>         | <i>Yes</i> |
| <i>4. Corrective action measures and remediation</i> | <i>Yes</i>        | <i>Yes</i> |
| <i>5. How inspections will take place</i>            | <i>Yes</i>        | <i>Yes</i> |

From Table 5.2 it can be seen that the review of the literature in Chapter Two identified all but one of the issues pertaining to the National Inspection Plan (2013). This can be explained quite simply because the National Inspection Plan (2013) has only recently been published and the brainstorming sessions with the IOWA were in advance of the publication of the plan by the EPA (2013).

#### **5.4.2 Installation of On-Site Wastewater Treatment Systems (OSWTS's)**

The review of literature has identified that there is a significant amount of legislation in relation to the installation of OSWTS's. The DoEHLG (2011) has indicated though that the legislation that has been in place for quite some considerable amount of time has not been implemented however and that this has led to poorly sited and constructed systems (Daly, 2003; Gill *et al.*, 2005 & EPA, 2010). The IOWA (2011) have confirmed this assertion that there has been little

or no follow up of installed systems to ensure that they have been properly constructed and the ECJ (2009) have prosecuted Ireland for not maintaining a record of these systems when constructed or having a suitable inspection regime in place to ensure that they work properly. The GSI (2011) also suggest that where systems have been designed in accordance with legislation and relevant codes of practice, builders have ignored this design in the construction phase. Table 5.3 links the findings of the literature review and PBE from the IOWA committee.

**Table 5.3: Cross-referencing installation issues from findings of the literature review and from practice-based experience**

| <i>Installation of OSWTS's</i>   | <i>Literature</i> | <i>PBE</i> |
|--|-------------------|------------|
| <b>1. The need for contractors to be trained and / or qualified with appropriate insurance</b> | <i>Yes</i>        | <i>Yes</i> |
| <b>2. Obtain a certificate of installation</b>   | <i>Yes</i>        | <i>Yes</i> |
| <b>3. Liability on contractor if works not completed properly</b>                              | <i>No</i>         | <i>Yes</i> |
| <b>4. The need for installation of systems to be supervised by a competent person</b>          | <i>Yes</i>        | <i>Yes</i> |
| <b>5. Installed in accordance with Part H of Building Regulations 2010</b>                     | <i>Yes</i>        | <i>Yes</i> |
| <b>6. Registered with Local Authority under National Inspection Plan</b>                       | <i>Yes</i>        | <i>Yes</i> |
| <b>7. Have correct materials been used</b>   | <i>Yes</i>        | <i>Yes</i> |
| <b>8. Designed in accordance with the EPA (2010) Code of Practice</b>                          | <i>Yes</i>        | <i>Yes</i> |

Table 5.3 illustrates that the review of literature and the PBE from the IOWA committee are identical except for one issue. The literature review did not raise the issue of contractor liability where they are found to be negligent in the construction phase. The issue of contractor negligence has been referred to by Daly (2003) & Gill *et al.* (2005) in the literature but they stop short of calling for

prosecution or sanction. In the brainstorming sessions with the IOWA the need to bring prosecutions against negligent contractors was a very poignant issue and one where there was consensus amongst the participants, including the author of this research. The need to sanction those contractors who negligently or will-fully undermine the on-site wastewater treatment process is considered a priority by the author as it places homeowners at risk of fines, prosecution or significant further remedial works.

#### **5.4.3 Operation & Maintenance of On-Site Wastewater Treatment Systems (OSWTS's)**

The literature review identified that there is significant and comprehensive existing research and publication in the area of operation and maintenance for OSWTS's. The IOWA (2011) has explicitly referred to the need for general maintenance and the EPA (2013) has addressed the issues of operation and maintenance in the National Inspection Plan. The fact that 27% of OSWTS's have failed their inspection under the National Inspection Plan (EPA, 2013) for not being regularly de-sludged and 26% failed for simple operation and maintenance (EPA, 2014) clearly illustrates that just referring to these matters in policy documents and legislation is not working. Gray (2004) has referred to the fact that there is little concern amongst homeowners to ensure that their OSWTS's are operating properly and it is from that research it has been concluded that many homeowners adopt and 'out of sight, out of mind' approach to their domestic wastewater facilities. The Department of Freshwater Studies at the Dundalk Institute of Technology (2005) identified in their research that the newly constructed systems that were causing as much pollution as older ones in light of their maintenance contracts not being enforced and SWAN (2010) have suggested that approximately 90% of systems that are required to have maintenance contracts as part of their planning permission have let the contracts lapse. Table 5.4 provides the issues that have been raised from the literature search and also from the practice based experience of the author.

**Table 5.4: Cross-referencing operation & maintenance issues from findings of the literature review and from practice-based experience**

| <b><i>Operation &amp; Maintenance</i></b>                              | <b><i>Literature</i></b> | <b><i>PBE</i></b> |
|--|--------------------------|-------------------|
| <b><i>1. Level of sludge in primary settlement tank</i></b>            | <i>Yes</i>               | <i>Yes</i>        |
| <b><i>2. Excessive fats &amp; grease accessing system</i></b>          | <i>Yes</i>               | <i>Yes</i>        |
| <b><i>3. Where rainwater is discharging</i></b>                        | <i>Yes</i>               | <i>Yes</i>        |
| <b><i>4. Over reliance on bleach &amp; disinfectant</i></b>            | <i>Yes</i>               | <i>Yes</i>        |
| <b><i>5. The need for a maintenance contract</i></b>                   | <i>Yes</i>               | <i>Yes</i>        |
| <b><i>6. Ventilation of the system</i></b>                             | <i>No</i>                | <i>Yes</i>        |
| <b><i>7. Traceability of removed sludge</i></b>                        | <i>Yes</i>               | <i>Yes</i>        |
| <b><i>8. Recording mechanism for maintenance &amp; de-sludging</i></b> | <i>Yes</i>               | <i>Yes</i>        |
| <b><i>9. Know the location of the OSWTS</i></b>                        | <i>Yes</i>               | <i>Yes</i>        |
| <b><i>10. Who to contact if you have a breakdown</i></b>               | <i>No</i>                | <i>Yes</i>        |
| <b><i>11. Is there ground compaction near the OSWTS</i></b>            | <i>Yes</i>               | <i>Yes</i>        |

Table 5.4 has again demonstrated that there is a general consensus between the issues raised from the literature search and from the PBE. The National Inspection Plan (EPA, 2013) has summarised much of the existing literature and guidance on the management of OSWTS's that has gone before. The author has however identified two very practical issues that homeowners need to be aware of that could have a huge influence on the performance of their OSWTS. The first issue refers to the aerobic bacterial process that takes place in the on-site wastewater process. In order for this process to operate effectively it is necessary that oxygen is available to the bacteria in the primary settlement tank (Gill *et al.* & 2005; GSI). The experiences outlined from the PBE was that there is often no ventilation provided to OSWTS's and that this will significantly reduce the treatment process and the subsequent effluent quality that is discharging to surface water and groundwater. The second issue raised in the PBE that hasn't been identified in the literature review is the need for homeowners to have a point of contact if they find that their system is not working or has broken down. For example, if a motorist's

car breaks down they know they can call companies such as the AA or the RAC for assistance. A similar scenario would be of benefit to homeowners for their OSWTS but the PBE determined that this issue would be better raised in the system failure and troubleshooting section.

#### 5.4.4 On-Site Wastewater Treatment System Failure & Troubleshooting

The findings the literature review and from the PBE are that there is significant and widespread failure in the performance and operation of a very large number of OSWTS's (Gray, 2004; Gill *et al.* 2005; EPA, 2008, GSI, 2011 & EPA, 2013). The reference by the EPA (2014) to the fact that just over half of systems have failed due to not de-sludging (27%) or for not undertaking simple operation and maintenance (26%) means that 47% have failed for more serious reasons than could be related to system failure. This is one of the indicative reasons why the level of pollution in Ireland's groundwater resource is of such concern to the ECJ (2009) in their prosecution of Ireland for failing to properly manage discharges from OSWTS's. Table 5.5 again cross references the findings of the literature review with the PBE workshop;

Table 5.5: Cross-referencing system failure issues from findings of the literature review and from practice-based experience

| <i>System Failure</i>                                  | <i>Literature</i> | <i>PBE</i> |
|--|-------------------|------------|
| <i>1. Ponding on the site</i>                          | <i>Yes</i>        | <i>Yes</i> |
| <i>2. Direct discharge to surface water from house</i> | <i>Yes</i>        | <i>Yes</i> |
| <i>3. Wastewater backing up in house</i>               | <i>Yes</i>        | <i>Yes</i> |
| <i>4. Primary tank leaking</i>                         | <i>Yes</i>        | <i>Yes</i> |
| <i>5. Who to contact – competent contractor</i>        | <i>No</i>         | <i>Yes</i> |
| <i>6. Remediation grant assistance</i>                 | <i>Yes</i>        | <i>Yes</i> |
| <i>7. Liability of contractor / builder</i>            | <i>No</i>         | <i>Yes</i> |



There is a correlation in Table 5.5 with Table 5.4 from the point of view of the literature review and the need for a point of contact if a homeowner discovers their OSWTS is failing. The recent publication of the National Inspection Plan (EPA, 2013) is a very comprehensive and thorough document but it is silent on the need for homeowners to have access to competent contractors. The example that has been referred to in section 5.2.4 is similar to the suggestion made in the brainstorming sessions and is the protocol that is adopted in relation to approved and accredited gas installers and service technicians. This arrangement provides for only trained, accredited and approved engineers to carry out installations and repairs to gas services. A similar registration of competent contractors for OSWTS's would provide confidence to homeowners that they are using a contractor that is proficient in the OSWTS industry.

#### **5.4.5 Remediation of On-Site Wastewater Treatment Systems (OSWTS's)**

According to the IOWA (2011) the provision for the remediation of non-performing or poorly performing OSWTS's is a critical step for Ireland to achieve compliance with the WFD and also to comply with the directions of the ECJ (2009). Crucially though, early interventions with homeowners to improve system maintenance may prevent the need for expensive remediation works. The United States Environmental Protection Agency (2005) suggest that prevention is better than cure and that remediation in many cases and proper maintenance can prevent the need for expensive remediation works. However, the EPA (2013) refer to the fact that many OSWTS's in Ireland are so poorly constructed and maintained that remediation is the only viable option. Table 5.6 outlines the key remediation issues that have been raised from the literature review and from practical based experience.

**Table 5.6: Cross-referencing remediation issues from findings of the literature review and from practice-based experience**

| <i><b>Remediation</b></i>                                    | <i><b>Literature</b></i> | <i><b>PBE</b></i> |
|--|--------------------------|-------------------|
| <i><b>1. The planning permission implications</b></i>        | <i>No</i>                | <i>Yes</i>        |
| <i><b>2. Remediation funding</b></i>                         | <i>Yes</i>               | <i>Yes</i>        |
| <i><b>3. Register of competent contractors</b></i>           | <i>No</i>                | <i>Yes</i>        |
| <i><b>4. Legal issues if remediation not carried out</b></i> | <i>Yes</i>               | <i>Yes</i>        |
| <i><b>5. Re-inspection after improvement works</b></i>       | <i>Yes</i>               | <i>Yes</i>        |
| <i><b>6. Advisory report requirements</b></i>                | <i>Yes</i>               | <i>Yes</i>        |

Table 5.6 has illustrated and cross-referenced the remediation issues that have been raised from the literature review and from the practical based experience. Once again there is consensus in the cross-referencing that the issues raised in the literature review are valid and need to be addressed in the model for homeowners to better understand and manage their OSWTS's. However the PBE from the brainstorming sessions has again referred to the need for the registration of contractors. The importance of this issue is made clear by virtue of it appearing in almost all sections of the model and it's validity to installation, operation, maintenance, registration and remediation of OSWTS's. A second issue which has been referred to by the PBE is the need for the proposed knowledge model to inform homeowners of the possible planning implications of remediation works. Sections 2.4.2 & 2.4.6 have discussed the relevant planning legislation that applies in Ireland in relation to all forms of development and critically the replacement and/or alterations to an OSWTS are classified as development. Therefore, a homeowner if acting unknowingly could carry out remediation works to their OSWTS and not be aware that they require planning permission. Accordingly, the knowledge model that is to be developed as part of this research must flag this planning issue to homeowners so that they do not risk planning enforcement proceedings and possible fines or prosecution.

## **5.5 Validation Questionnaires**

A critique for the use of questionnaires has been discussed in detail in Chapter Four and the questionnaire is a very useful tool for gathering data from a wide audience. Fowler (2002) affirms the critical importance of the design and selection of appropriate questions to meet the research aim and objectives. Based on the findings of the literature review and the PBE the researcher generated and developed a set of questions for the questionnaire that were designed to verify and validate the contents for the knowledge model for homeowners. As the survey questionnaire respondents were going to be asked for their opinions on performance and management related issues, it was felt that the Likert scale approach was the most appropriate to ascertain responses. The five-point scale (strongly disagree, disagree, uncertain, agree or strongly agree) is commonly used in attitude assessment to indicate the respondent's level of agreement or disagreement with each statement. Further, they were supplemented with some open-ended questions that would require more time and thought to complete. The key target information for the questionnaire can be summarised as follows;

- The professional background of the participant
- The respondent's opinion on how serious the OSWTS problem is in Ireland at present
- Their opinion on how accountable homeowners are in the on-site wastewater treatment process
- The respondent's opinion on the need to educate and inform homeowners
- The type of knowledge that homeowners need so as to better manage OSWTS's
- To identify what, if any, deficiencies exist in existing homeowner knowledge and understanding
- The practical issues that are causing OSWTS to operate poorly
- The respondents opinion to homeowner liability in the subject area
- Any comments / suggestions that the respondent has on how information and / or knowledge could be conveyed upon homeowners

The proposed question format and draft questionnaire were presented to the Committee of the IOWA to provide an opportunity for feedback and to enhance the validity and reliability of the questions. The questions were discussed to discover any shortcomings as recommended by Suanders et al (2003) who suggest that asking an expert group to comment on the representativeness and suitability of the questions and the structure of the research instrument at an initial stage is very important. This provided an opportunity for some refinements and amendments prior to the actual scoping study (Mitchell, 1996) and provided the participants in the PBE stage the opportunity to confirm that the questionnaire reflected the issues identified in the workshop.

#### **5.5.1 The Questionnaires**

A total of 89 completed or partially completed questionnaires were returned from respondents at the IOWA conference. The total registered attendance at the conference on the day was 106 and all attendees were provided with a copy of the questionnaire. This represents a total completion rate of 83.96%, however, there were some questions un-answered or blank on a number of completed questionnaire forms.

#### **5.5.2 Responses to Professional Background of Participants**

Figure 5.4 illustrates the number of completed or partially completed questionnaires from the respective professional groups;

Figure 5.4 number of completed responses by professional group

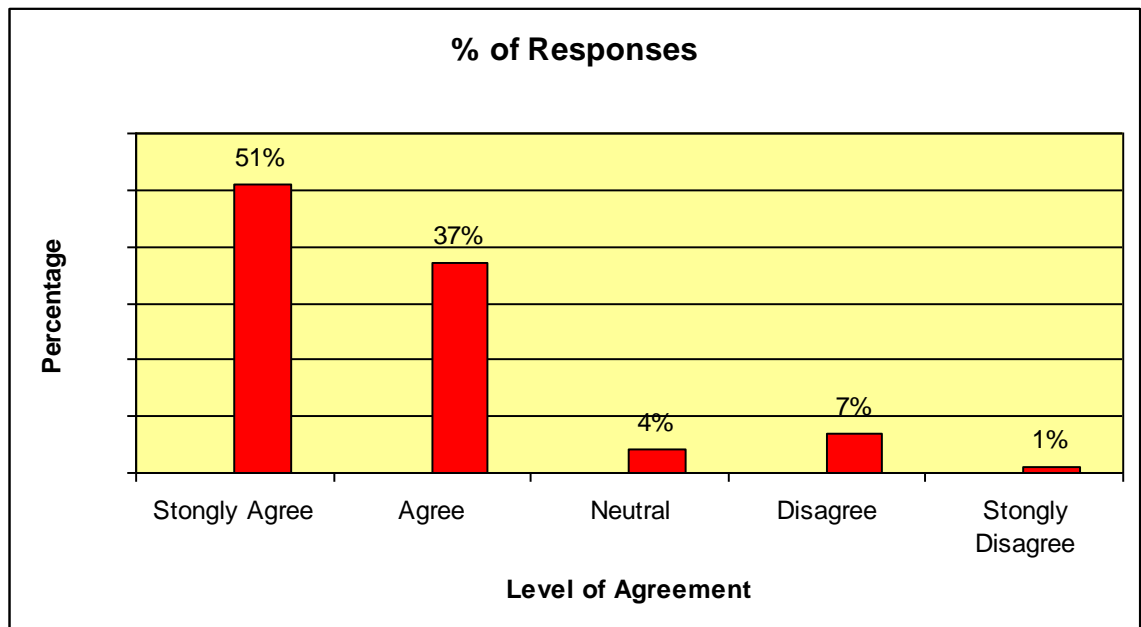
| Professional Background<br>Of Participant: | No. of<br>Responses | % of<br>Sample | No. of Unusable<br>Responses |
|--|---------------------|----------------|------------------------------|
| OSWTS Manufacturer /<br>Supplier           | 15                  | 16.86%         | 0                            |
| On-Site Assessor                           | 39                  | 43.82%         | 0                            |
| Local Authority Representative             | 12                  | 13.48%         | 0                            |
| EPA Representaive                          | 0                   | 0%             | 0                            |
| Legislator /<br>DoEHLG Representative      | 3                   | 3.37%          | 0                            |
| Academic / Researcher                      | 2                   | 2.25%          | 0                            |
| Member of Interest / Lobby<br>Group        | 0                   | 0%             | 0                            |
| OSWTS Installer / Builder                  | 12                  | 13.48%         | 0                            |
| Other                                      | 6                   | 6.74%          | 0                            |

The following provides the responses to the questions from the participant's perspective section of the questionnaire. There is also a summary of the additional comments which were provided by the participants to these questions.

### 5.5.2.1 Response to Question 2

Question 2: OSWTS's are potentially an environmental hazard and source of significant pollution in Ireland

**Table 5.7: Percentage Responses to Question Two**



The additional comments that were made in relation to this question are as follows;

- There needs to be a full scale assessment of existing systems and proposals for upgrading and improvement
- OSWTS's are a source of pollution if not installed correctly or on unsuitable sites
- Provide 100% grant assistance for new systems to be installed. A lot of money will be returned to the state by providing employment and tax etc.

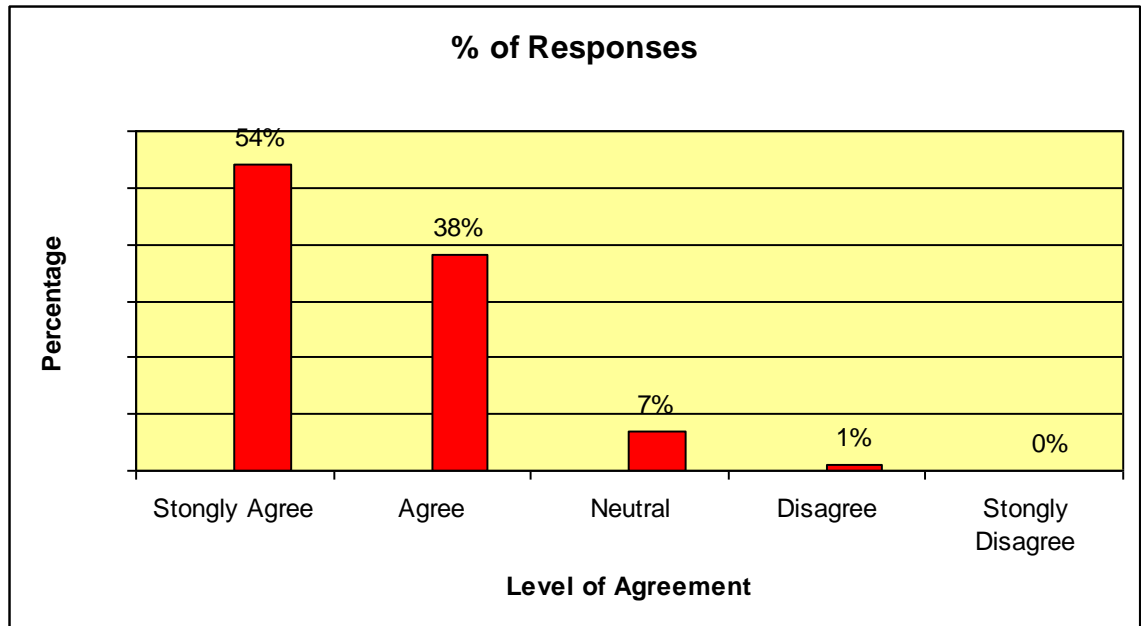
- OSWTS's are only a problem if not assessed or maintained properly
- Not all OSWTS are / pose a potential hazard
- OSWTS's need to be addressed as a source of pollution
- Depends on location, construction and maintenance
- There is a lack of knowledge on their use and maintenance. They are not used as intended
- Better enforcement and meaningful regulation required
- Enforced maintenance required
- Discharges from local authority systems pose a much greater hazard

There was a response rate of 88% in the strongly agree or agree options for this particular question and this clearly demonstrates that professionals in the on-site wastewater industry feel that OSWTS's are a potential environmental hazard. In the 11 questionnaires where additional comments were provided, it is notable that 4 referred to maintenance as being important while 3 others suggest the need for enforcement, regulation or system improvement.

#### **5.5.2.2 Response to Question 3**

Question 3: The performance and management of OSWTS's is a significant problem in Ireland at present

Table 5.8: Percentage Responses to Question Three



The additional comments that were made in relation to this question are as follows;

- There should be a standard list of OSWTS designs and on-site assessors should choose from this list only so as to provide consistency
- The management of the construction phase of OSWTS is a problem
- Not all systems are problematic
- There needs to be more control on annual maintenance by local authorities
- This performance of OSWTS depends on location, construction and maintenance
- Most OSWTS's work satisfactorily if maintained properly
- Lack of knowledge on the use and maintenance of systems and they are not used as intended
- Better enforcement is required for operation and maintenance
- The lack of regulation is the significant problem
- Better follow up by local authorities on maintenance and provision of more funds

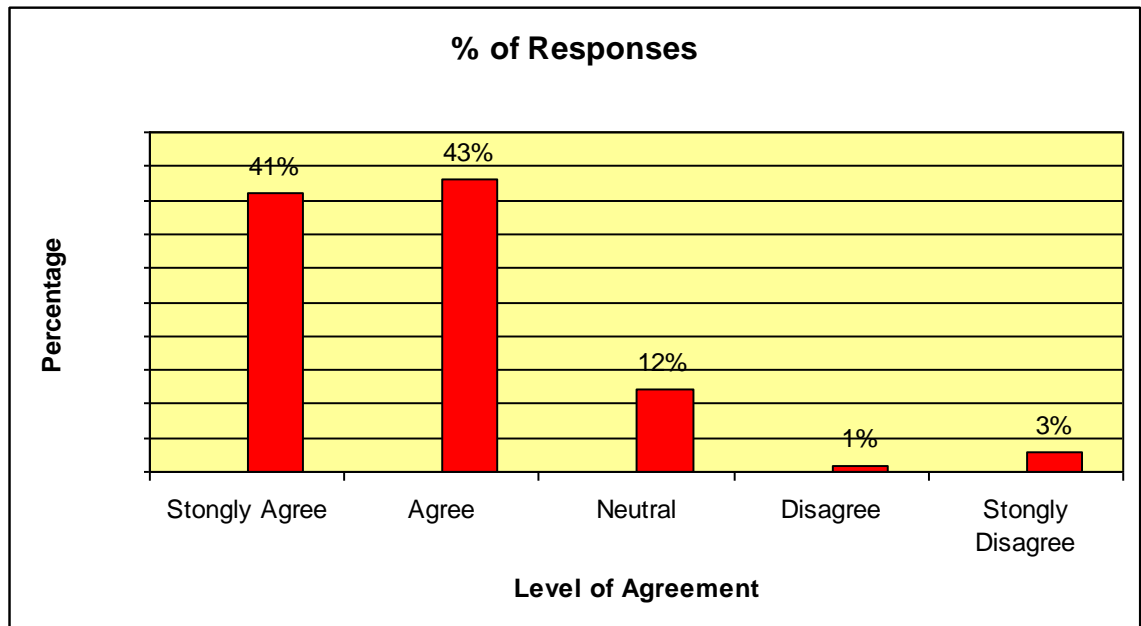


There was a response rate of 92% in the strongly agree or agree options for this particular question and this clearly demonstrates that professionals in the on-site wastewater industry feel that OSWTS's is a significant problem in Ireland at present. 10 of the respondents provided additional comments for this question and on this occasion 6 of the respondents mentioned maintenance as a specific issue of concern. Enforcement, regulation and management of systems are mentioned in 4 of the responses.

### 5.5.2.3 Response to Question 4

Question 4: Homeowners should be held responsible for the performance and management of their OSWTS as directed by the Water Services (Amendment) Act, 2012

**Table 5.9: Percentage Responses to Question Four**



The additional comments that were made in relation to this question are as follows;

- OSWTS's should be monitored in all aspects of construction and maintenance
- Some form of financial assistance needs to be provided for older systems
- Homeowners need help and education
- Homeowners should only be held accountable if they have been given prior financial assistance and expertise to design and maintain the OSWTS
- Others have responsibilities too
- They must be educated to the requirements of the Water Services Act, 2007
- Homeowners need to be educated on how their system works
- The 'polluter pays' principle should apply
- Depends on the relevant regulations when the OSWTS was installed
- Local authorities, EPA, site assessors and installers should be involved in educating homeowners
- The registration of systems needs to be undertaken
- They may have no knowledge on OSWTS's
- Manufacturers should also hold responsibility
- There should be a balance of responsibility between homeowner and system supplier / installer for new systems
- There should be more inspections by local authorities to check on performance and maintenance
- Older systems should not be regulated in the same way as more modern systems

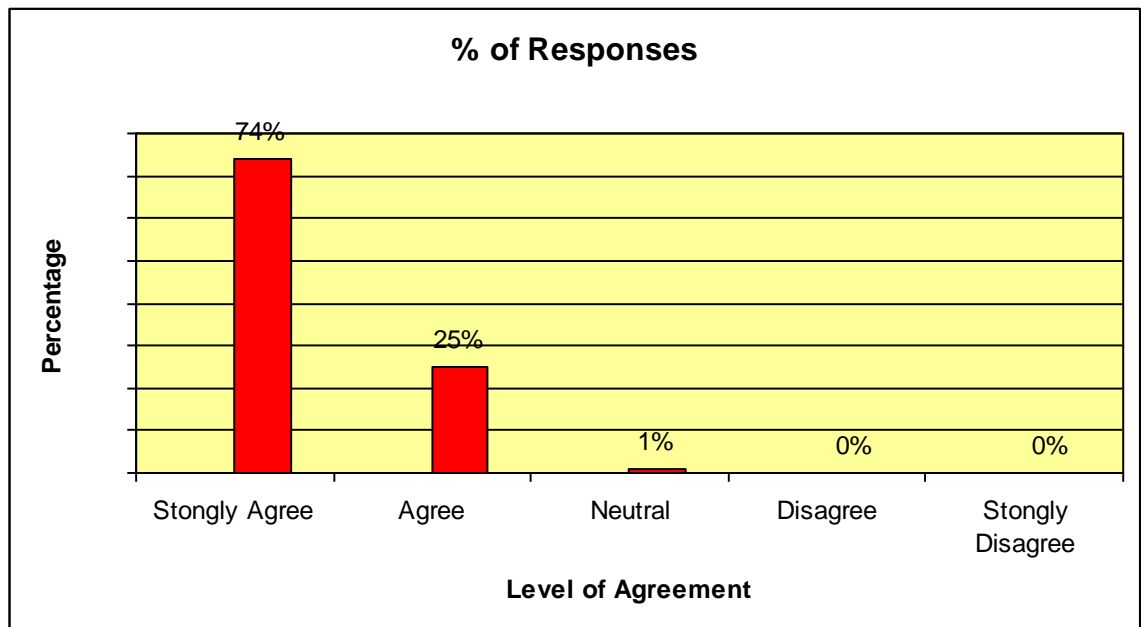
There was a response rate of 84% in the strongly agree or agree options for this particular question and this illustrates that professionals believe that homeowners should be held responsible for OSWTS performance and management. In 16 of the returned survey questionnaires there were additional comments provided and 4 of these referred to education of homeowners, while others referred to a lack of knowledge as being a contributory factor in the poor performance and management of OSWTS's. There were also 4 references to others holding some

responsibility to ensure OSWTS's performed properly and this included system installers, manufacturers and local authorities.

#### 5.5.2.4 Response to Question 5

Question 5: There is an urgent need for homeowners to improve their knowledge and understanding of the on-site wastewater treatment process and knowledge of their roles and responsibilities

**Table 5.10: Percentage Responses to Question Five**



The additional comments that were made in relation to this question are as follows;

- Education should be made available
- Education needs to start from national school onwards
- Homeowners need education on how their systems should work
- Outreach programs with communities in high risk areas to provide information
- Public information campaign required

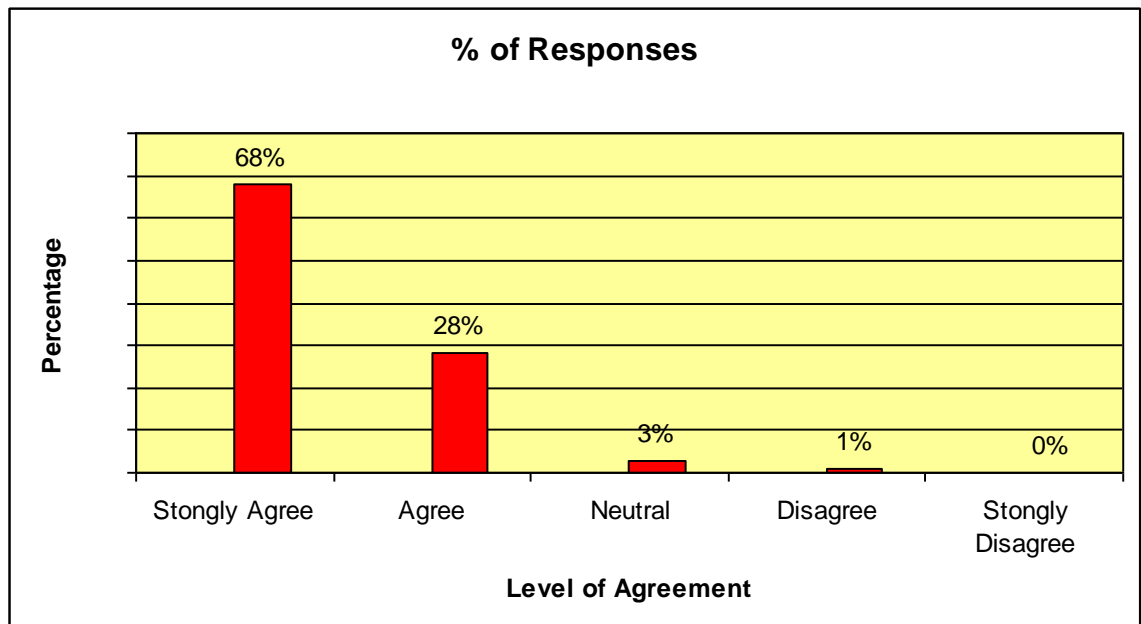
- Council booklets and web-sites
- Education at school level

There was a response rate of 99% in the strongly agree or agree options for this particular question and this overwhelmingly confirms that homeowners need to improve their understanding and knowledge of OSWTS's as well as their knowledge of their roles and responsibilities. There were 7 respondents who provided additional comments or suggestions and in 4 of these there was a reference to education and 2 referred to the provision of information.

#### 5.5.2.5 Response to Question 6

Question 6: Existing guidance for homeowners in relation to OSWTS's has been ineffective in the transfer of knowledge and understanding

**Table 5.11: Percentage Responses to Question Six**



The additional comments that were made in relation to this question are as follows;

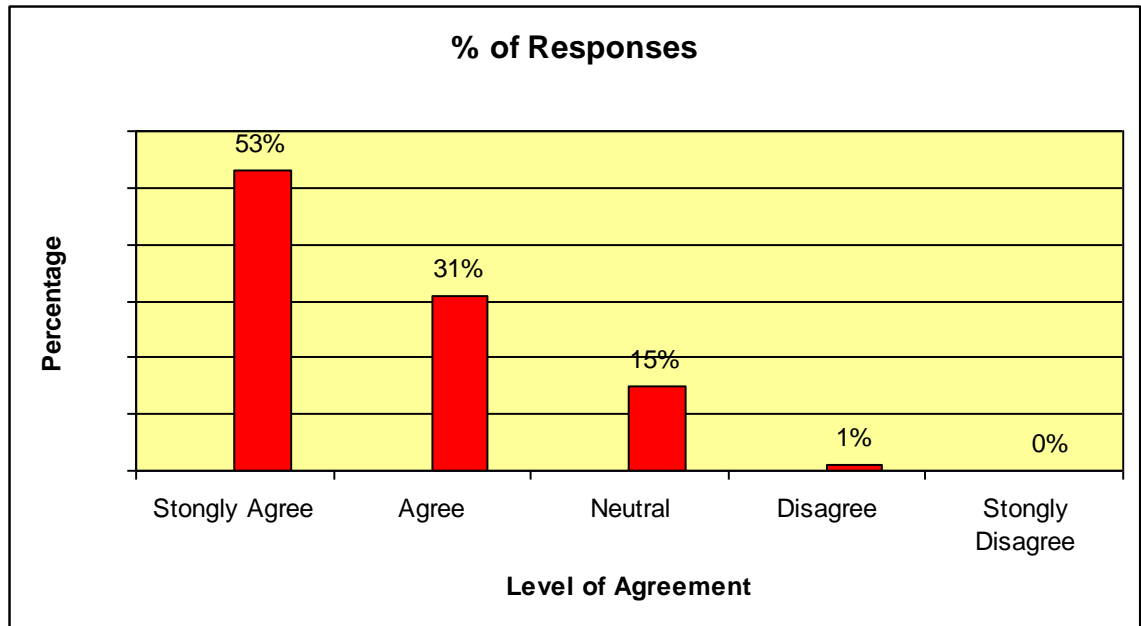
- Most people don't have clue what it's about
- Homeowners need to be educated on how their systems work
- "Fit it and forget it" is the attitude in Ireland
- Homeowners only think about their OSWTS when they have a problem
- Generally homeowners don't understand the requirements
- Why should guidance for professionals be responsible for knowledge transfer and understanding to homeowners. The education of homeowners is a different thing – a public education campaign

There was a response rate of 96% in the strongly agree or agree options for this question and hence this clearly demonstrates that existing guidance is ineffective for educating and informing homeowners in relation to their OSWTS. The additional comments display a variety of insights from a lack of concern to a lack of understanding on the part of homeowners. The final comment is somewhat more poignant whereby existing guidance is deemed to be only for professionals and not actually for homeowners at all. The education of homeowners is deemed to require its own specific education campaign.

#### **5.5.2.6 Response to Question 7**

Question 7: A significant number of OSWTS's are poorly designed, operated and maintained in your area

Table 5.12: Percentage Responses to Question Seven



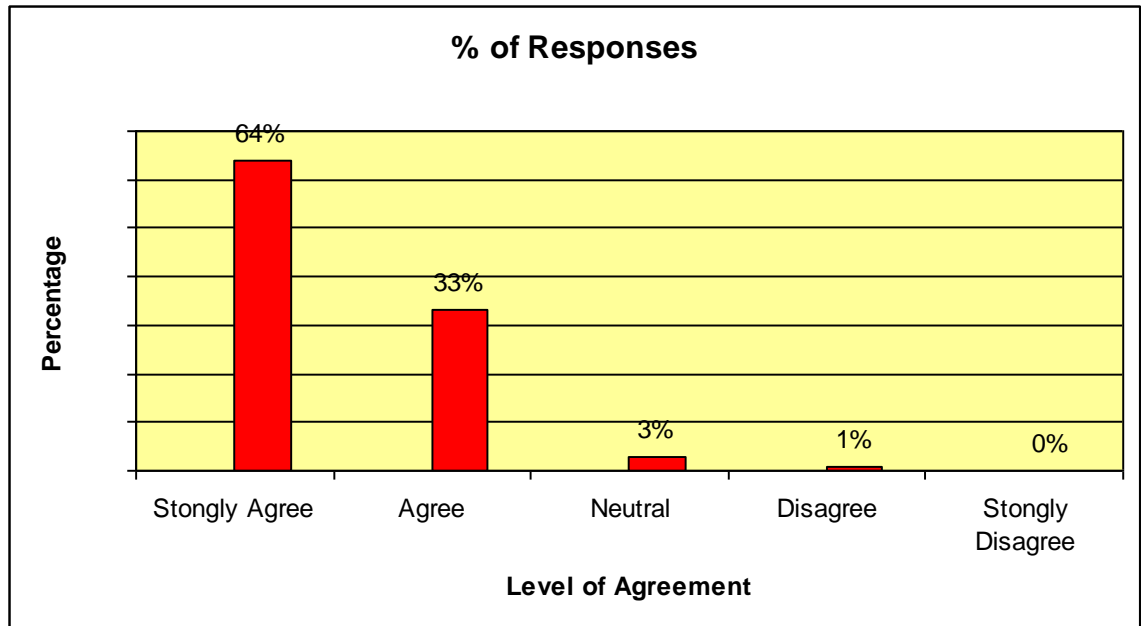
The additional comments that were made in relation to this question are as follows;

- Mandatory maintenance contracts are required
- This is an enforcement issue and should be done by the local authority

There was a response rate of 84% in the strongly agree or agree options for this question but the neutral rate did reach 15%. There were only 2 additional comments to this question and they suggested mandatory maintenance contracts and the need for enforcement in relation to poorly performing and managed OSWTS's.

#### 5.5.2.7 Response to Question 8

Question 8: OSWTS's are usually not serviced properly or maintained in accordance with the design specifications or planning conditions

**Table 5.13: Percentage Responses to Question Eight**

The additional comments that were made in relation to this question are as follows;

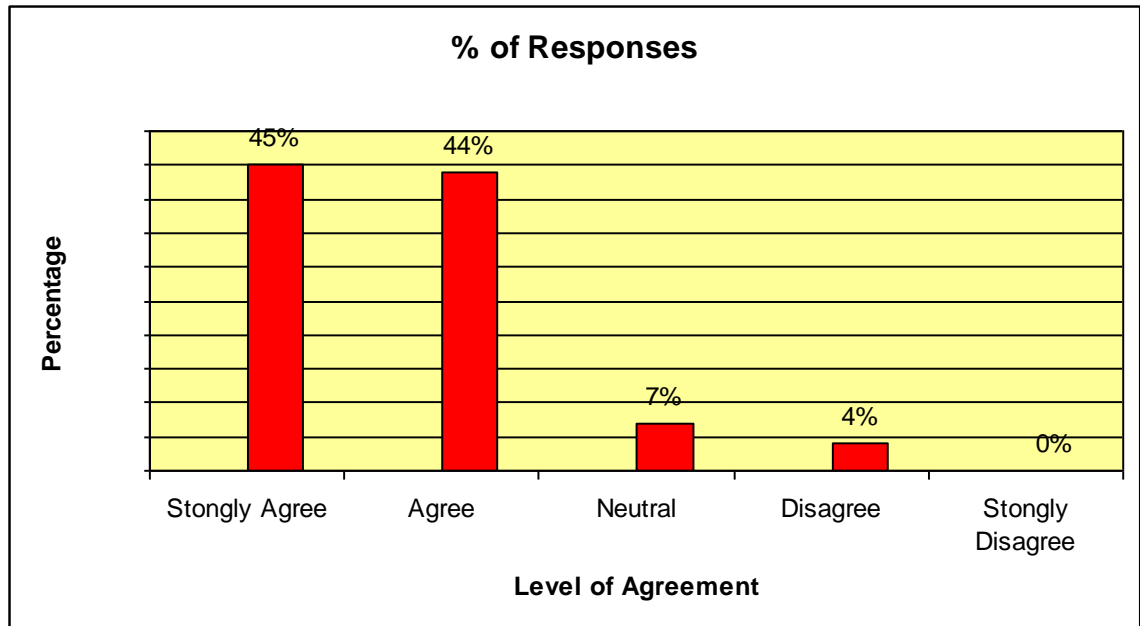
- Homeowners need to be educated in how their system works so that they understand what is required of them
- Mandatory maintenance contracts are required
- This is an enforcement issue and should be properly enforced

There was a response rate of 97% in the strongly agree or agree options for this question and there were just 3 additional comments. One referred to the need for education while the others referred clearly to enforcement of mandatory maintenance of OSWTS's.

#### **5.5.2.8 Response to Question 9**

Question 9: Many homeowners do not realise that OSWTS's require on-going maintenance at all

Table 5.14: Percentage Responses to Question Nine



The additional comments that were made in relation to this question are as follows;

- They have no knowledge of their responsibilities
- Many don't even know where their OSWTS is, never mind knowing how to maintain it
- Homeowners know – they just refuse to pay the money for maintenance of their systems
- Due to a lack of knowledge
- Mandatory maintenance contracts are required
- They know but choose to turn a blind eye

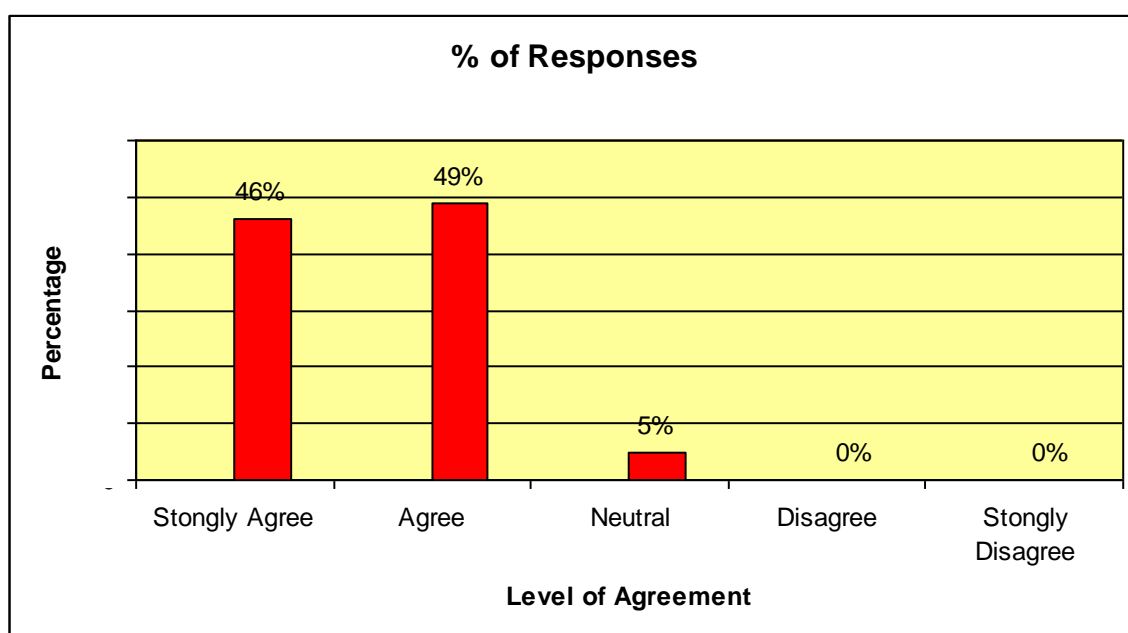
There was a response rate of 89% in the strongly agree or agree options for this question with 7% of respondents remaining neutral. There were 6 additional comments made on this occasion and all but one referred to knowledge and knowing. In some instances this related to ignorance of the maintenance requirements while the others suggest that homeowners know the maintenance that is required but choose to overlook it.



### 5.5.2.9 Response to Question 10

Question 10: There needs to be a significant improvement in OSWTS performance if Ireland is to achieve its objectives under the Water Framework Directive

**Table 5.14: Percentage Responses to Question Ten**



The additional comments that were made in relation to this question are as follows;

- Maintenance!!
- Strong regulation that is well enforced
- Awareness and grant assistance is what is required
- This is not the only area that requires improvement
- There are many other issues in relation to the WFD that need to be addressed
- N.B. maintenance

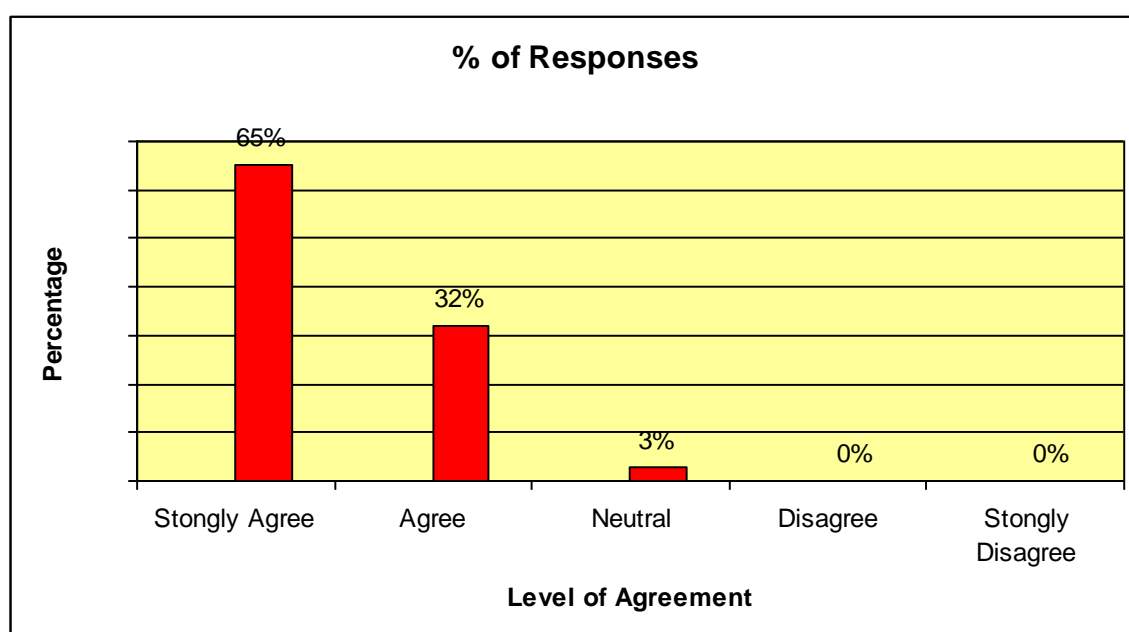
There was a response rate of 95% in the strongly agree or agree options for this question which confirms the consensus that there needs to be a significant

improvement in the performance of OSWTS's in Ireland. The additional comments are balanced between and emphasis on maintenance of OSWTS's and identifying that there are other issues relevant to the WFD other than just OSWTS's.

#### 5.5.2.10 Response to Question 11

Question 11: The education and training of homeowners is an important step in improving the performance of OSWTS's

**Table 5.15: Percentage Responses to Question Eleven**



The additional comments that were made in relation to this question are as follows;

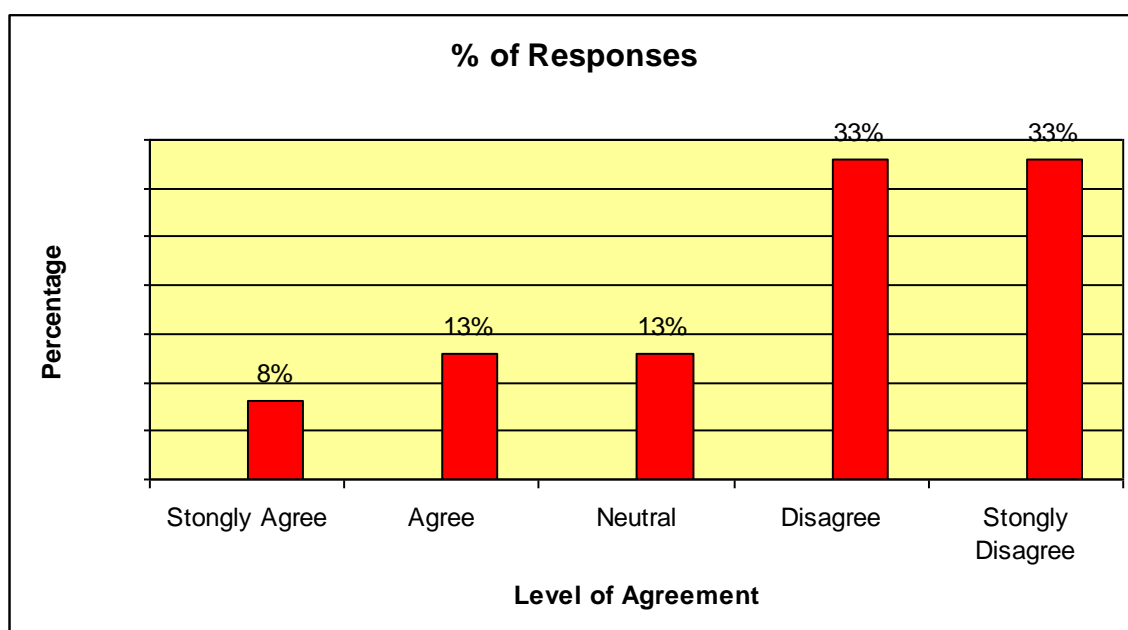
- Homeowners must be responsible for their own systems' performance
- County councillors and politicians need to be educated too
- An A4 or A5 leaflet handed out with every planning permission with bullet points for important points
- Good education needs to start early such as in schools

There was a response rate of 97% in the strongly agree or agree options for this question which illustrates strong support for an improvement in the education and training of homeowners in relation to the maintenance and management of OSWTS's. There were just 4 additional comments in this instance and these varied in nature and in what is required to improve the current issues in the subject area.

#### 5.5.2.11 Response to Question 12

Question 12: The inspection and monitoring of OSWTS's by Local Authorities is sufficient to educate homeowners on how to manage and maintain their OSWTS

**Table 5.16: Percentage Responses to Question Twelve**



The additional comments that were made in relation to this question are as follows;

- Local authorities will not educate homeowners
- The inspection of OSWTS's will help to focus the mind but more needs to be done in relation to education

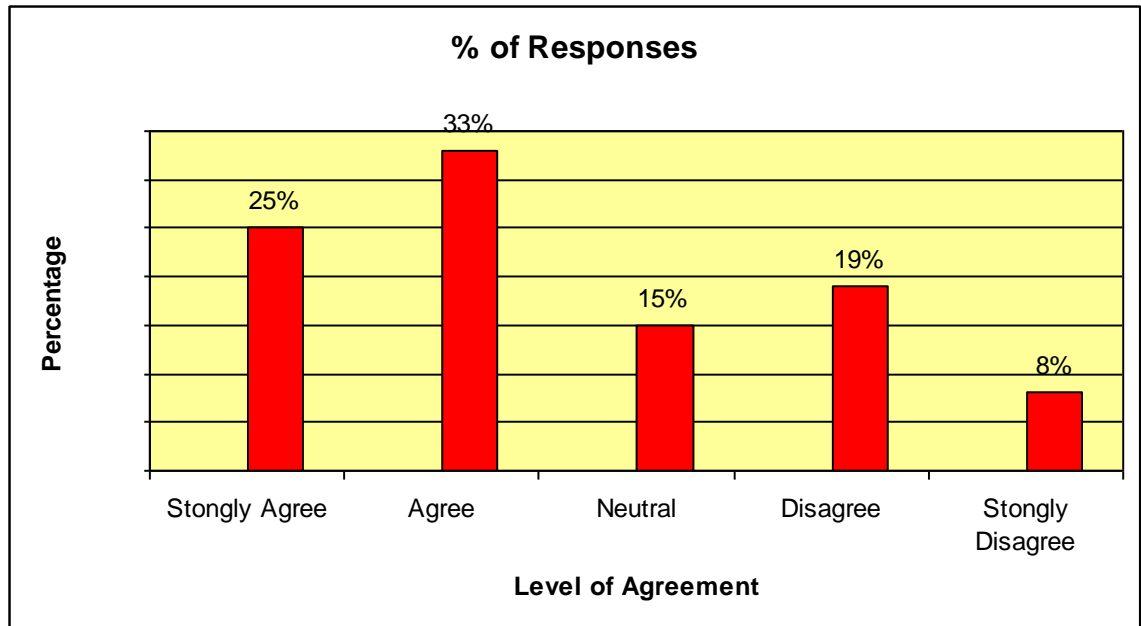
- Homeowners need to be responsible for their system
- Cannot assign responsibility for education to any one sector such as the local authority
- The local authorities have insufficient staff to educate homeowners
- It may concentrate their minds a bit
- Only if the inspections actually happen
- Education required outside the remit of local authorities

There was a response rate of 66% in the disagree or strongly disagree options for this question which suggests that there is limited confidence in the proposed inspection regime being a suitable vehicle to educate homeowners on how to better manage and maintain their OSWTS. Nevertheless, 21% of the responses were in the agree or strongly agree options, so there is not an overwhelming consensus that the local authority inspections will not provide education to homeowners. The additional comments point to lack of resources in the local authorities as a barrier to providing the education and training of homeowners as well as there being a need for other mechanisms other than local authorities to educate homeowners in relation to OSWTS's.

#### **5.5.2.12 Response to Question 13**

Question 13: The cost of having OSWTS's services and maintained is prohibitive for homeowners and leads to a lack of necessary works being undertaken

Table 5.17: Percentage Responses to Question Thirteen



The additional comments that were made in relation to this question are as follows;

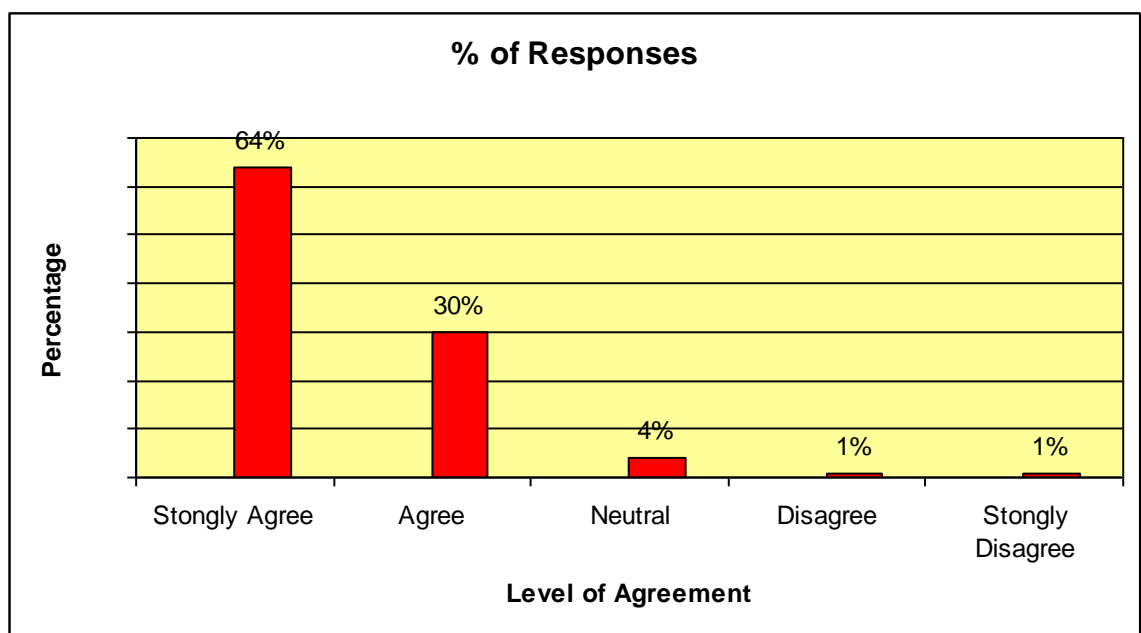
- Licensed companies should be franchised to undertake maintenance of on-site systems
- The cost of having an OSWTS serviced and properly maintained is not excessive. The behaviour of homeowners is that the system isn't important and "out of sight – out of mind".
- The cost is not prohibitive but there is a lack of necessary works
- There is no incentive for homeowners to properly maintain their systems
- Cost should not be an excuse
- Maintenance needs to be a condition of planning and adhered to

There was a very balanced response to this question across the range from strongly agree to strongly disagree. This illustrates that professionals in the OSWTS industry have varying opinions on the matter of cost and whether this is a barrier to the proper management and maintenance of OSWTS's.

### 5.5.2.13 Response to Question 14

Question 14: A simple and easy to understand knowledge model that summarises the relevant legislation and guidance in relation to OSWTS's and that helps homeowners to understand their legal responsibilities and obligations towards OSWTS's would be useful

**Table 5.18: Percentage Responses to Question Fourteen**



The additional comments that were made in relation to this question are as follows;

- This needs to be easy to understand as much of the guidance for OSWTS's is hard to understand
- This would end up in the bin as there would be no incentive for homeowners to use it
- This is not a simple situation and a booklet through the letterbox will not work
- This should be used in conjunction with inspections of the OSWTS
- Legislation and enforcement required to support this

- This should include a strong emphasis on the benefits to the environment of good compliance and maintenance

There was a response rate of 94% in the strongly agree or agree options for this question which supports and justifies the need for this research project. The development of the knowledge model is seen as useful in the endeavour of educating and informing homeowners on how to better manage and maintain their OSWTS. There were a number of additional comments in this instance ranging from suggestions that the model would end up in the bin to the need for legislation to support the objective of the model and it becoming part of the OSWTS inspection regime.

#### **5.5.2.14 Responses to Additional Comments**

The following are the summarised additional comments from Section 3 of the questionnaires. As discussed in section 5.3.1.3 this part of the questionnaire provided an opportunity to validate and shape the adoption of modelling by affording participants an option to suggest additions to the model or identify alternative mechanisms to educate and inform homeowners on OSWTS management and maintenance. A total of 20 respondents or 22.47% of the sample completed the additional comments section with the following comments being provided;

- Education of homeowners should take place in advance of the inception of the inspection of OSWTS's
- Information campaign similar to that undertaken for the Building Energy Rating process for OSWTS's
- A television advertisement campaign

- The EPA Code of Practice is very hard to understand and very technical and not suitable to educate homeowners
- Booklet / fliers / leaflets should be delivered to all homes outlining requirements of new legislation and consequences of non-compliance. Also should include typical maintenance requirements for OSWTS's
- An information document / booklet could be distributed with planning permission documents as an information tool and also serve as a service record for the OSWTS for maintenance and de-sludging of the system
- All forms of media should be used to educate the homeowners on their responsibilities
- Information to be provided in conjunction with communication about registration requirement of systems
- More effort required to educate communities in their approach to environmental protection is required
- Education of homeowners is required but must be done in a careful manner
- It is the responsibility of all people involved in the wastewater industry to educate homeowners from site assessors, system suppliers & installers etc.
- National advertising campaign required similar to that used in recent drink-driving campaigns
- Education must instil the thought that you are responsible for the treatment of your own wastewater



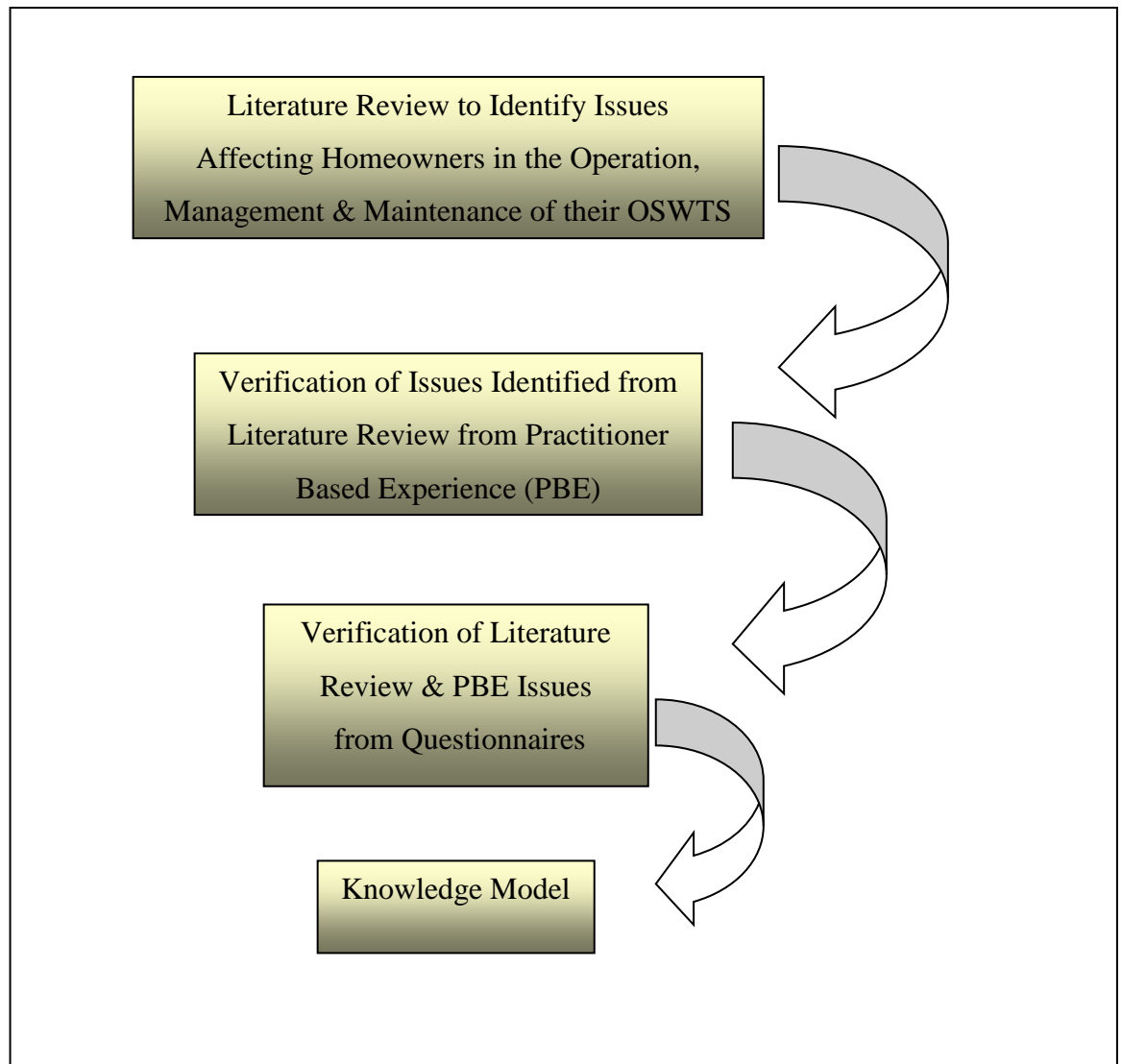
- The issue of wastewater from OSWTS's needs to be prioritised in the same way as re-cycling is for household waste
- More information to be available on web-sites
- There is an under-utilisation of enforcement mechanisms such as the planning acts, building control acts. Incorrectly designed and constructed OSWTS's should be deemed "illegal development" and the education of professionals is also important
- Start an educational programme in schools so that the next generation of homeowners are more responsible towards OSWTS's
- Provide a web-site that is well advertised and informs people of the effects on health of OSWTS's and outlines penalties for pollution
- Training should be provide to homeowners by the companies that supply OSWTS to homeowners
- Enforce maintenance contracts from OSWTS suppliers so that homeowners have to comply with manufacturers recommendations
- All local authority web-sites should have OSWTS information in the form of a national education campaign
- The EPA Code of Practice is very technical and hard to understand

## **5.6 Verification of Issues in Knowledge Model**

Figure 5.2 illustrates how the contents to be incorporated into the knowledge model have developed from the broad literature review that has been undertaken

in Chapters Two and Three to a focused knowledge model that will be developed in Chapter Six. The development of the structure set out in Figure 5.5 for the knowledge model follows the research methodology that was formulated in Chapter Four to achieve the aim and objectives of the research.

**Figure 5.5 Formulation of Knowledge Model**



## **5.7 Chapter Summary**

This Chapter has verified the issues identified in Chapters Two and Three as the areas where homeowners need education on in relation to their OSWTS's. The review of existing literature has I identified the very precarious position that Ireland has found itself in and the urgent need to comply with the ECJ (2009) ruling against Ireland for its poorly managed and maintained OSWTS's. This is against the current backdrop of over half the OSWTS's that have been inspected under the National Inspection Plan (2013) have failed (EPA, 2014). Chapter Six will now move on to use the building blocks identified in this Chapter to formulate the knowledge model for homeowners.

## **CHAPTER SIX – KNOWLEDGE MODEL DEVELOPMENT**

### **6.0 Introduction**

The purpose of this chapter is to outline and discuss the development of the knowledge model which aims to promote a better understanding of OSWTS's amongst the homeowners who rely upon these systems to treat their domestic wastewater. Chapter Two has highlighted the very precarious position that Ireland currently finds itself in from OSWTS's and the significant impact that these systems are having on the environment and the health of the general public. The significant shortcomings in performance standards and homeowner knowledge pertaining to OSWTS's were clearly identified in Chapter Two as well as the very rapidly changing legislative environment which governs the liability for poorly performing systems (Gray 1994; Daly, 2001; Flynn & Kroger, 2003; Gray, 2004; Gill *et al*, 2005; EPA, 2008; Daly & Craig, 2009; Gormley, 2009; EPA, 2009 & EPA, 2010). Chapter Three reviewed various modelling techniques which have been developed for knowledge transfer and their applicability for this model development was discussed. Chapter Four provided a critique of the research methodology and the philosophical standpoint of the author. This philosophy has shaped the methodology that is to be employed in the development of the proposed model setting out a roadmap for how this research project will proceed to completion. Chapter Five then moved on to commence the primary research phase by undertaking workshop sessions with industry experts to determine from PBE the deficiencies in homeowner knowledge and understanding in relation to their OSWTS's. The findings of the PBE were then verified by undertaking a questionnaire with the wider IOWA membership as well as providing an opportunity for further issues to be identified by participants. This Chapter will now move on to utilise the findings of the literature review and the verified findings of the PBE to develop the homeowner knowledge model.

## **6.1 The Need for the Model**

The Water Services (Amendment) Act 2012 which has been discussed in detail in section 2.4.9 was recently enacted in Ireland and the publication of the National Inspection Plan for OSWTS's (EPA, 2013) clearly illustrates the priority that is being placed on the issue by the Irish Government. The imposition of substantial fines upon Ireland on foot of the ECJ Ruling (C188-08) as outlined in section 2.6.10 has focused political attention on an environmental issue that has plagued Ireland for decades (GSI, 2009; IOWA 2011 & EPA, 2013). The National Inspection Plan (EPA, 2013) places clear and unambiguous responsibilities upon homeowners to ensure that their OSWTS's are maintained and working properly. Furthermore, the plan directs that in circumstances where systems are not maintained or working properly, or where they are causing nuisance to the general public, remediation will be required by the homeowner. There will also be a requirement that homeowners commence an on-going maintenance plan to improve the performance of their OSWTS's. The problem that has been identified in section 2.6.9 still remain in relation to the lack of knowledge by homeowners on what an OSWTS is, how it should work or how it needs to be maintained. Gray (2004) has outlined that in many cases there was no intention of maintenance of the newly installed septic tank system or the realisation that any attention was necessary. He points out that unfortunately this responsibility is not always taken seriously, with the attitude 'out of sight out of mind'.

The EPA (2013) outline in the National Inspection Plan that there is provision for what they refer to as 'citizen engagement' in the procedures for the inspection of OSWTS's. The initial intention of the Plan (EPA, 2013) as discussed in section 2.4.9 is to advise, educate and assist the public in relation to the subject area prior to the commencement of inspections in July 2013. The EPA (2013) have outlined that this citizen engagement will be the responsibility of local authorities with the EPA overseeing the process. The rapid nature in which the legislation has been initiated however has led to issues of concern as suggested by Gray (2013) that the situation has become quite confused and much of the good will that was out there appears to be evaporating very quickly.

This goodwill referred to by Gray (2013) resulted from strong media coverage of the National Inspection Plan (EPA, 2013) and the environmental need to improve water quality under the WFD. The EPA (2013) to make homeowners aware of what to expect in the inspection process for their OSWTS's has developed educational tools in the form of web based videos and frequently asked questions. Critically however and as suggested by the IFA (2012) there needs to be a targeted campaign at educating and informing homeowners that are not familiar with the use of information technology. Section 2.5.5 of this research has identified that currently the only comprehensive literature available for OSWTS's is the EPA (2010) Code of Practice which is a very technical publication that examines issues of a hydrological and engineering perspective. This document does offer guidance on the installation and management of OSWTS's but again this is targeted at a professional audience. Chapin (1971) has warned in section 3.0 that an exchange of information that is laborious, involved or tortuous usually breaks down in practice and this provides the argument for the development of something other than reams of text such as the EPA (2010) Code of Practice but from a homeowner's perspective. The fact that homeowners will from July 2013 have their systems inspected on matters of management and performance makes it a priority for them to be educated and informed in a clear and concise manner that is comprehensive, but not unnecessarily complicated (IOWA, 2012). The sanctions that can apply to homeowners in the event of pollution, poor construction or maintenance from the OSWTS are significant and a prosecution under Section 70(A) of the Water Services (Amendment) Act 2012 can attract a fine, imprisonment or both.

The knowledge model that is being developed in this research is targeted specifically at the audience of homeowners with a clear focus of avoiding the unnecessary complications mentioned by the IOWA (2012). The adoption of a visual approach will make the learning process for homeowners more simplified (Chapin; 1971, Jones; 1986 & Tah; 2004). Schultz (2002) has suggested that education is the key to changing behaviour and that techniques to develop change in behaviour that require minimal repeated interventions are most beneficial (Young, 1993).

Therefore and as discussed in detail in Chapter Two there exists an urgent need for an educational tool that is targeted specifically at homeowners that is concise so that it avoids the pitfalls suggested by Chapin (1971). The knowledge model is also necessary to ensure that Ireland fulfils the requirements of the ECJ (2009) by ensuring that a change in homeowner behaviour leads to an improvement in ground and water quality, which is also the key target of the WFD. An appropriate knowledge model will need to adopt a three tier approach so that it informs on the relevant legislation, educates homeowners on what they need to do and that minimises the need for future interventions by preventing a recurrence of poor behaviour or OSWTS neglect. Therefore the knowledge model will need to be iterative whereby it doesn't have a fixed start or end, moreover it is an on-going process to ensure that homeowners improve their behaviour and knowledge and remain that way. This model will provide a basis for an informed homeowner who is aware of their legal responsibilities in relation to their OSWTS. It will also provide a foundation for a moral obligation to ensure that their OSWTS is properly managed and maintained.

## **6.2 Model Definition**

The Collins English Dictionary (2012) defines model as a 'structural plan or basis of a project' in one context and also as 'a structure supporting something'. According to Faraj (2011) there are different meanings for the term model and it is important to illustrate these differences prior to proceeding with the definition of the model that is to be developed as part of this research. The term model is used in a variety of situations that are often sufficiently different to necessitate a clear understanding of what term is meant by the term (Beyh, 2004). This variety of situations where the term model is used and as referred to by Beyh (2004) leads to a lack of cohesiveness across models (Rubenstein-Montano *et al.*, 2001). Wiig *et al.* (1997) has defined as a set of guiding principles and a methodology that can be thought of as a specific and detailed description of how to carry out the ideas and objectives.

In the context of knowledge management there appears to be a little less certainty as to exactly what the model is, or how it should be manifested as referred to by Rubenstein-Montano *et al.*, (2001);

- there is no single definition of what constitutes knowledge management;
- there are many concepts that are common to multiples, but the ordering or structure of the models varies.

(Rubenstein-Montano *et al.*, 2001)

In this thesis the model for homeowners to better understand and manage their OSWTS depicts a tool that is intended to act as a support or guide for the building of something that expands the model into something useful. Clearly the guiding principles and methodology of how to carry out ideas and objectives as referred to by Wiig *et al.* (1997) should be adopted in this case and the model can be seen as a decision-making tool to assist homeowners in a knowledge management context.

### **6.3 Model Development & Structure**

The development of the model is based on the tabulation of results from the comprehensive literature review undertaken in Chapter Two as well as from Practice-Based Experience (PBE) which has been verified through the questionnaires with the wider IOWA membership. The key findings of the secondary research from Chapter Two in relation to OSWTS's can be briefly summarised as follows;

- There are almost 500,000 OSWTS's in Ireland at present (CSO, 2012).
- The EPA (2006) has identified that the most significant groundwater contaminants and/or contaminant indicators in Ireland are faecal bacteria,



viruses and other microbiological contaminants. OSWTS's contribute to these contaminants as identified by Daly (2003), Gill et al (2005), EPA (2009) EPA (2010) & EPA (2013).

- Ireland has E.coli levels seven times that of Northern Ireland and the Netherlands, eighteen times that of Scotland and twenty eight times the levels recorded in England and Wales (Nix, 2010). The presence of even a single E.coli in drinking water is unacceptable as it indicates that the source is contaminated with faecal matter (EPA, 2009).
- The EPA (2008) outlines that groundwater is a valuable natural resource in Ireland that is used in food and industrial processing, as well as being an important source of drinking water, but is often contaminated by inadequate wastewater treatment systems (Daly, 2003; Gill et al, 2005; EPA, 2009), the most significant being faecal bacteria, viruses and other microbiological contaminants (EPA, 2006).
- In certain counties particularly in the midlands, the proportion of population that derives its drinking water from groundwater is very high such as north Cork 90%, Roscommon 86% Offaly 60% Laois 54% and Kilkenny 52% (EPA, 1999).
- The continuing decline in Ireland's water quality was highlighted by Lucey et al (1999) and also by Irvine et al (2000) where they recognised that Ireland's responses to water pollution were completely ineffective.
- There is much evidence suggesting that on-site systems may be a significant and underestimated source of nutrient input to water bodies in rural catchments Beal *et al* (2004); Daly (2003); Gill *et al* (2005) & EPA (2013).
- Since 2003 the European Commission has been in repeated contact with the DoEHLG seeking a proper system of inspection and maintenance, and

the ECJ found that the laws, guidelines and policy circulars in place in Ireland didn't have the "indisputable binding force necessary" for the effective application of EU laws to protect human health and the environment (Nix, 2010).

- The very swift adoption of the Water Services (Amendment) Act 2012 and the publication of the National Inspection Plan for OSWTS's (EPA, 2013) illustrates that the issue has gained significant priority in light of the ECJ (2009) prosecution of Ireland in relation to OSWTS's.

All of the factors identified from the primary and secondary research undertaken to date have shaped and developed the knowledge model to be adopted. The model to be adopted will be in the form of a flowchart and the critique for this choice is outlined in Section 3.7.4.

## **6.4 Knowledge Model**

Chapter Three has examined in detail the various information and knowledge modelling options and techniques that are available. Harris (1999) outlined in section 3.0 that information graphics for operational purposes are used by millions of people on a daily basis for such things as improving their efficiency and effectiveness, improving quality, solving problems, planning, teaching, training, monitoring processes etc. The modelling techniques that were chosen for analysis in section 3.7 were selected on the basis of an assumed applicability to environmental scenarios such as wastewater treatment and from examples of where they have been used in real world situations. This approach was adopted as a full examination of all modelling techniques would merit a thesis of their own and to reflect the resource limitations of this particular research project. The concept of knowledge modelling has been selected as most appropriate to this research topic. Mitchell (2000) asserts that knowledge differs from information in that it is predictive and can be used to guide action while information merely is data in context. Knowledge is information combined with experience, context,

interpretation, and reflection. It is a high-value form of information that is ready to apply to decisions and actions (Davenport et al., 1998). The model for homeowners as discussed earlier in Chapter Five is pivotally concerned with guiding their decisions and actions and affirms the selection of a knowledge model over and above an information model.

Modelling is a difficult area however because the process itself is a constructive problem solving activity for which no single “good” solution exists (Schreiber & Wielinga, 1998). Nevertheless, the need to persevere regardless of this difficulty has been clearly identified in Chapters Two and Four. Ireland must ensure that homeowners improve the performance of their OSWTS’s or the imposition of fines and penalties from the ECJ will continue and morally the health of the general public and the environment will continue to suffer (EPA, 2013). Modelling offers an opportunity to avoid the pitfalls outlined by Chapin (1971) whereby reams of text in large documents will fail to educate homeowners. Glassey (2009) suggests that “models are used to provide a framework to describe concepts and to reason about these concepts in order to create new knowledge and this new education will help to shape behavioural change and decision making amongst homeowners and how they manage and maintain their OSWTS. Andriole (1989) has outlined that decision support tools should contain models of selected decision situations and they should support several phases of the decision process and Schultz (2002) outlines that education is often seen as the key to changing behaviour. Schultz (2002) queries however whether education is sufficient to change behaviour on its own and suggests that knowledge-based interventions such as modelling is an alternative educational approach that focuses on changing social norms. The adoption of the flowchart for this knowledge model has been influenced predominantly by Tah (2004) and this decision is justified from the critique of flowcharts in section 3.7.4. Tah (2004) suggests that a flowchart is a graphic representation of the sequence of steps that make up a process and affirms the benefit of the visual approach by stating that the use of flowcharts is really a reinforcement of the fact that it is easier to understand something presented graphically rather than when it is described. The model to be developed in this research is directed at an audience of homeowners who will use the model on a

voluntary basis and it is critical that the model makes a strong impact from possibly only a scan read. Furthermore, the model is intended to become an aid to homeowners if they have problems or a breakdown with their OSWTS and as outlined by Lewis (1971) the flowchart is an aid to troubleshooting and that it helps to clarify issues without the need for extensive detailed text.

## **6.5 The Knowledge Model for Homeowners**

The previous sections of Chapter Six have discussed the need for a knowledge model to educate and inform homeowners on how to better understand, manage and maintain their OSWTS's. The legal implications for homeowners in the subject area have been examined and the sources of the legislation behind the National Inspection Plan (EPA, 2013) have been identified. The critique for the use of a knowledge model as an alternative to a predominantly text based system has been considered with the benefits of a graphic representation outlined. The critical issues that need to form part of the knowledge model have been identified from the review of existing literature and also from the practice based experience as discussed in section 5.3. At this point in the research journey the following summarisation can be made from the research undertaken;

- Ireland is in urgent need of an improvement in on-site wastewater treatment performance from dwellings not connected to municipal wastewater facilities.
- There is a clear lack of education, knowledge and understanding amongst the general public on how OSWTS's should be operated, managed and maintained.
- A significant change in behaviour is required in the on-site wastewater industry.

- The risks to public health, the environment and the significant fines being imposed on Ireland by the ECJ (C188-08) make the issue of OSWTS's a priority.
- The liability for public nuisance and pollution from OSWTS's rests solely and exclusively with homeowners and there must be a concerted effort to improve their knowledge and understanding of their legal obligations.
- The research need is justified for the knowledge model for homeowners.

### **6.5.1 The Development of the Knowledge Model**

Section 5.3 has illustrated the progression of the knowledge model for homeowners from an initial research proposal through to an actual knowledge intervention tool that is intended to improve behaviour and understanding by homeowners towards their OSWTS's. Table 6.1 outlines how the structure and the contents of the individual flowcharts in the model developed. The various contents of each flowchart that forms part of the overall model have been derived from the relevant legislation, the secondary research and then also from the primary research undertaken.

Table 6.1 Process of Model Development

| <i>Component of the Knowledge Model:</i> | <i>Source &amp; Justification of the Component:</i>  |
|--|--|
| Title Page:                              | <p>The title of the model was derived from the aim of the research project and justified from the interviews and questionnaires.</p> <p>The use of bright colours was a common suggestion from the participants in the workshop session.</p>   |
| Index:                                   | <p>The index was developed from the drivers and barriers to sustainable on-site wastewater treatment as set out in Figure 5.2 in Chapter Five.</p> <p>Figure 5.3 identifies the key factors that influence OSWTS performance from the workshop session and these headings have instigated the flowchart titles within the model.</p> |
| Tabs on Model for Individual Flowcharts  | In the workshop session it was suggested that there should be a mechanism to differentiate between the issues that could affect the homeowner's OSWTS and the suggestion of tabs was referenced by one of the participants.  |
| Record Keeping Tab - Pink                | A common theme from the questionnaires with the IOWA membership as outlined in Section 5.5.2 was that the homeowner needed to maintain their records and that the  |

|   |  |
|---|--|
|   | <p>knowledge model could accompany proper record keeping.</p> <p>Each Flowchart refers to this at the bottom as the homeowner may only refer to the tab that is relevant to them at a particular time. By having this suggestion on each chart it will prevent the homeowner from missing the point.</p>   |
| <p><b>Installation Tab – Blue</b></p> <p>Justification of contents of this Flowchart</p>  | <p>A certificate of installation is required to comply with Part H of Building Regulations (2012).</p> <p>Planning permissions usually require that homeowners have an on-going maintenance agreement with system manufacturers.</p> <p>The white components of this flowchart are derived from the Water Services (Amendment) Act, 2012.</p> <p>The pink section on record keeping is in order to comply with the requirements of the National Inspection Plan (EPA, 2014).</p> |
| <p><b>Registration Tab – Green</b></p> <p>Justification of contents of this Flowchart</p> | <p>A certificate of installation is required to comply with Part H of Building Regulations (2012).</p>   |

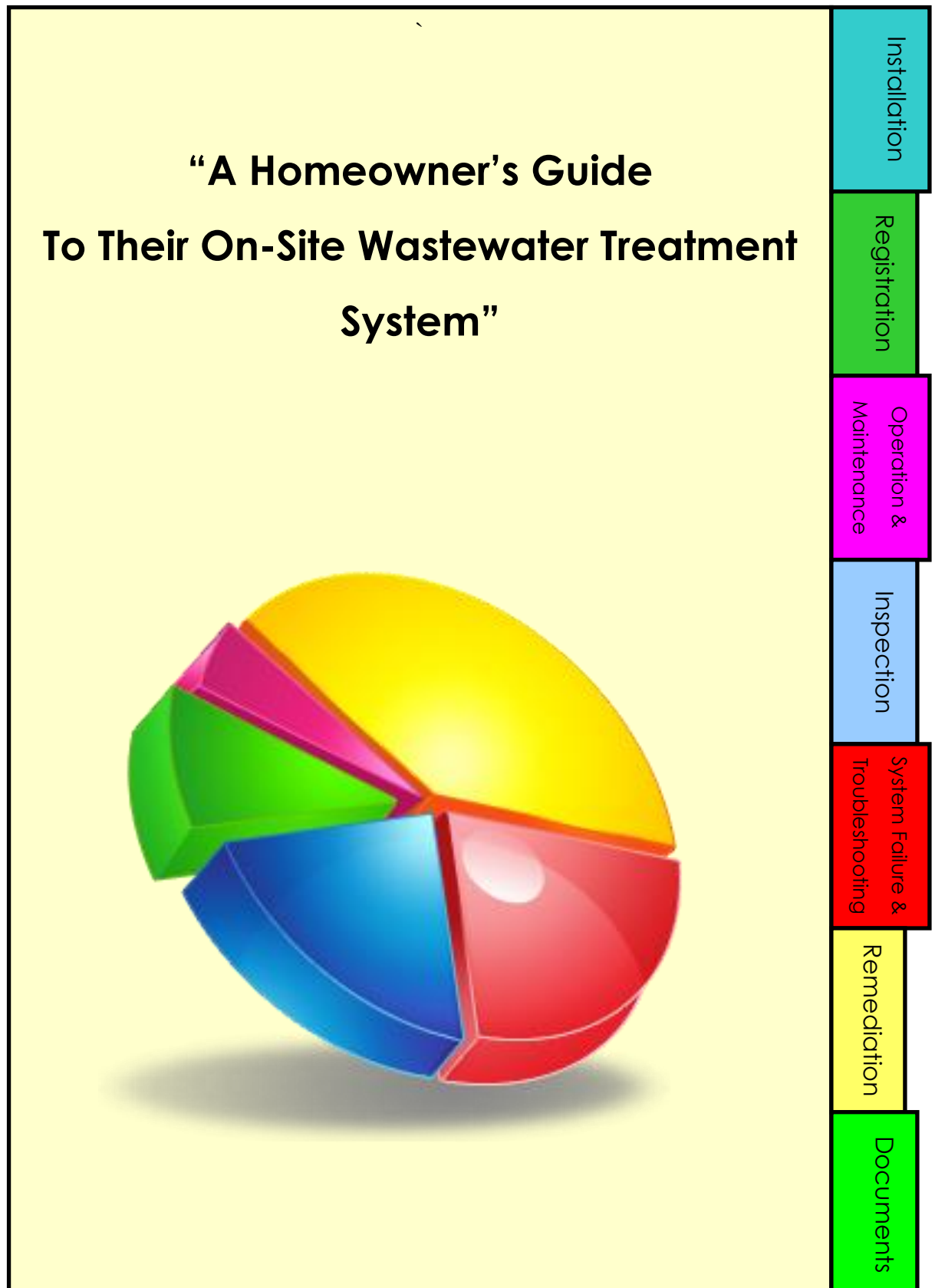
|                                |   |
|--------------------------------|---|
|                                | <p>The registration of OSWTS's is required under the Water Services (Amendment) Act, 2012.</p> <p>A certificate of installation is required to comply with Part H of Building Regulations (2012).</p> <p>The pink section on record keeping is in order to comply with the requirements of the National Inspection Plan (EPA, 2014).</p>  |
| Operation & Maintenance - Pink | <p>Planning permissions usually require that homeowners have an on-going maintenance agreement with system manufacturers.</p> <p>The contents of this flowchart are extracted from the EPA Code of Practice (2010) for Wastewater Treatment and Disposal System for Single Houses.</p> <p>The pink section on record keeping is in order to comply with the requirements of the National Inspection Plan (EPA, 2014).</p> |
| Inspection – Light Blue        | <p>The National Inspection Plan (EPA, 2014) directs that record keeping is required in order to comply with inspections to be carried out on</p>  |



|  |  |
|--|--|
|  | <p>OSWTS's.</p> <p>Certificate of confirmation as referred to in green is also a requirement of The National Inspection Plan (EPA, 2014)</p> <p>The pink section on record keeping is in order to comply with the requirements of the National Inspection Plan (EPA, 2014).</p>  |
| System Failure & Troubleshooting - Red | <p>The contents of this flowchart in white are referenced as common problems from the EPA Code of Practice (2010) for Wastewater Treatment and Disposal System for Single Houses.</p> <p>The literature review in Chapter Two has also informed some of the contents which were validated from the workshop sessions and questionnaires in Chapter Five.</p> <p>A certificate of installation is required to comply with Part H of Building Regulations (2012).</p> <p>The pink section on record keeping is in order to comply with the requirements of the National Inspection Plan (EPA, 2014).</p> |

|                             |  |
|-----------------------------|--|
| <b>Remediation - Yellow</b> | <p>The reference in the blue tabs to the certificate confirming the OSWTS has passed the inspection is a requirement of The National Inspection Plan (EPA, 2014)</p> <p>A certificate of installation is required to comply with Part H of Building Regulations (2012).</p> <p>The tabs in white are extracted from the DoEHLG for the grant scheme that is available for the remediation of problematic and ineffective OSWTS's.</p> <p>The pink section on record keeping is in order to comply with the requirements of the National Inspection Plan (EPA, 2014).</p> |
|-----------------------------|--|

## 6.5.2 Knowledge Model Cover



### 6.5.3 Index & Content

**Installation**

**Registration**

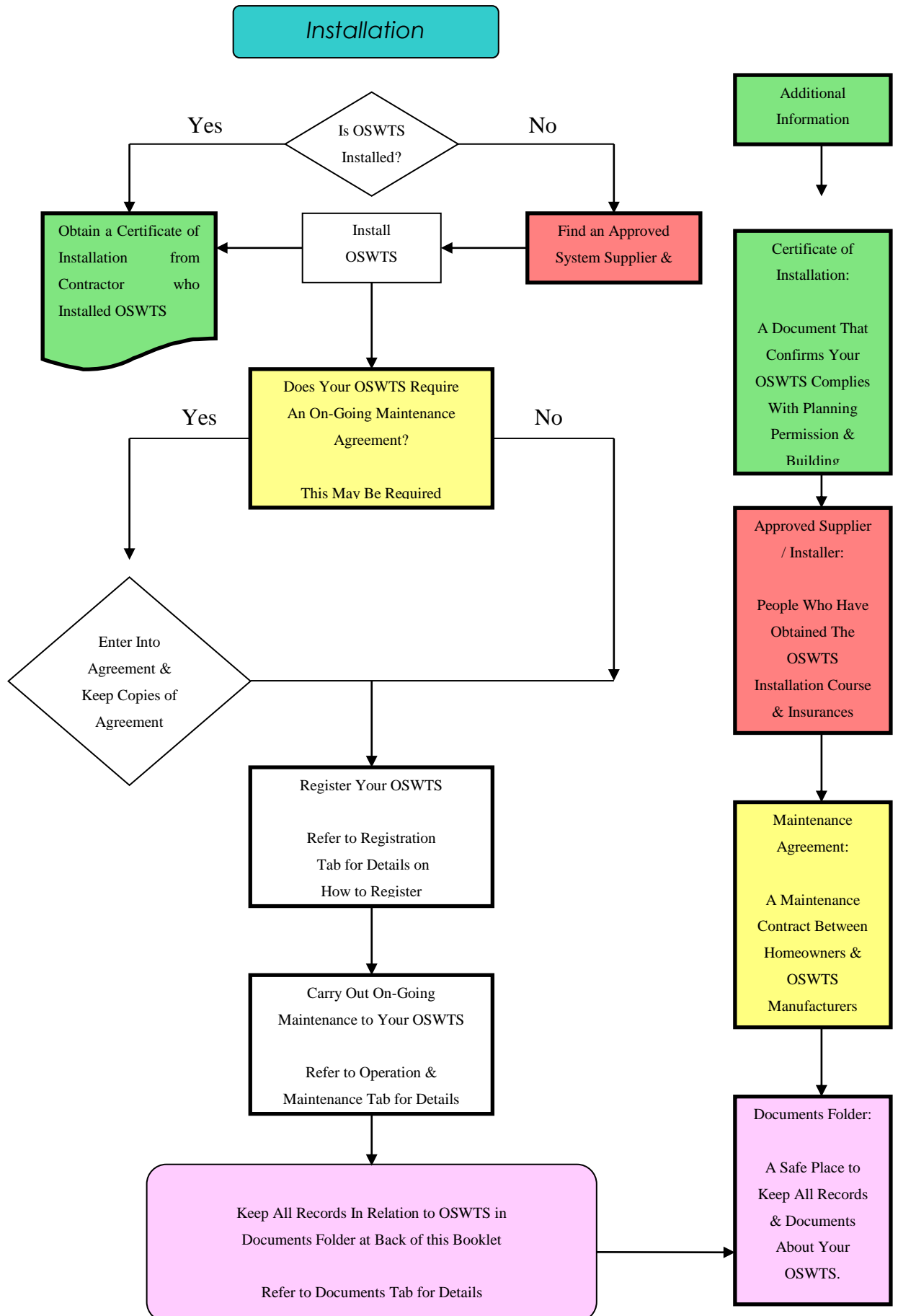
**Operation &  
Maintenance**

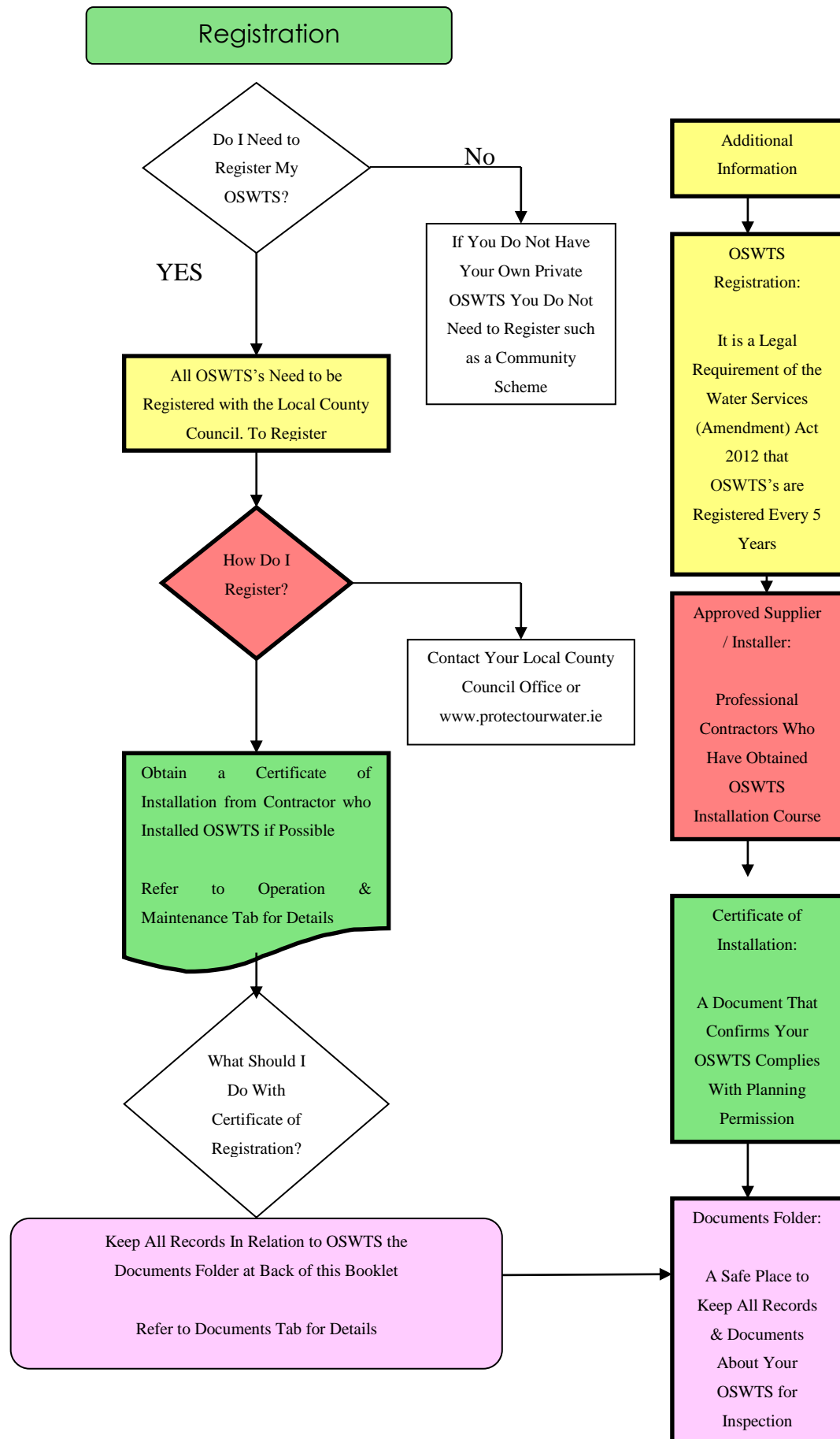
**Inspection**

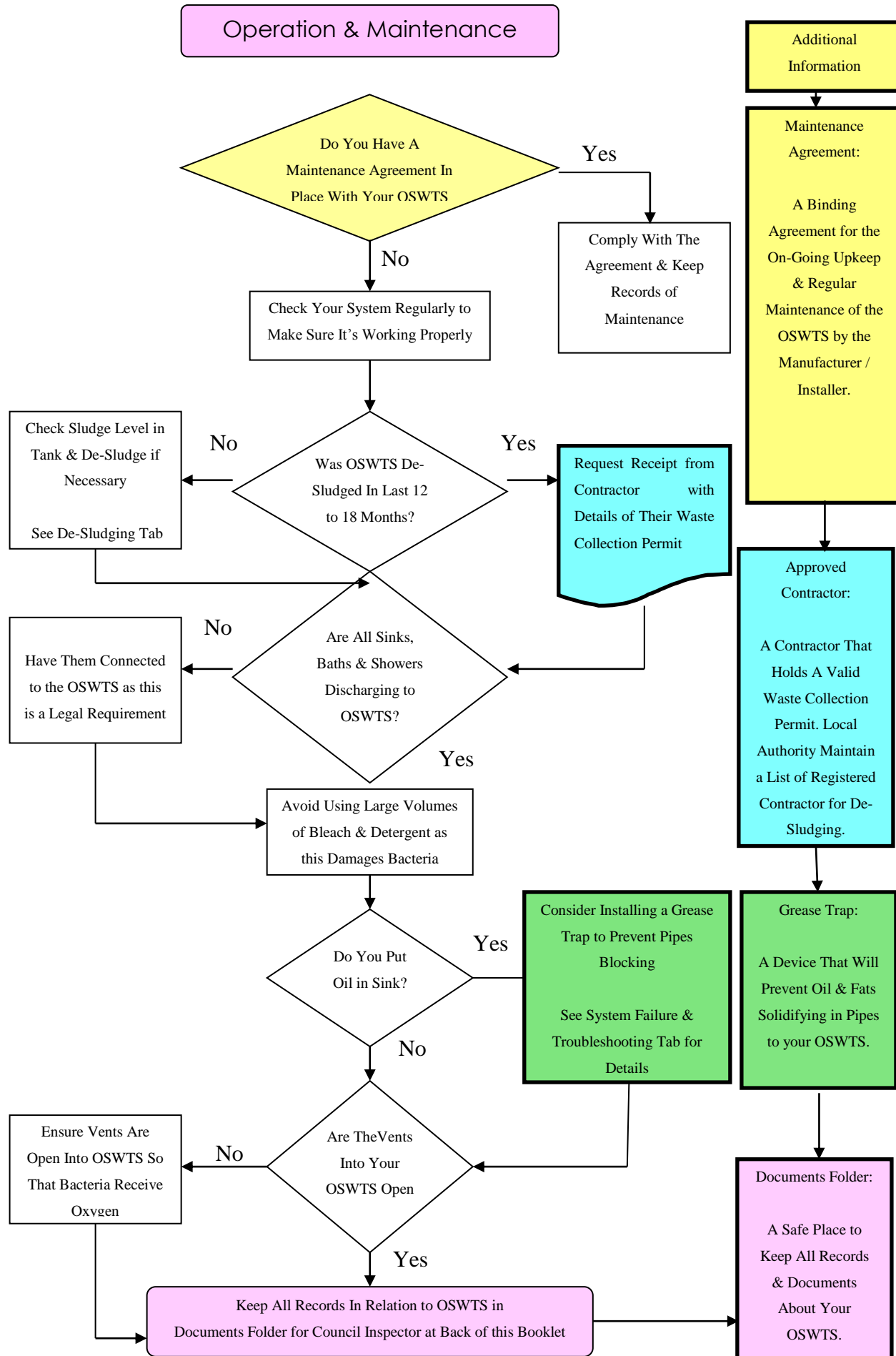
**System Failure &  
Troubleshooting**

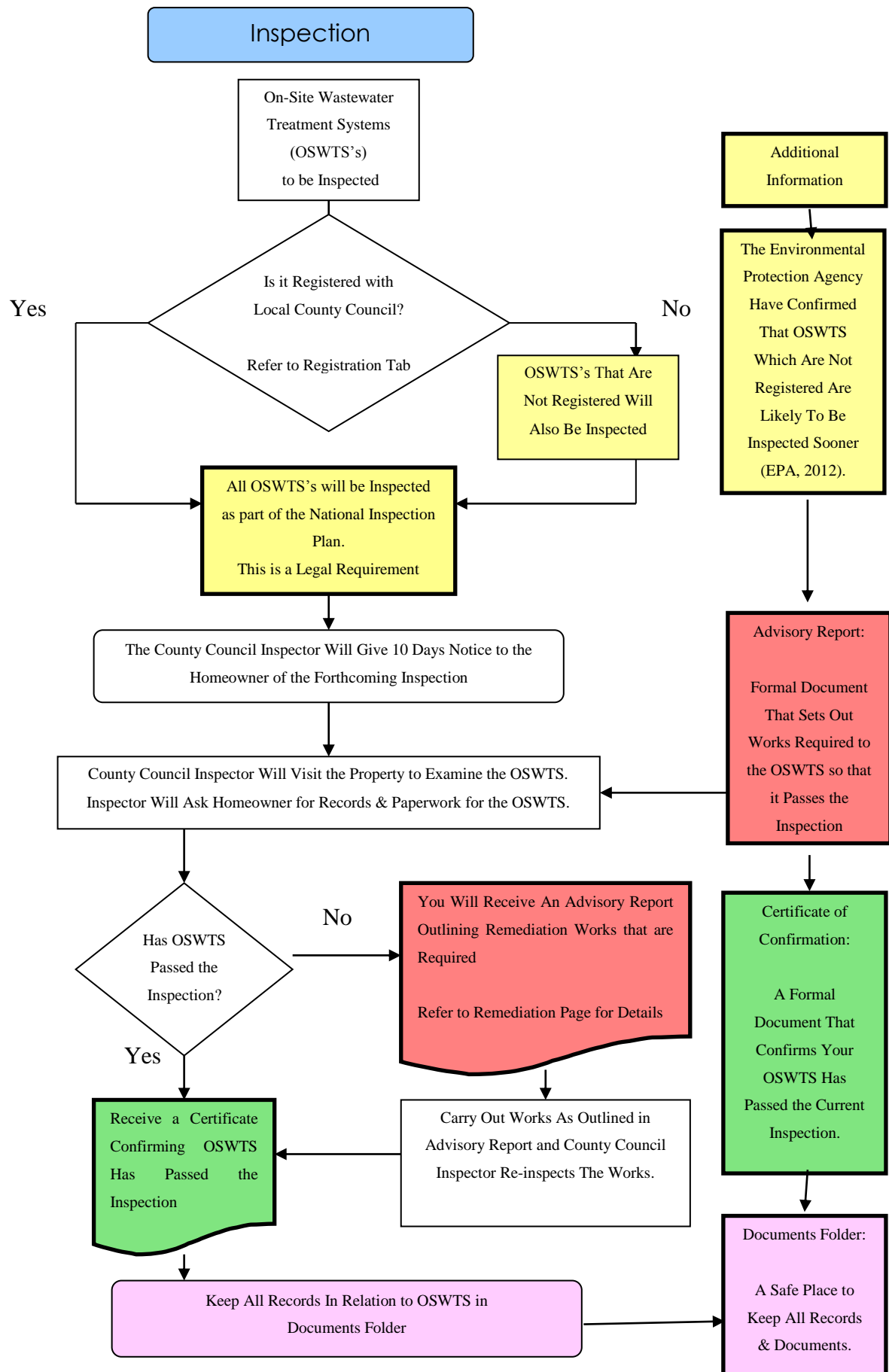
**Remediation**

**Documents**















#### **6.5.4 Documents**

The research has identified that it is very important from homeowners to retain all documentation that relates to their OSWTS. As outlined in Chapter Two the Water Services (Amendment) Act 2012 makes provision for periodic inspections of OSWTS's by Local Authority Inspectors and one of the critical components of these inspections is the checking of registration and maintenance details. The findings outlined in Chapter Five from the workshop held with the IOWA Executive Committee clearly illustrate that industry professionals place a strong emphasis on the knowledge model providing a mechanism for the homeowner to retain these important documents. Accordingly the model will provide a section for the recording of documents such as de-sludging certificates, registration forms, maintenance reports and also any other material that relates to the OSWTS.

#### **6.6 Chapter Summary**

This chapter has developed the knowledge model for the issues that need to be addressed therein so that homeowners can better understand and manage their OSWTS's. These issues have been identified from the comprehensive literature review that was undertaken in Chapter Two as well as from the practical based experience of the author which has developed in the on-site wastewater industry as well as from the research with industry peers. The structure of the model has been developed from the critique of modelling and decision support tools that have been discussed in Chapter Three. This critique has concluded that a flowchart would be the most effective tool to convey knowledge and decision support to homeowners. The knowledge model that has been developed and set out in Chapter Five must be fit for purpose and effective in the education of homeowners in relation to their OSWTS's. The following chapter will evaluate the knowledge model from the perspective of industry experts and homeowners to determine its validity in the subject area.

## **CHAPTER SEVEN – MODEL VALIDATION**

### **7.0 Introduction**

Chapter Six formulated a knowledge model that aims to provide homeowners with a better understanding and knowledge of their OSWTS's which will lead to behavioural change in the management and maintenance of these systems. Ultimately the development of this knowledge model encompasses the aim of the research as outlined in section 1.4 as well as the associated objectives of improving OSWTS performance and reducing or reversing environmental damage will be achieved from a more knowledgeable homeowner (Wilson, 1998). The intended behavioural change that will result from the decision support offered to homeowners by the model has been extensively discussed in Chapter Five and will inevitably lead to reduction in groundwater pollution and the consequent risks from OSWTS's to public health. These health risks as outlined in section 2.2.1 illustrate the magnitude of the problem that Ireland faces and the need for urgent action. Furthermore, the on-going prosecution and penalties that are being imposed upon Ireland on foot of the ECJ (2009) ruling highlight the importance of this research (Daly, 2003; Gill et al, 2005; EPA, 2009; EPA, 2012; EPA, 2013 & GSI, 2014).

The concept of a knowledge model for homeowners has developed from the findings of the research undertaken in Chapters Two and Three of this thesis with Chapter Four outlining the methodology that has been adopted for the research project to proceed to completion in consideration of the philosophical perspective of the researcher. Chapters Five and Six have outlined the findings of the primary research undertaken and demonstrated the issues that need to be considered in the knowledge model. Chapter Seven now moves on to evaluate the knowledge model as initially developed and examines the refinements that have been made on foot of the structured interviews that have taken place. This Chapter begins by providing a background of and justification for the audience that has been selected as part of the evaluation process. The Chapter will then examine and outline the

design of the methodology that has been adopted to evaluate the model and the anticipated issues surrounding the collection and analysis of the findings. The Chapter then proceeds to undertake the evaluation with the target audience which is made up as follows;

1. A questionnaire to professionals in the on-site wastewater industry to confirm what knowledge interventions are required for homeowners in relation to their OSWTS's. This forms the basis of the validation of the content to be contained in the knowledge model
2. Structured interviews with industry experts on the knowledge model to validate its content and structure.
3. Structured interviews with a random selection of homeowners to evaluate the practicability of the knowledge model in a real world scenario and to validate the content and structure.

Chapter Seven will then present the findings of the evaluation phase with the target audience and illustrate the refinements to the knowledge model that have occurred. A discussion and reflection of the research methods adopted will be followed by a summary of the evaluation phase and this will conclude Chapter Seven.

## **7.1 The Target Audience for Evaluation of the Knowledge Model**

In order to assess the validity of the proposed knowledge model a broad and extensive evaluation is required within the industry in which the knowledge model is designed to operate. There are a number of reasons why this comprehensive evaluation is required but perhaps the most pertinent reason is to mitigate the risk of bias in the research (Woolgar, 1988). Chapter Four has observed that in research which encompasses the tacit knowledge of the researcher there is a huge threat to the reliability and validity of the research from

bias (Schon, 1983). Schon (1983) refers to this form of research as ‘reflective research’ and outlines that it is a very valid and robust research method. Jarvis (1998) on the other hand refers to this research as ‘practitioner research’ which ultimately develops theory from practice. Tacit knowledge has been referred to by Knight & Ruddock (2008) as knowledge based on life experiences which by its nature is harder to reference and justify. While this is knowledge generated outside of the traditional academic environment, it is nonetheless knowledge that is a powerful source of production (Marshall, 1972). Pathirage (2009) suggests that the solutions to problems in the built environment are very reliant upon tacit knowledge and that this tacit knowledge is critical in the achievement of sustainable built environments. Polanyi (1958) however asserts the difficulty with defining the concept and states that tacit knowledge is such an elusive and subjective awareness to the individual that it cannot be articulated in words. Section 5.2.2 has defined in quite some detail the concept of practitioner or reflective research but the key message that resonates from this is the need to address the issue of bias (Eraut, 1994). This bias referred to by Eraut (1994) can be closely aligned with the reference to ‘subjective’ by Polanyi (1958) and be the source of attack to the validity of tacit knowledge in research.

In light of this very real threat of bias and the subjectivity in the research, it is necessary therefore to undertake a robust evaluation of the knowledge model for homeowners. It is this need for a robust evaluation that has influenced the decision to evaluate the model with experts in the on-site wastewater industry as well as generally with architects, engineers, surveyors, site assessors, academics, legislators, installers and manufacturers. Furthermore, and to again ensure the validity of the knowledge model there will also be an evaluation with randomly selected homeowners to ascertain how useful and reliable the model is in providing decision support and education to the target audience. This triangulation of participants in the validation phase will ensure that there is a comprehensive critical review of the validity and reliability of the model as discussed in section 4.6. Sutrisna (2010) refers to the testing of validity and reliability of research as the essential ingredients to develop the credibility to state that the aim and objectives of the research project have been met. Guba & Lincoln (1994) go a

little further than credibility however where they list the following alternative criteria for ensuring the research achieves its aim and objectives;

- Trustworthiness
- Credibility
- Dependability
- Transferability
- Confirmability

Accordingly, by engaging and testing the knowledge model with industry experts, practitioners and homeowners the overall suite of tests referred to by both Guba & Lincoln (1994) and Sutrisna (2010) can be undertaken. The next section of Chapter Six will move on to examine how the validation process will work and analyse the findings of the validation.

## **7.2 Questionnaires of Industry Professionals at the IOWA Conference 2013**

Chapter Four has discussed the methodology that has been adopted for this research and there has been a comprehensive critique of the methods adopted in the research to gather the necessary data in the subject area. An important conclusion that has been drawn from the literature review in Chapter Two is that the lack of knowledge and understanding amongst homeowners in relation to OSWTS's is so broad that there is little point in surveying them on what they don't know, or what they need to know (Chynoweth, 2011). The adoption of knowledge modelling as a method to address these deficiencies in homeowner knowledge and understanding of OSWTS's has been discussed in Chapter Three and specifically section 3.3.3 details the modelling techniques which have the capability to convey essential information and knowledge onto homeowners in a clear, concise and logical manner. The attributes of these modelling techniques

provide opportunities for learning in an easy to understand and concise manner (Harris 1999; Martensson 2000; Wierzbicki *et al* 2000; Tah, 2004; Giaglis, 20xy; Glassey 2009 & Lee 2011). Irvine (2005) has argued however that there is no one size that fits all in modelling and therefore careful consideration must be given to the information and knowledge that is to be conveyed to homeowners in the actual model developed as part of this research. The need for careful consideration that is referred to by Irvine (2005) has prompted the research to consider what knowledge is deficient amongst homeowners so that the model to be developed addresses this knowledge deficiency. As outlined in Chapter Two and above there is no point in questioning homeowners about what they don't know so an alternative source of data is required. A comparative scenario exists in the healthcare industry which is discussed in section 4.3 and as this scenario is outlined by Lee (2009) whereby the professionals who advise patients on health issues are the ones who are researched to identify deficiencies in practice and procedures in that industry. This practitioner inquiry provides insightful data on the issues being researched where the patients themselves would not be informed or knowledgeable, as in the case of homeowners and their OSWTS's. In drawing from the experience of the healthcare industry, this research has therefore engaged with professionals from the on-site wastewater industry to validate the homeowner knowledge model that has been developed. The target audience for the questionnaire is the IOWA which includes the following professionals as set out in Figure 7.1;



**Figure 7.1: IOWA Profile of Membership**

|               |                         |                       |                            |
|---------------|-------------------------|-----------------------|----------------------------|
| Planners      | System Installers       | Site Assessors        | Policy Makers              |
| Trainers      | Regulators              | Inspectors            | EPA Staff                  |
| System        | Builders                | Academics             | Elected<br>Representatives |
| Manufacturers | Designers               | Distributors          | Architects                 |
| Engineers     | Certification<br>Bodies | Building<br>Surveyors |                            |

(Source: IOWA, 2008)

### 7.2.1 Questionnaire Objectives

The objectives of the questionnaire undertaken with the general IOWA membership can be summarised as follows;

- To identify the professional background of the participant and their opinion of how serious the OSWTS problem is in Ireland presently
- To identify if the industry believes that there is a deficiency in homeowner knowledge and understanding in relation to OSWTS's and if homeowners need to be better informed and made aware of their legal responsibilities
- To identify the issues and reasons that the industry believe are causing OSWTS's to operate so poorly
- To provide an insight into how knowledge could be conveyed to homeowners about their OSWTS's and to obtain theories that they may have.

### **7.2.2 Questionnaire Development**

The issues identified in the literature review in Chapter Two and from the practical based experience as discussed in section 5.2.2 were used to develop the questionnaire which is one of the triangulated methods (Yin, 2009) adopted to evaluate the need for the homeowner as discussed in section 6.1. Sections 4.5.1 and 4.5.3 have discussed in comprehensive detail the process and justification for the development of the questionnaire and its subsequent use in this research. These sections have also provided the critique and process that led to the development of the sections within the questionnaire and the actual questions themselves. The following are the questions that have been used in the questionnaire;

Question One in the questionnaire sought the professional background of the participant and Table 6.2 provides the responses to this question. The following are the other specific questions from the questionnaire undertaken at the IOWA Conference;

Question 2: OSWTS's are potentially an environmental hazard and source of significant pollution in Ireland.

Question 3: The performance and management of OSWTS's is a significant problem in Ireland at present.

Question 4: Homeowners should be held responsible for the performance and management of their OSWTS as directed by the Water Services (Amendment) Act, 2012.

Question 5: There is an urgent need for homeowners to improve their knowledge and understanding of the on-site wastewater treatment process and knowledge of their roles and responsibilities.

Question 6: Existing guidance for homeowners in relation to OSWTS's has been ineffective in the transfer of knowledge and understanding.

Question 7: A significant number of OSWTS's are poorly designed, operated and maintained in your area.

Question 8: OSWTS's are usually not serviced properly or maintained in accordance with the design specifications or planning conditions.

Question 9: Many homeowners do not realise that OSWTS's require on-going maintenance at all.

Question 10: There needs to be a significant improvement in OSWTS performance if Ireland is to achieve its objectives under the Water Framework Directive.

Question 11: The education and training of homeowners is an important step in improving the performance of OSWTS's.

Question 12: The inspection and monitoring of OSWTS's by Local Authorities is sufficient to educate homeowners on how to manage and maintain their OSWTS.

Question 13: The cost of having OSWTS's serviced and maintained is prohibitive for homeowners and leads to a lack of necessary works being undertaken.

Question 14: A simple and easy to understand graphic knowledge model that summarises the relevant legislation and guidance in relation to OSWTS's and that helps homeowners to understand their legal responsibilities and obligations towards OSWTS's would be useful.

Question 15: Please provide any additional comments.

### **7.2.3 Questionnaire Process & Practical Issues**

In accordance with the ethical procedures discussed in section 4.6 a cover sheet for the questionnaire was provided to state its purpose and indicated that all the responses would be confidential and no individuals would be identified in the subsequent reports. In addition, instructions on how to complete the questionnaire were included at the head of each section. The questions were specific to homeowner related issues and covered matters such as behaviour, legislation, education and knowledge. The questions were divided into three sections as follows;

- Professional Background of Participant
- Participant's Perspective
- Additional Comments

The questionnaire was undertaken as part of the IOWA Annual Conference which took place in September 2013. The questionnaires were distributed to the attendees at the conference and the research project was introduced to the audience at the conference introduction by the researcher. This provided the researcher an opportunity to answer questions from the attendees prior to the completion of the questionnaire report. A total of 89 completed or partially completed questionnaires were returned from respondents at the conference. The total registered attendance at the conference on the day was 106 and all attendees were provided with a copy of the questionnaire. This represents a total completion rate of 83.96% but there were some questions un-answered or blank on a number of completed questionnaire forms.

## 7.2.4 Questionnaire Responses from IOWA Conference 2013

Section 4.5.1 has outlined that the IOWA is the only dedicated on-site wastewater association in Ireland presently and therefore the association provides a unique access to a diverse range of professionals who work in the on-site wastewater industry as outlined in Table 6.1. Table 6.2 illustrates the number of completed or partially completed questionnaires that were received from the respective professional groups at the IOWA Conference in 2013;

**Table 7.1: Completed Questionnaires from Professionals at the IOWA Conference 2013**

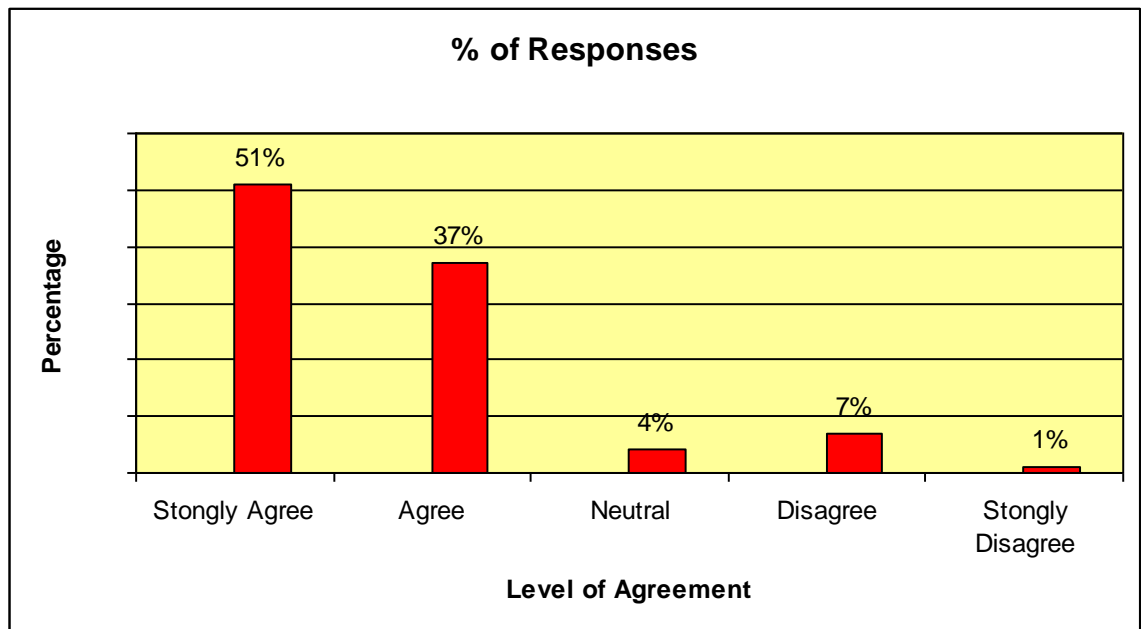
| <b>Professional Background<br/>Of Participant:</b> | <b>No. of<br/>Responses</b> | <b>% of<br/>Sample</b> | <b>No. of Unusable<br/>Responses</b> |
|--|-----------------------------|------------------------|--------------------------------------|
| <b>OSWTS Manufacturer /<br/>Supplier</b>           | <b>15</b>                   | <b>16.86%</b>          | <b>0</b>                             |
| <b>On-Site Assessor</b>                            | <b>39</b>                   | <b>43.82%</b>          | <b>0</b>                             |
| <b>Local Authority Representative</b>              | <b>12</b>                   | <b>13.48%</b>          | <b>0</b>                             |
| <b>EPA Representative</b>                          | <b>0</b>                    | <b>0%</b>              | <b>0</b>                             |
| <b>Legislator /<br/>DoEHLG Representative</b>      | <b>3</b>                    | <b>3.37%</b>           | <b>0</b>                             |
| <b>Academic / Researcher</b>                       | <b>2</b>                    | <b>2.25%</b>           | <b>0</b>                             |
| <b>Member of Interest / Lobby<br/>Group</b>        | <b>0</b>                    | <b>0%</b>              | <b>0</b>                             |
| <b>OSWTS Installer / Builder</b>                   | <b>12</b>                   | <b>13.48%</b>          | <b>0</b>                             |
| <b>Other</b>                                       | <b>6</b>                    | <b>6.74%</b>           | <b>0</b>                             |

The following provides the responses to the questions from the participant's perspective section of the questionnaire. There is also a summary of the additional comments which were provided by the participants to these questions.

### Response to Question 2

Question 2: OSWTS's are potentially an environmental hazard and source of significant pollution in Ireland?

**Table 7.2: Summary of Responses to Question Two from Questionnaire**



The additional comments that were made in relation to this question are as follows;

- There needs to be a full scale assessment of existing systems and proposals for upgrading and improvement
- OSWTS's are a source of pollution if not installed correctly or on unsuitable sites
- Provide 100% grant assistance for new systems to be installed. A lot of money will be returned to the state by providing employment and tax etc.
- OSWTS's are only a problem if not assessed or maintained properly

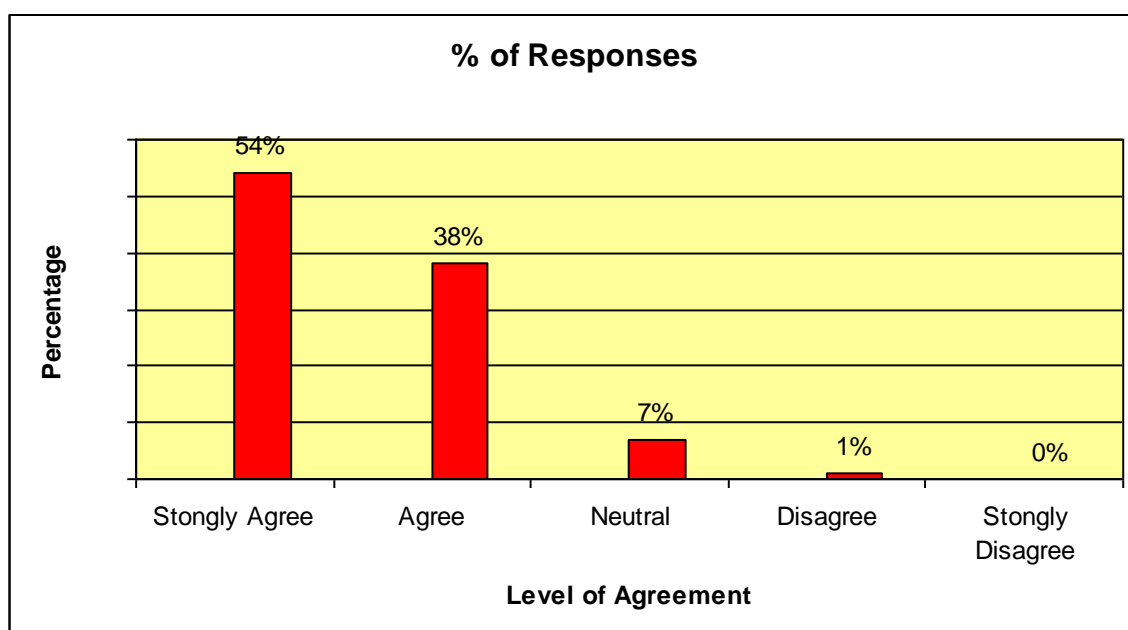
- Not all OSWTS are / pose a potential hazard
- OSWTS's need to be addressed as a source of pollution
- Depends on location, construction and maintenance
- There is a lack of knowledge on their use and maintenance. They are not used as intended
- Better enforcement and meaningful regulation required
- Enforced maintenance required
- Discharges from local authority systems pose a much greater hazard

There was a response rate of 88% in the strongly agree or agree options for this particular question and this clearly demonstrates that professionals in the on-site wastewater industry feel that OSWTS's are a potential environmental hazard. In the 11 questionnaires where additional comments were provided, it is notable that 4 referred to maintenance as being important while 3 others suggest the need for enforcement, regulation or system improvement.

### Response to Question 3

Question 3: The performance and management of OSWTS's is a significant problem in Ireland at present

**Table 7.3: Summary of Responses to Question Three from Questionnaire**



The additional comments that were made in relation to this question are as follows;

- There should be a standard list of OSWTS designs and on-site assessors should choose from this list only so as to provide consistency
- The management of the construction phase of OSWTS is a problem
- Not all systems are problematic
- There needs to be more control on annual maintenance by local authorities
- This performance of OSWTS depends on location, construction and maintenance
- Most OSWTS's work satisfactorily if maintained properly
- Lack of knowledge on the use and maintenance of systems and they are not used as intended
- Better enforcement is required for operation and maintenance
- The lack of regulation is the significant problem
- Better follow up by local authorities on maintenance and provision of more funds

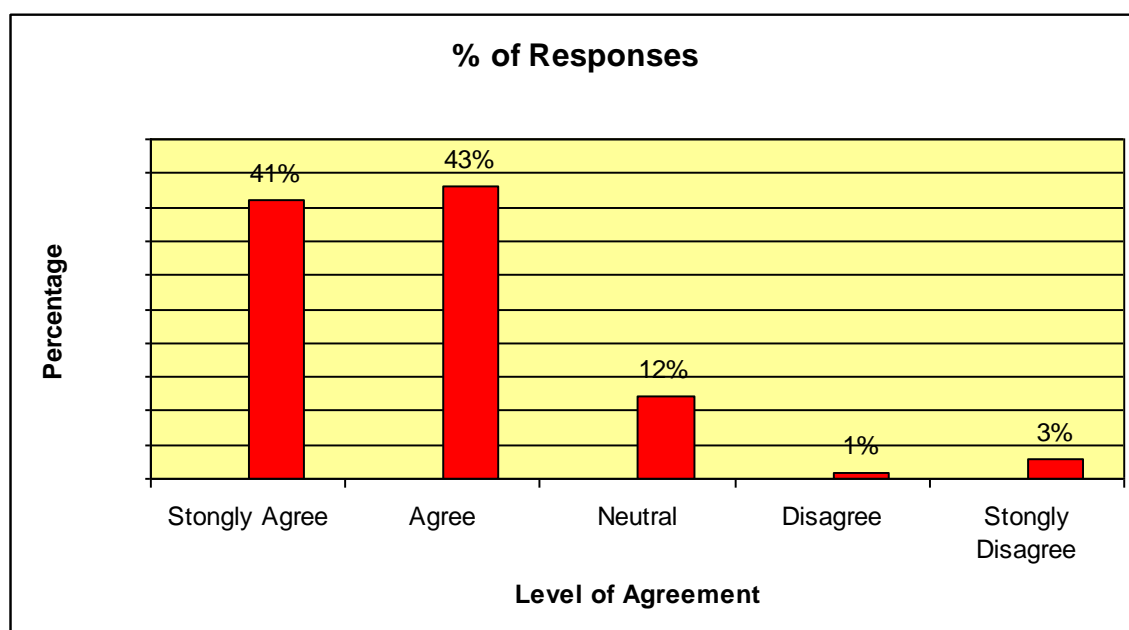


There was a response rate of 92% in the strongly agree or agree options for this particular question and this clearly demonstrates that professionals in the on-site wastewater industry feel that OSWTS's is a significant problem in Ireland at present. 10 of the respondents provided additional comments for this question and on this occasion 6 of the respondents mentioned maintenance as a specific issue of concern. Enforcement, regulation and management of systems is mentioned in 4 of the responses.

#### Response to Question 4

Question 4: Homeowners should be held responsible for the performance and management of their OSWTS as directed by the Water Services Act, 2007

**Table 7.4: Summary of Responses to Question Four from Questionnaire**



The additional comments that were made in relation to this question are as follows;

- OSWTS's should be monitored in all aspects of construction and maintenance
- Some form of financial assistance needs to be provided for older systems

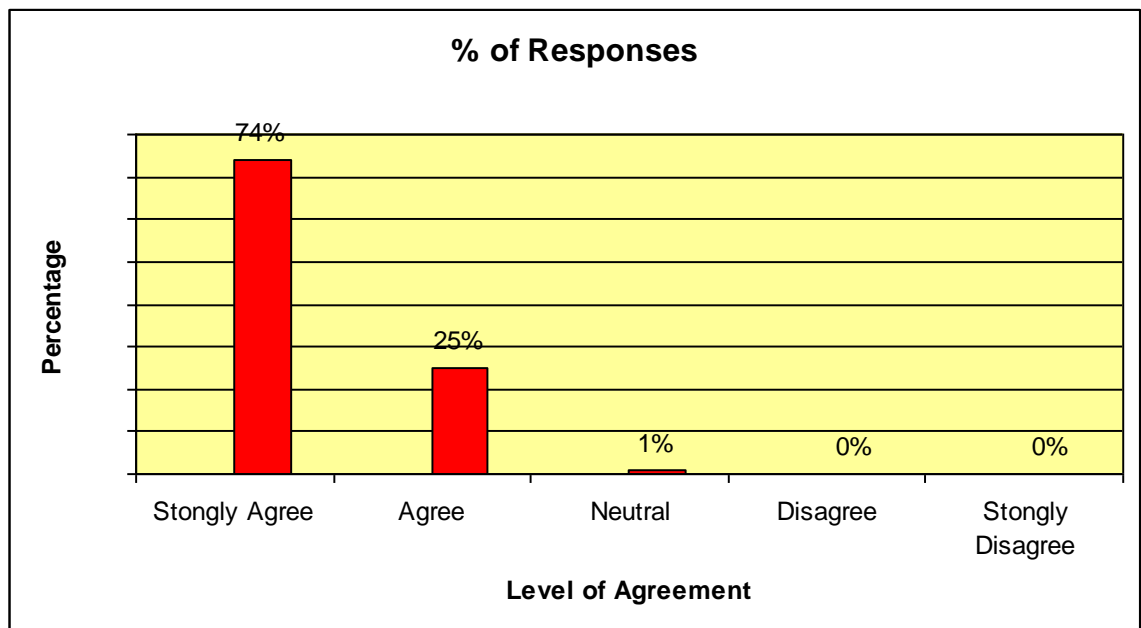
- Homeowners need help and education
- Homeowners should only be held accountable if they have been given prior financial assistance and expertise to design and maintain the OSWTS
- Others have responsibilities too
- They must be educated to the requirements of the Water Services Act, 2007
- Homeowners need to be educated on how their system works
- The 'polluter pays' principle should apply
- Depends on the relevant regulations when the OSWTS was installed
- Local authorities, EPA, site assessors and installers should be involved in educating homeowners
- The registration of systems needs to be undertaken
- They may have no knowledge on OSWTS's
- Manufacturers should also hold responsibility
- There should be a balance of responsibility between homeowner and system supplier / installer for new systems
- There should be more inspections by local authorities to check on performance and maintenance
- Older systems should not be regulated in the same way as more modern systems

There was a response rate of 84% in the strongly agree or agree options for this particular question and this illustrates that professionals believe that homeowners should be held responsible for OSWTS performance and management. In 16 of the returned survey questionnaires there were additional comments provided and 4 of these referred to education of homeowners, while others referred to a lack of knowledge as being a contributory factor in the poor performance and management of OSWTS's. There was also 4 references to others holding some responsibility to ensure OSWTS's performed properly and this included system installers, manufacturers and local authorities.

### Response to Question 5

Question 5: There is an urgent need for homeowners to improve their knowledge and understanding of the on-site wastewater treatment process and knowledge of their roles and responsibilities.

**Table 7.5: Summary of Responses to Question Five from Questionnaire**



The additional comments that were made in relation to this question are as follows;

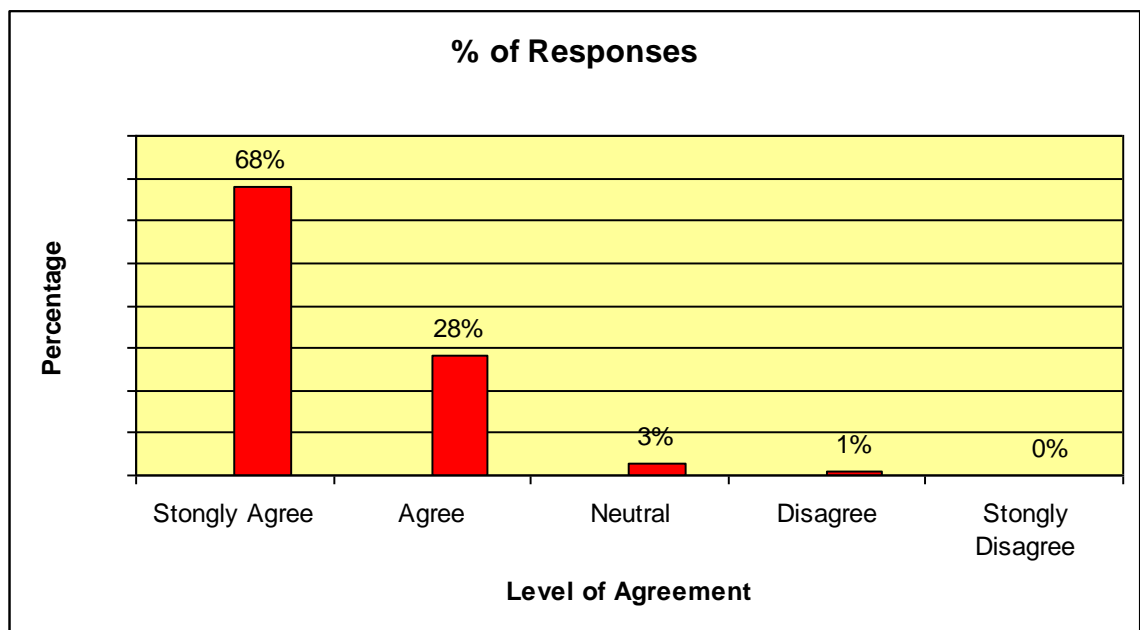
- Education should be made available
- Education needs to start from national school onwards
- Homeowners need education on how their systems should work
- Outreach programs with communities in high risk areas to provide information
- Public information campaign required
- Council booklets and web-sites
- Education at school level

There was a response rate of 99% in the strongly agree or agree options for this particular question and this overwhelmingly confirms that homeowners need to be improve their understanding and knowledge of OSWTS's as well as their knowledge of their roles and responsibilities. There were 7 respondents who provided additional comments or suggestions and in 4 of these there was a reference to education and 2 referred to the provision of information.

#### Response to Question 6

Question 6: Existing guidance for homeowners in relation to OSWTS's has been ineffective in the transfer of knowledge and understanding

**Table 7.6: Summary of Responses to Question Six from Questionnaire**



The additional comments that were made in relation to this question are as follows;

- Most people don't have a clue what it's about
- Homeowners need to be educated on how their systems work
- "Fit it and forget it" is the attitude in Ireland
- Homeowners only think about their OSWTS when they have a problem
- Generally homeowners don't understand the requirements

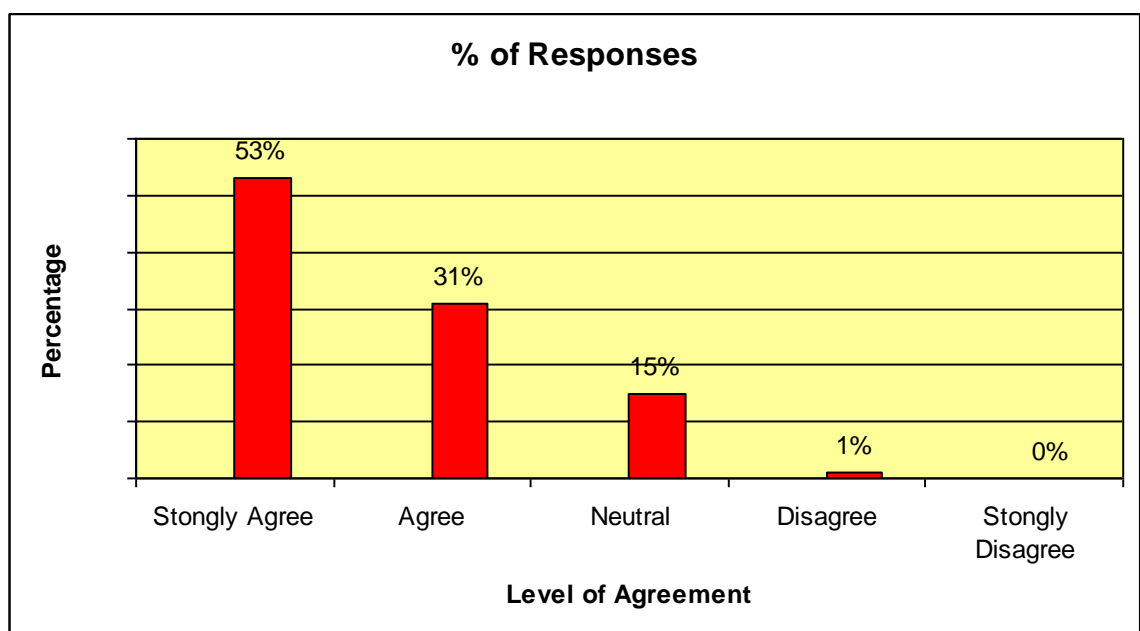
- Why should guidance for professionals be responsible for knowledge transfer and understanding to homeowners. The education of homeowners is a different thing.

There was a response rate of 96% in the strongly agree or agree options for this question and hence this clearly demonstrates that existing guidance is ineffective for educating and informing homeowners in relation to their OSWTS. The additional comments display a variety of insights from a lack of concern to a lack of understanding on the part of homeowners. The final comment is somewhat more poignant whereby existing guidance is deemed to be only for professionals and not actually for homeowners at all. The education of homeowners is deemed to require its own specific education campaign.

#### Response to Question 7

Question 7: A significant number of OSWTS's are poorly designed, operated and maintained in your area

Table 7.7: Summary of Responses to Question Seven from Questionnaire



The additional comments that were made in relation to this question are as follows;

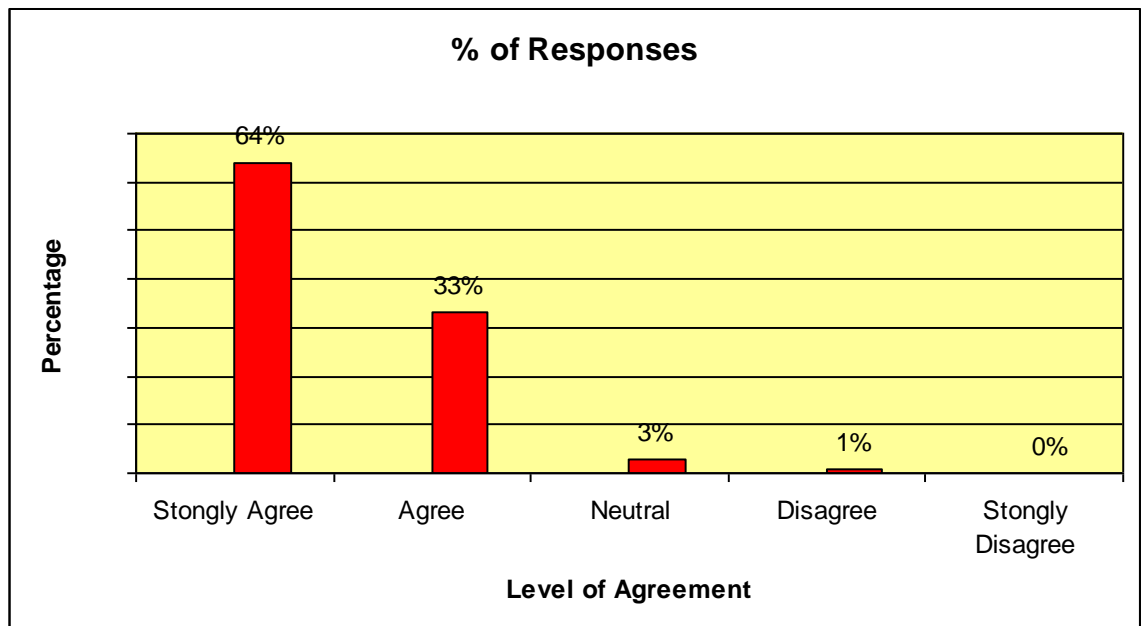
- Mandatory maintenance contracts are required
- This is an enforcement issue and should be done by the local authority

There was a response rate of 84% in the strongly agree or agree options for this question but the neutral rate did reach 15%. There were only 2 additional comments to this question and they suggested mandatory maintenance contracts and the need for enforcement in relation to poorly performing and managed OSWTS's.

#### Response to Question 8

Question 8: OSWTS's are usually not serviced properly or maintained in accordance with the design specifications or planning conditions

**Table 7.8: Summary of Responses to Question Eight from Questionnaire**



The additional comments that were made in relation to this question are as follows;

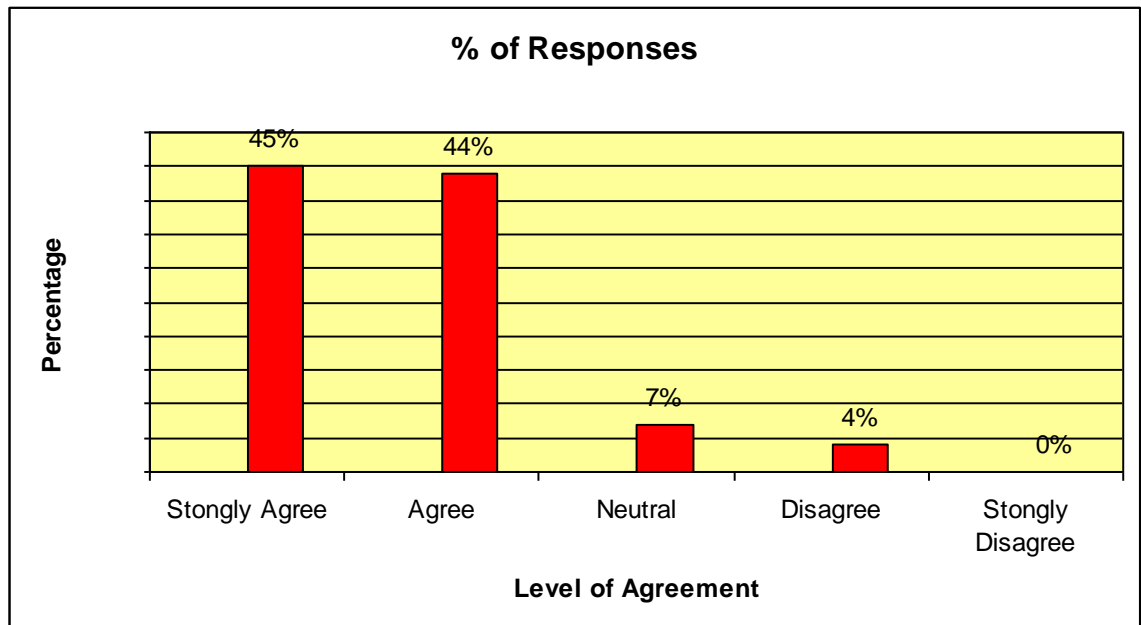
- Homeowners need to be educated in how their system works so that they understand what is required of them
- Mandatory maintenance contracts are required
- This is an enforcement issue and should be properly enforced

There was a response rate of 97% in the strongly agree or agree options for this question and there were just 3 additional comments. One referred to the need for education while the others referred clearly to enforcement of mandatory maintenance of OSWTS's.

#### Response to Question 9

Question 9: Many homeowners do not realise that OSWTS's require on-going maintenance at all

Table 7.9: Summary of Responses to Question Nine from Questionnaire



The additional comments that were made in relation to this question are as follows;

- They have no knowledge of their responsibilities

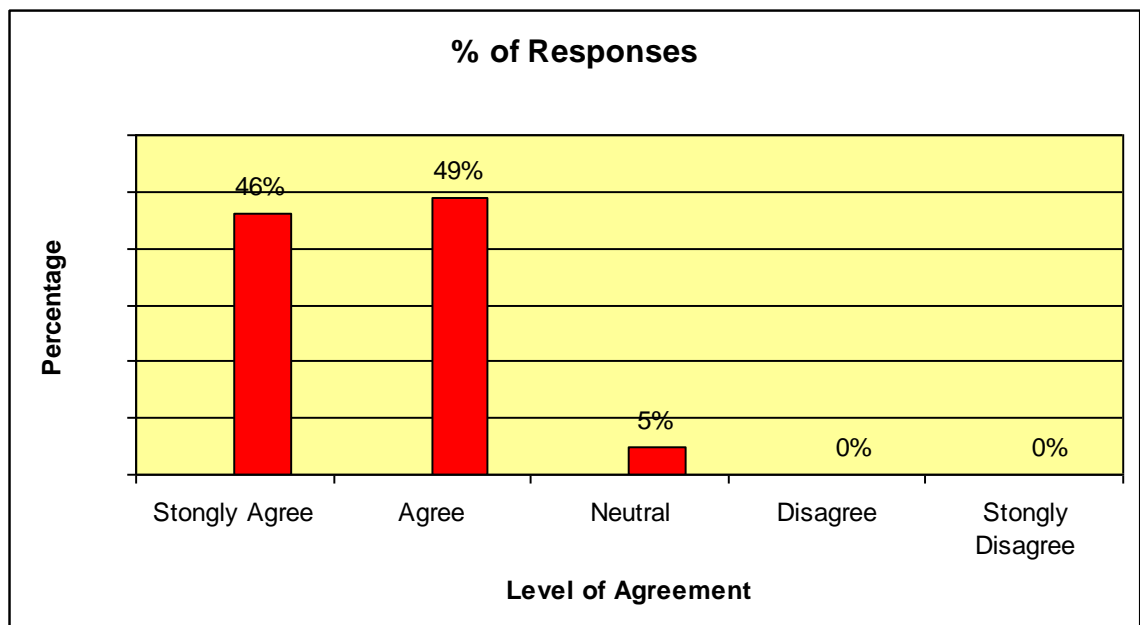
- Many don't even know where their OSWTS is, never mind knowing how to maintain it
- Homeowners know – they just refuse to pay the money for maintenance of their systems
- Due to a lack of knowledge
- Mandatory maintenance contracts are required
- They know but choose to turn a blind eye

There was a response rate of 89% in the strongly agree or agree options for this question with 7% of respondents remaining neutral. There were 6 additional comments made on this occasion and all but one referred to knowledge and knowing. In some instances this related to ignorance of the maintenance requirements while the others suggest that homeowners know the maintenance that is required but choose to overlook it.

#### Response to Question 10

Question 10: There needs to be a significant improvement in OSWTS performance if Ireland is to achieve its objectives under the WFD;

**Table 7.10: Summary of Responses to Question Ten from Questionnaire**





The additional comments that were made in relation to this question are as follows;

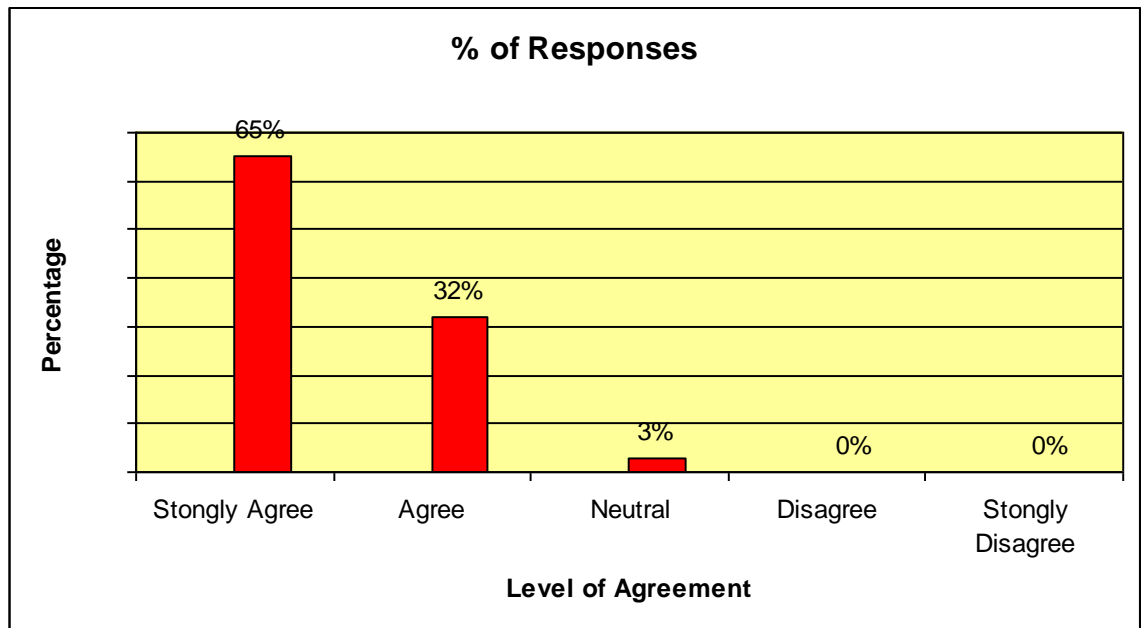
- Maintenance!!
- Strong regulation that is well enforced
- Awareness and grant assistance is what is required
- This is not the only area that requires improvement
- There are many other issues in relation to the WFD that need to be addressed
- N.B. maintenance

There was a response rate of 95% in the strongly agree or agree options for this question which confirms the consensus that there needs to be a significant improvement in the performance of OSWTS's in Ireland. The additional comments are balanced between and emphasis on maintenance of OSWTS's and identifying that there are other issues relevant to the WFD other than just OSWTS's.

#### Response to Question 11

Question 11: The education and training of homeowners is an important step in improving the performance of OSWTS's

**Table 7.11: Summary of Responses to Question Eleven from Questionnaire**



The additional comments that were made in relation to this question are as follows;

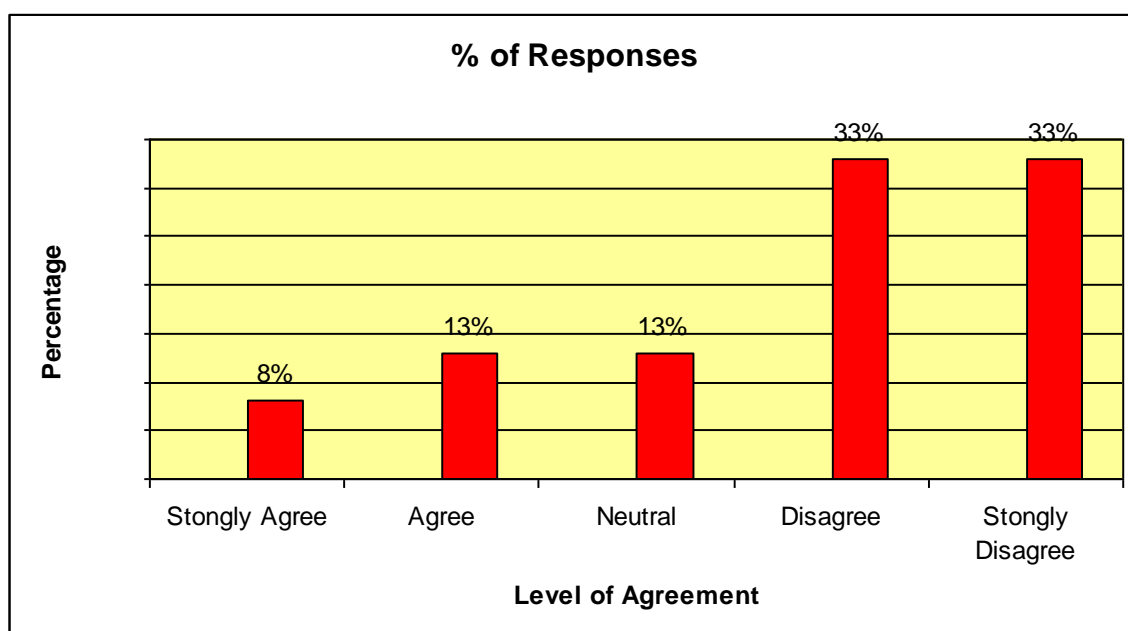
- Homeowners must be responsible for their own systems' performance
- County councillors and politicians need to be educated too
- An A4 or A5 leaflet handed out with every planning permission with bullet points for important points
- Good education needs to start early such as in schools

There was a response rate of 97% in the strongly agree or agree options for this question which illustrates strong support for an improvement in the education and training of homeowners in relation to the maintenance and management of OSWTS's. There were just 4 additional comments in this instance and these varied in nature and in what is required to improve the current issues in the subject area.

### Response to Question 12

Question 12: The inspection and monitoring of OSWTS's by Local Authorities is sufficient to educate homeowners on how to manage and maintain their OSWTS

**Table 7.12: Summary of Responses to Question Twelve from Questionnaire**



The additional comments that were made in relation to this question are as follows;

- Local authorities will not educate homeowners
- The inspection of OSWTS's will help to focus the mind but more needs to be done in relation to education
- Homeowners need to be responsible for their system
- Cannot assign responsibility for education to any one sector such as the local authority
- The local authorities have insufficient staff to educate homeowners
- It may concentrate their minds a bit
- Only if the inspections actually happen

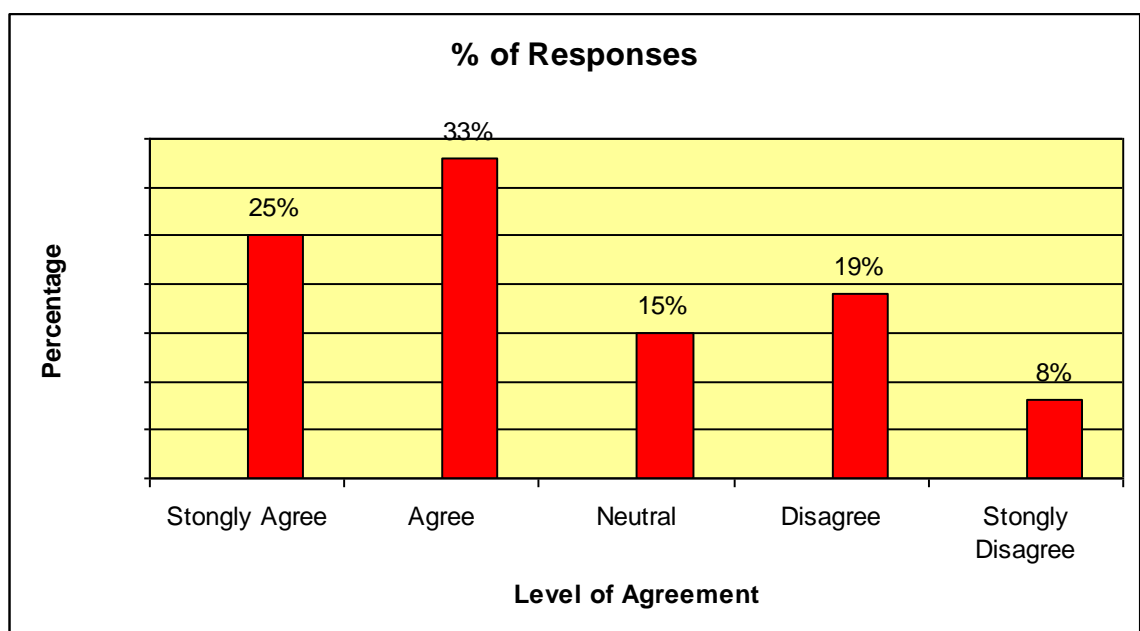
- Education required outside the remit of local authorities

There was a response rate of 66% in the disagree or strongly disagree options for this question which suggests that there is limited confidence in the proposed inspection regime being a suitable vehicle to educate homeowners on how to better manage and maintain their OSWTS. Nevertheless, 21% of the responses were in the agree or strongly agree options, so there is not an overwhelming consensus that the local authority inspections will not provide education to homeowners. The additional comments point to lack of resources in the local authorities as a barrier to providing the education and training of homeowners as well as there being a need for other mechanisms other than local authorities to educate homeowners in relation to OSWTS's.

#### Response to Question 13

Question 13: The cost of having OSWTS's services and maintained is prohibitive for homeowners and leads to a lack of necessary works being undertaken

Table 7.13: Summary of Responses to Question Thirteen from Questionnaire



The additional comments that were made in relation to this question are as follows;

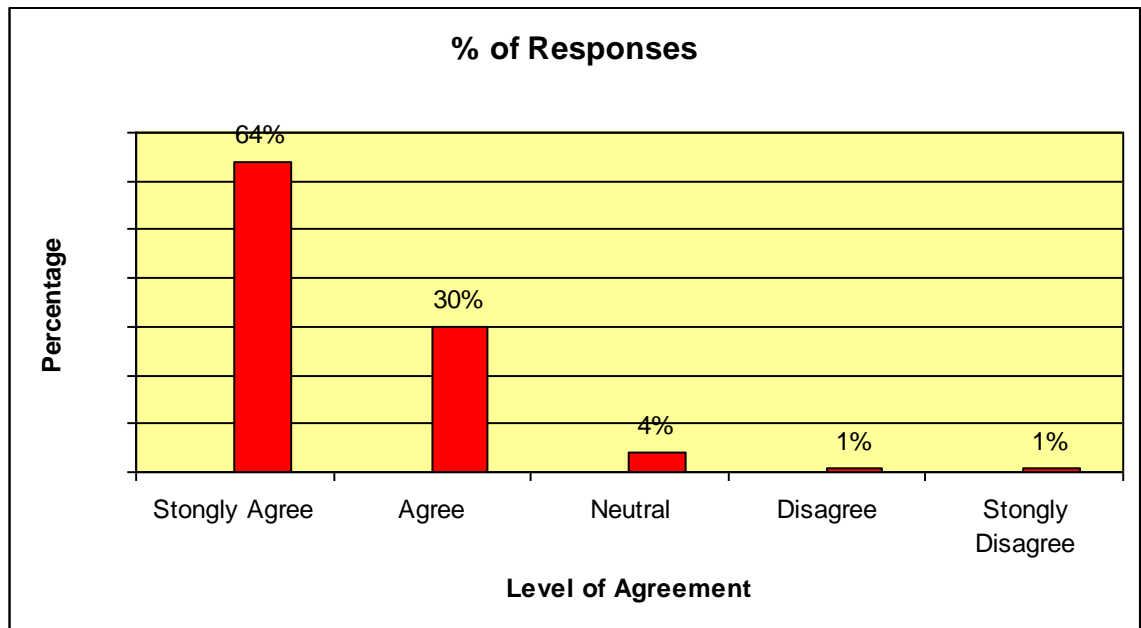
- Licensed companies should be franchised to undertake maintenance of on-site systems
- The cost of having an OSWTS serviced and properly maintained is not excessive. The behaviour of homeowners is that the system isn't important and "out of sight – out of mind".
- The cost is not prohibitive but there is a lack of necessary works
- There is no incentive for homeowners to properly maintain their systems
- Cost should not be an excuse
- Maintenance needs to be a condition of planning and adhered to

There was a very balanced response to this question across the range from strongly agree to strongly disagree. This illustrates that professionals in the OSWTS industry have varying opinions on the matter of cost and whether this is a barrier to the proper management and maintenance of OSWTS's.

#### Response to Question 14

Question 14: A simple and easy to understand knowledge model that summarises the relevant legislation and guidance in relation to OSWTS's and that helps homeowners to understand their legal responsibilities and obligations towards OSWTS's would be useful

**Table 7.14: Summary of Responses to Question Fourteen from Questionnaire**



The additional comments that were made in relation to this question are as follows;

- This needs to be easy to understand, as much of the guidance for OSWTS's is hard to understand
- This would end up in the bin as there would be no incentive for homeowners to use it
- This is not a simple situation and a booklet through the letterbox will not work
- This should be used in conjunction with inspections of the OSWTS
- Legislation and enforcement required to support this
- This should include a strong emphasis on the benefits to the environment of good compliance and maintenance

There was a response rate of 94% in the strongly agree or agree options for this question which supports and justifies the need for this research project. The development of the homeowner is seen as useful in the endeavour of educating and informing homeowners on how to better manage and maintain their OSWTS.

There were a number of additional comments in this instance ranging from suggestions that the model would end up in the bin to the need for legislation to support the objective of the model and it becoming part of the OSWTS inspection regime.

#### **7.2.4.1 Additional Comments from Questionnaire at IOWA Conference 2013**

The following are the summarised additional comments from the analysed questionnaires. As discussed in sections 4.5.1 & 4.5.3 the questionnaire provided an opportunity to validate and shape the adoption of modelling by affording participants an option to suggest inclusions to the knowledge model or identify alternative mechanisms to educate and inform homeowners on OSWTS management and maintenance. A total of 20 respondents or 22.47% of the sample completed the additional comments section with the following comments being provided;

- Education of homeowners should take place in advance of the inception of the inspection regime for OSWTS's
- Information campaign similar to that undertaken for the Building Energy Rating process for OSWTS's
- A television advertisement campaign
- The EPA Code of Practice is very hard to understand and very technical and not suitable to educate homeowners
- Booklet / fliers / leaflets should be delivered to all homes outlining requirements of new legislation and consequences of non-compliance. Also should include typical maintenance requirements for OSWTS's

- An information document / booklet could be distributed with planning permission documents as an information tool and also serve as a service record for the OSWTS for maintenance and de-sludging of the system
- All forms of media should be used to educate the homeowners on their responsibilities
- Information to be provided in conjunction with communication about registration requirement of systems
- More effort required to educate communities in their approach to environmental protection is required
- Education of homeowners is required but must be done in a careful manner
- It is the responsibility of all people involved in the wastewater industry to educate homeowners from site assessors, system suppliers & installers etc.
- National advertising campaign required similar to that used in recent drink-driving campaigns
- Education must instil the thought that you are responsible for the treatment of your own wastewater
- The issue of wastewater from OSWTS's needs to be prioritised in the same way as re-cycling is for household waste
- More information to be available on web-sites
- There is an under-utilisation of enforcement mechanisms such as the planning acts, building control acts. Incorrectly designed and constructed



OSWTS's should be deemed "illegal development" and the education of professionals is also important

- Start an educational programme in schools so that the next generation of homeowners are more responsible towards OSWTS's
- Provide a web-site that is well advertised and informs people of the effects on health of OSWTS's and outlines penalties for pollution
- Training should be provided to homeowners by the companies that supply OSWTS's
- Enforce maintenance contracts from OSWTS suppliers so that homeowners have to comply with manufacturers recommendations
- All local authority web-sites should have OSWTS information in the form of a national education campaign
- The EPA Code of Practice is very technical and hard to understand

### **7.2.5 Summary of Findings from the Questionnaires**

The purpose of the questionnaires as discussed in section 4.5.1 was to verify that the findings in the literature review as set out in Chapter Two are relevant and correct. The practice based experience of the IOWA committee as discussed in sections 5.2.2 & 5.2.3 unreservedly confirm the findings of the literature review and the researcher's own practical experience. The questionnaires provided an opportunity to validate the topics that were chosen for inclusion in the model from practitioners across Ireland and to triangulate the findings of the qualitative research with quantitative research (King, 2004). In summary there was consensus between the findings of the literature review in Chapter Two and the findings of the questionnaires in this Chapter. Furthermore, the findings of the questionnaires

from a national perspective also reflect the practice based research discussed in section 5.4 so there is again consensus that the issues proposed for inclusion in the knowledge model are valid, necessary and correct and therefore validate the content of the knowledge model. Within the additional comments section of the questionnaire however as outlined in 6.3.4.1 there were a wide variety of suggestions and these may form the basis for future research and will be discussed later in this Chapter.

### **7.3 Structured Interviews with Industry Experts**

As discussed in section 7.2 the IOWA is currently the only representative organisation for practitioners in the on-site wastewater industry in Ireland. Members come from a diverse professional background that includes architects, engineers, surveyors, site assessors, academics, legislators, installers and on-site system manufacturers. Section 4.5.2 has discussed the merit of undertaking the structured interviews with the executive committee of the IOWA and the justification for same. The critique of adopting structured interviews has been extensively examined also in section 4.5.2 and to summarise the key reasons are to ensure that the best use of limited time is used and that all participants are asked direct questions about the homeowner. The concern of adopting semi-structured or unstructured interviews at the validation stage would have been that the interviews would have drifted onto wider environmental matters and not be exclusively focused on the homeowner model that is being developed.

#### **7.3.1 Structured Interview Objectives**

The objectives of the structured interviews can be summarised as follows;

- To identify if the topics outlined in the knowledge model are relevant for homeowners in relation to their OSWTS's.

- To determine if the interviewees believe that homeowners have been provided with sufficient information on the topics in the model.
- To gauge interviewee's opinion on the use of the graphical presentation of data rather than the use of text.
- To seek opinion on how useful the interviewees believe the knowledge model will be in practice.
- To seek explicit opinion on any errors or omissions in the model and general suggestions on alterations or amendments that may improve the knowledge model or any additional comments.

### **7.3.2 Interview Process & Practical Issues**

The executive committee of the IOWA is made up of members that are based across Ireland. From a practical perspective this could have necessitated quite some travel and expense in undertaking the structured interviews. Accordingly, in consultation with the IOWA executive committee the decision was taken that the interviews could take place at one of the IOWA committee meetings where all committee members would be in attendance. One of the concessions that had to be made for practical reasons was that the interviews would be limited to twenty minutes or thereabouts so that committee members were not unduly delayed on the day. This concession further justified the adoption of structured rather than semi or unstructured interviews in light of the time constraint. As part of the agreed concession to the twenty minute duration for the interviews, the executive committee agreed to peruse the homeowner model in advance of the interview. Therefore the twenty minute duration of the interviews could be reserved for questioning and to achieve the objectives of the evaluation. A number of practical issues arose in the process of undertaking the interviews on the day of the IOWA executive committee meeting. Unfortunately one of the members was unable to

attend due to ill health on the day and the researcher was unable to schedule an alternative date for interview with this member. While the time keeping on the day was intended to be quite rigid and structured, a number of the participants were inclined to drift off into discussing issues not part of the evaluation process and this consumed some of the allocated time set aside for the structured questions.

### **7.3.3 Structured Interview Questions**

The development of interview questions is a complex and sophisticated process (Yin, 2010). The objectives of the structured interviews are set out in section 6.2.1 and a practical issue was achieving these five objectives in a twenty minute timeframe. In reality only one question could be asked for each objective area with a view to a four minute discourse on that objective area with a very brief opportunity for closing comments by the researcher and the interviewee at the end. The structured questions that were developed in light of this time constraint are the following;

- i) Are the topics contained in the model relevant for homeowners to know and will they educate and influence the homeowner on their responsibilities in relation to their OSWTS?
- ii) Is there a sufficient amount of detail on each of the topics for the homeowner to know their role and responsibilities in each of the topic areas and to know when they need to seek professional advice and/or assistance with their OSWTS?
- iii) Is the use of graphics in your opinion an effective means of providing a sufficient amount of knowledge to the homeowner without falling into the trap of going into broad technical detail that could be beyond the comprehension of a homeowner?

- iv) In your own opinion how useful do you believe this knowledge model will be in practice and why?
- v) What errors or omissions do you feel are evident from the knowledge model and what changes would you make to it? Have you any additional comments?

### **7.3.4 Analysis of Findings from Structured Interviews**

A thematic analysis strategy was adopted for the analysis of the data collected from the structured interviews undertaken to evaluate the homeowner as discussed in section 4.5.2. In this approach the comments and responses that relate to the specific questions in the structured interviews have been grouped together (King, 2004) and the process of analysing this qualitative data follow the steps outlined by Gillham (2000) as follows;

1. Transcription of the interview: The researcher produced a transcript of the interview responses from the tape recordings.
2. Definition of priority categories: The researcher devised a set of categories to reflect the structured interview questions and the issues from the homeowner.
3. Coding process: The researcher went through the transcripts manually identifying the key themes related to the evaluation. This involved reading and coding the interview transcripts. As the themes were identified, they were highlighted with a colour and each theme was then assigned to the pre-determined subject category.
4. Revise transcripts: The researcher re-read the interview transcripts to ensure that all themes and categories were correctly coded and that nothing was omitted, incorrectly coded or over-emphasised

5. Presenting the findings: The researcher reported the findings and provided quotes from the respondents to support them. A number of findings are presented in tabular format as a means of facilitating the presentation of the qualitative data.

### **7.3.5 Factors Identified from the Structured Interviews**

The interviewees that participated in the structured interviews are elected members of the IOWA Executive Committee and in that regard it is not possible to retain their exclusive anonymity. However, for the purposes of the interviews their responses are noted as 1 – 4 only and there is no association between their names and the responses that they provided. The tape recordings would also be destroyed upon completion of the research. This was informed to the participants and all were satisfied that this was acceptable.

#### **7.3.5.1 Question One Responses from Interviews**

To identify if the topics outlined in the knowledge model are relevant for homeowners in relation to their OSWTS's the interviewees were asked the following question;

*“Are the topics contained in the model relevant for homeowners to know and will they educate and influence the homeowner on their responsibilities in relation to their OSWTS?”*













The aim of this question is to determine if the topics contained in the knowledge model are relevant. The literature review in Chapter Two was explicit that there is a significant shortcoming in homeowner knowledge in relation to OSWTS's but the literature review did not identify specifically what these shortcomings are. The practice based experience has informed the research on the issues that need to be addressed and the responses to this question from the industry experts are vital to

properly evaluate the model. The key priority terms from Question One are as follows;

- *Topics & Relevance*
- *Educate*
- *Influence*

Table 6.1 summarises the responses from the interviewees to Question One;

Table 7.14: Summary of Responses to Question One from Structured Interviews

| <i>Priority Categories from Question One</i>  | <i>Yes</i>  | <i>No</i>   | <i>Not Sure</i>   |
|---|---|---|---|
| <i>Are the topics in the model relevant to homeowners?</i>                            |   |   |   |
| <i>Interviewee 1</i>  |  |   |   |
| <i>Interviewee 2</i>  |  |   |   |
| <i>Interviewee 3</i>  |  |   |   |
| <i>Interviewee 4</i>  |  |   |   |
| <i>Will the homeowner be educated by the topics in the on their responsibilities?</i> |   |   |   |
| <i>Interviewee 1</i>  |  |   |   |
| <i>Interviewee 2</i>  |  |   |   |
| <i>Interviewee 3</i>  |  |   |   |
| <i>Interviewee 4</i>  |  |   |   |
| <i>Will the homeowner be influenced by the topics to change their behaviour?</i>      |   |   |   |
| <i>Interviewee 1</i>  |  |   |   |
| <i>Interviewee 2</i>  |   |  |   |
| <i>Interviewee 3</i>  |   |   |  |
| <i>Interviewee 4</i>  |  |   |   |

There was consensus between all of the interviewees that the topics in the model are relevant for homeowners to know and that they should have knowledge of these topics or have a mechanism to easily find out about them. The knowledge model was well received by all of the interviewees who each confirmed that the homeowner would undoubtedly be educated by its contents. There was one exception this where Interviewee No. 3 suggested that some homeowners are from a technical or perhaps engineering background and they would most likely have a technical or practical knowledge already. Nevertheless, Interviewee No. 3 qualified this by saying that having a recording method as part of the model of important dates and contact details for recording purposes would be useful and practical.

#### **7.3.5.2 Question Two Responses from Interviews**

The second structured question for the interviews seeks to identify if there is sufficient detail on each of the topics in the knowledge model so that the homeowner knows their role and responsibilities. There is a second stage to this question whereby the interviewee is asked if the homeowner will be aware when and if they need to seek professional assistance of advice in relation to their OSWTS.

Question Two is as follows;

*“Is there a sufficient amount of detail for the homeowner to appreciate their role and responsibilities in each of the topic areas and to know when they need to seek professional advice and/or assistance with their OSWTS?”*













The priority terms from Question Two are as follows;

- *Sufficient amount of detail on each of the topics*
- *Will the homeowner know their role and responsibilities*



- Will they know when to seek professional advice or assistance with their OSWTS

**Table 7.15: Summary of Responses to Question Two from Structured Interviews**

| <b>Priority Categories from Question Two</b>   | <b>Yes</b>  | <b>No</b> | <b>Not Sure</b>  |
|--|---|-----------|--|
| <b><i>Is there a sufficient amount of detail on each of the topics?</i></b>                  |   |           |  |
| <b><i>Interviewee 1</i></b>  |    |           |  |
| <b><i>Interviewee 2</i></b>  |   |           |   |
| <b><i>Interviewee 3</i></b>  |    |           |  |
| <b><i>Interviewee 4</i></b>  |    |           |  |
| <b><i>Will the homeowner know their role and responsibilities?</i></b>                       |   |           |  |
| <b><i>Interviewee 1</i></b>  |    |           |  |
| <b><i>Interviewee 2</i></b>  |   |           |  |
| <b><i>Interviewee 3</i></b>  |  |           |  |
| <b><i>Interviewee 4</i></b>  |  |           |  |
| <b><i>Will they know when to seek professional advice or assistance with the OSWTS's</i></b> |   |           |  |
| <b><i>Interviewee 1</i></b>  |  |           |  |
| <b><i>Interviewee 2</i></b>  |  |           |  |
| <b><i>Interviewee 3</i></b>  |  |           |  |
| <b><i>Interviewee 4</i></b>  |  |           |  |

Once again there was general consensus between the interviewees on the components of this question with the exception of Interviewee No. 2 who expressed a concern that the knowledge model may be too basic and general for some homeowners. In commenting that the level of detail was most likely sufficient for the majority of homeowners, there may be a certain element of homeowners that would like an opportunity to gain a further insight into the on-site wastewater process.

### 7.3.5.3 Question Three Responses from Interviews













The third structured question for the interviews seeks to determine the interviewee's opinion on the use of a graphic means to convey knowledge rather than the usual textual guidance. The literature review on modelling techniques in Chapter Three was explicit on the benefits of graphic representation in certain circumstances (Chapin, 1971; Cook & Berrenberg 1981, Harris, 1999; Tah, 2004; Glassey, 2009 & Lee, 2011) and specifically in circumstances where long winded text could lose the interest of the reader as suggested by Chapin (1971). The literature review in Chapter Two identified that there is no specific homeowner guidance currently in place in Ireland for OSWTS's and that this is one of the drivers for the production of the homeowner model. This issue was brought to the attention of the interviewee in the introductory discussion.

*“Is the use of a graphic model in your opinion an effective means of providing a sufficient amount of knowledge to the homeowner without falling into the trap of going into broad technical detail that anecdotally could be beyond the comprehension of a homeowner?”*

The priority terms from Question Three are as follows;

- Is the graphic model effective to provide sufficient knowledge
- Does the flowchart avoid too much detail
- Could too much detail confuse homeowners

Table 7.16: Summary of Responses to Question Three from Structured Interviews

| <i>Priority Categories from Question Three</i>                            | <i>Yes</i>  | <i>No</i> | <i>Not Sure</i>   |
|---|---|-----------|---|
| <b><i>Is the flowchart effective to provide sufficient knowledge?</i></b> |   |           |   |
| <i>Interviewee 1</i>  |    |           |   |
| <i>Interviewee 2</i>  |   |           |    |
| <i>Interviewee 3</i>  |    |           |   |
| <i>Interviewee 4</i>  |    |           |   |
| <b><i>Does the flowchart avoid too much detail?</i></b>                   |   |           |   |
| <i>Interviewee 1</i>  |    |           |   |
| <i>Interviewee 2</i>  |    |           |   |
| <i>Interviewee 3</i>  |    |           |   |
| <i>Interviewee 4</i>  |    |           |   |
| <b><i>Could too much detail confuse homeowners?</i></b>                   |   |           |   |
| <i>Interviewee 1</i>  |  |           |   |
| <i>Interviewee 2</i>  |   |           |  |
| <i>Interviewee 3</i>  |  |           |   |
| <i>Interviewee 4</i>  |  |           |   |

Interviewee No. 2 again expressed a concern that some homeowners may find the knowledge model limited in the amount of knowledge that it could convey but was satisfied as were all other interviewees that there was not too much detail in the model. In relation to the third priority term Interviewee No. 2 outlined an opinion that sometimes not providing enough information or knowledge could be as damaging as providing too much. At this point a suggestion was made by Interviewee No. 2 that the model may benefit from having a reference to the EPA Code of Practice (2010) or the National Inspection Plan (2013) for those homeowners who wished to gain further knowledge than what is provided by the model.

#### 7.3.5.4 Question Four Responses from Interviews

The fourth question in the structured interviews was in two distinct stages with the first seeking an opinion from the interviewee on how useful they felt the model would be and then moving on to ask why they felt that this would be the case.

*“In your own opinion how useful do you believe this homeowner model will be in practice and why?”*

The summary of the interviewee responses to this question are set out in the following citations;

##### Interviewee No. 1

*“The model should be a useful tool for the homeowner and the fact that it is specific to the homeowner is a very good idea.”*

*“There is no doubt that the coloured design of the document will make it more eye-catching and interesting for the reader.”*

*“It is useful to have a recording mechanism for maintenance and de-sludging but my concern is that the homeowner will mislay or lose the model as so often happens with manuals and so on.”*

##### Interviewee No. 2

*“The model is a novel idea and it does contain the relevant issues that a homeowner needs to be aware of. I would have concerns though that it will not be read or even looked at. Unless you (the author) are going to visit every house to introduce the concept it may just become another piece of junk-mail”.*

*“The problem that I see for your model is that many homeowners do actually know what they should be doing, they just choose not to do any maintenance or repairs to their systems. This is an enforcement issue and until people*

*(homeowners) see fines and penalties being imposed there will be little or no change.”*

*“Perhaps now that the National Inspection Plan is in place for on-site systems there may be cause for optimism that your model will arrive when homeowners have questions and therefore reach a captive audience”.*

#### Interviewee No. 3

*“I think the book (model) is a very good idea and it should be a success”.*

*“The model reminds me of a little bit of a board game like Monopoly © whereby you land on a certain box and you have to move to somewhere else. This I think will make it (the model) more interesting to the homeowner to use and out of curiosity they will be entertained by the bright colours”.*

*“Any knowledge will help to improve the way homeowners manage their septic tanks (OSWTS’s) if they take an interest to do so. The example I would use is that people know that they should clean their house when they are trying to sell it. You will still hear estate agents complain though about untidy houses and this is the same for OSWTS’s)”*

*“All we can do is try to make it clear to people that they have to maintain their systems (OSWTS’s) properly. If they bury their head in the sand unfortunately there is nothing you can do about it”.*

#### Interviewee No. 4

*“I believe that the model has a great chance of success so long as the momentum is there for people to take and interest in their OSWTS. If you had done this a few years ago it wouldn’t have gotten off the ground because people just didn’t care”.*

*“The model looks well, and is bright and eye-catching so it is likely to stand out from other leaflets and things”.*

*“There is an appetite from the public at the moment for information about septic tanks (OSWTS’s) as people get to grips with the new legislation. The timing and the delivery of the book are important and if you can get it delivered soon it will have a bigger impact”.*

### **7.3.5.5 Question Five Responses from Interviews**

The fifth and final question encompasses an open question for interviewee to comment upon changes that they would make to the model. As in the case of Question Four the results have been provided as citations as opposed to tabular reflect the open nature of the enquiry. Question Five is as follows;

*“What errors or omissions do you feel are evident from the model and what changes would you make to it? Have you any additional comments”*

#### **Interviewee No. 1**

*“This is a new idea to me and I’m not used to seeing flowcharts presented like this. I can’t really say whether there is anything omitted or if anything is specifically wrong, I’d really say you will only be able to tell that when you speak to homeowners”.*

*“Like I said about the errors and omissions, I think you will only be able to tell if it works when you try it out with ordinary homeowners”.*

*“I might say if you press me for something to change in the model is that you could put in a bit more explanation on the new Inspection Plan (EPA, 2013). I accept that you have mentioned it in there (the model) but it is only a small*

*reference and this is where homeowners are going to be prosecuted if they are polluting”.*

#### Interviewee No. 2

*“I’d be happy to say that you haven’t left anything out, just that you seem to have assumed that the homeowner will only need very basic knowledge. I agree that some people will not read a manual cover to cover, but some people do. Some people are also proficient in using an index so I’d probably say that a manual might be better”.*

*“You could consider using your flowcharts in the manual that I have suggested as they are bright and eye-catching which is to be commended. I don’t believe that one (a manual or the flowchart) or the other is right or wrong but I believe that you don’t have to choose between them. There are plenty of manuals that use pictures and words in combination”.*

*“Really I would say that you should give it a go now that you have come this far but I would suggest that you keep an open mind on maybe putting in more text if people have to keep asking questions or if they have an appetite for more knowledge about their wastewater system (OSWTS)”.*

#### Interviewee No. 3

*“It looks very impressive and professionally presented so well done on that anyway”.*

*“I can’t think of any issues that are missing and you have covered all of the important points, maybe a little too briefly perhaps but that’s just a first impression to me”.*

*“You are assuming that people will find graphics easier to use and understand than words and that may very well be the case but there is a lot of arrows and*

*lines which might be more confusing than reading a paragraph of text. Did you consider using a mixture of both?"*

*"It's a very good idea to have guidance that is targeted just at the homeowner because they do need to know where they stand legally and what is expected of them from the new legislation. I'd be concerned though that the public opposition to the new registration charge for OSWTS's and the forthcoming inspections will cause some revolt but that's not something that you or I can change".*

#### Interviewee No. 4

*"No changes look necessary to me anyway and I think you have all the important points covered".*

*"It's only just a minor thing but would you consider a few photos maybe in the troubleshooting section? This could help people to understand what you mean by sludge build up and so on".*

*"I'd be confident that the knowledge model will be a huge success and lets hope that it helps to solve the OSWTS problem".*

### **7.3.5.6 Summary of Findings from Structured Interviews with IOWA Committee**

The structured interviews provided an insightful evaluation of the homeowner model that has been developed as part of this research. There was complete consensus amongst the interviewees that the findings of the literature review in Chapter Two are accurate, relevant and correct and this is reflected in Table 6.1. The need for homeowners to better understand, manage and maintain their OSWTS's is a crucial step in achieving the objectives of the WFD and to prevent on-going risks to public health and the environment from OSWTS's as discussed in section 2.3.1. Table 6.1 has identified though that there are some issues of



homeowner responsibility being a challenge to the knowledge model and that while the model may educate and inform, it may not be powerful enough to motivate a change in homeowner behaviour.

Table 7.2 affirms that the majority of participants are satisfied that there is a sufficient amount of detail in the knowledge model to provide the homeowner with sufficient knowledge with one outlining that they are not sure if the model goes quite far enough. The concept and the use of flowcharting for homeowners is addressed in Table 7.3 and again there is a majority opinion that this approach is an effective means to provide knowledge to the homeowner and complete consensus that the flowchart does not go into too much detail. However, there was again a reference from one participant that they were not sure if enough detail is provided by the model to satisfy homeowners. Sections 7.2.5.4 & 7.2.5.5 have illustrated the more general comments made by the interviewees about the model and again there is a consensus that the structure, contents and presentation of the model will be an effective model for homeowners. This part of the evaluation did raise some additional information about the contents of the model and as a consequence some refinements were made that will be discussed in section 7.5.2. The key recommendations for refinement to the knowledge model in response to the structured interviews are as follows;

- i) Reference to the EPA web-site for the benefit of homeowners seeking more information.
- ii) A further reference to the National Inspection Plan (2013) from the EPA.
- iii) Additional text on some items.
- iv) Removal of some arrows to reduce confusion as the homeowner proceeds through the knowledge model.

## **7.4 Interviews with Homeowners**

The final stage of the evaluation phase involved structured interviews with homeowners. The structured interview is an effective tool for gathering specific qualitative data that can be analysed systematically. The interviews were undertaken with a small randomly selected sample of homeowners as discussed in section 4.6.4. The interviews measured the understanding and knowledge of homeowners before and after they used the knowledge model. The development of an interview structure can be difficult and therefore a pilot test of the interview was undertaken to ensure that the questions were suitable and derived the type of data that was required to validate the knowledge model. Yin (2009) has outlined that a pilot test will help to refine the data collection plans with respect to both the content of the data and the procedures to be followed. Some of the potential problem areas for the interview questions were the justification of the sample size and the sample representation of those chosen. In this case the number of interviews completed by homeowners was quite low at five, though the researcher did adopt the snowball effect in governing the final number. Therefore, if in each interview new data was identified the research could continue until data saturation was observed. The approach justified the adoption of a low number of homeowners initially and reflected the fact that the research required more than the homeowner just answering questions and that the interview was in three phases as outlined in section 4.6.4.

### **7.4.1 Structured Interview Objectives**

The objectives of the structured interviews with homeowners can be summarised as follows;

- To identify the homeowner's baseline knowledge relating to the management and maintenance of their OSWTS.
- To introduce the knowledge model to the homeowner.

- To see how the flowchart in the knowledge model works in a real world scenario.
- To compare and contrast the differences in homeowner responses to the questions when they have the knowledge model at hand.

#### **7.4.2 Structure of the Homeowner Interviews**

The homeowners who participated in the interviews engaged with the researcher to outline and discuss their learning outcomes and to communicate how they benefited, or did not benefit from exposure to the knowledge model. In essence, the completion of these structured interviews determined how the knowledge model performed in practice and the participant ultimately scored the model based on ease of understanding, relevance and clarity. The interview of homeowners was targeted at the general public who were met at a national trade show outlined in section 4.6.4. A possible threat to the validity of this approach is that the sample is not to be a large national one but there is no explicit reason to believe that the random sample provided inconsistent responses as all the relevant on-site wastewater legislation is consistent across the country. The literature review in Chapter Two identified that the level of ground and surface water contamination from domestic wastewater is pretty consistent throughout Ireland and therefore there is no reason to assume varying levels of knowledge across the country (EPA, 2005, 2006, 2008 & GSI, 2011).

The interviews with the randomly selected homeowners proceeded in three key stages;

Stage 1:       The perspective interviewee was invited to participate in the interview and in accordance with the requirements for ethical approval a declaration was read out explaining that the interview

was entirely anonymous and that no record of the participant's personal details would be retained.

Stage 2: The researcher asked the homeowner a list of fifteen preliminary questions before the knowledge model was introduced to determine the homeowner's existing knowledge about their OSWTS and how it should be managed and maintained.

Stage 3: The researcher presented a copy of the knowledge model to the homeowner and asked them to read it carefully. There was no specific time allocated for this stage of the interview so that the homeowner could read the model at their individual pace.

Stage 4: This stage of the research involved the researcher asking the homeowner the same fifteen questions again with the homeowner being asked to refer to the knowledge model before providing their responses.

Section 7.4.3 will now outline the questions that were developed for the structured interviews with homeowners.

### **7.4.3 Interview Questions for Homeowners**

The development of the questions for the structured interviews for homeowners considered the issues that are outlined in the literature review in Chapter Two and that have been validated by both the structured interviews with the IOWA executive committee and the questionnaires that were undertaken at the IOWA annual conference as set out in Sections 5.3 and 5.4. As discussed in Section 4.5.1.0 the development of interview questions is a complex and sophisticated process as referred to by Yin (2010) the pilot testing of the questions is undertaken to ensure that the questions were clear and easily understandable by

homeowners. The pilot testing that was undertaken did not raise any issues of concern or difficulty with the interview questions and are as follows;

1. What is an on-site wastewater treatment system?
2. How do you know your system is working?
3. How often do you have to register your OSWTS?
4. What is the legislation that governs OSWTS's?
5. What should you ask your installer for if you are having a new OSWTS fitted of some repair work done?
6. Why does your OSWTS need to be de-sludged?
7. How would you know your OSWTS needs to be de-sludged?
8. What should you check before letting the contractor de-sludge your OSWTS?
9. Why do you need to keep plenty of ventilation into your OSWTS?
10. What affect will putting too much cooking fats and grease down the sink have?
11. What affect does using too much bleach or detergents in the house have?
12. How would you know that your OSWTS has broken down or if there is a problem?
13. Who would you contact if you had a problem with your OSWTS?

14. What will happen if your system fails the forthcoming inspection by your local County Council?
15. Why is it important to maintain a record and receipts for any maintenance you carry out to your OSWTS?

When the pilot interviews were completed the participants were asked if there was any ambiguity or confusion from the questions. All three pilot interviewees confirmed that they were comfortable with the phraseology of the questions and that there was no need for amendment or re-wording in their opinion. The next section of this Chapter will now discuss the findings and results of the interviews with homeowners.

#### **7.4.4 Homeowner Interviews**

The procedure and justification for undertaking validation interviews with homeowners has been discussed in detail in Section 4.6.4. The knowledge model that has been developed in this research is targeted specifically at the audience of homeowners as discussed in Section 6.1. In light of the target audience being homeowners the validation phase would undoubtedly benefit from testing the usefulness of the knowledge model with a sample of homeowners. Chapter Four considered varying research methods with the use of structured interviews being identified as the most appropriate as the nature of the interview ensures that valuable time is not consumed discussing issues not specifically related to the knowledge model. As outlined earlier in section 7.4.2 the randomly selected homeowners were initially asked 15 questions in relation to their OSWTS with a particular focus on issues relating to their understanding and knowledge of the maintenance and management of the OSWTS before they were provided with a copy of the knowledge model. Once these questions were completed the homeowner was then given a copy of the knowledge model and asked to read same at their own pace. Once they had completed reading the model the same 15 questions were asked again with the interviewee being invited to refer to the

model as the questions were again asked. For illustration purposes the ‘before’ and ‘after’ responses for each individual question have been presented concurrently in Appendix 2.

The anonymity of the participants has been preserved as stipulated by the ethical procedures. The following is a profile of the interviewee that participated in the homeowner interviews;

| <b><u>Interviewee No:</u></b> | <b><u>Sex:</u></b> | <b><u>Age:</u></b> | <b><u>Domicile:</u></b> |
|-------------------------------|--------------------|--------------------|-------------------------|
| Interviewee 1                 | Male               | 45                 | Kildare (Midlands)      |
| Interviewee 2                 | Male               | 51                 | Meath (Midlands)        |
| Interviewee 3                 | Female             | 32                 | Clare (West)            |

#### 7.4.5 Summary of Findings with Homeowners

The interviews with homeowners identified that there was some slight variation in the level existing knowledge and understanding in the area of OSWTS’s amongst the participants prior to them being provided with the knowledge model. Fundamentally as set out in Appendix 2 the participants demonstrated a clear lack of knowledge in many key areas that are fundamental for the proper management of their OSWTS’s as follows;

- Registration

- Installation
- Operation & Maintenance
- System Failure
- Remediation

Appendix 2 illustrates that there was a marked improvement in the knowledge demonstrated by homeowners once they had referred to the knowledge model in relation to the key issues set out above from OSWTS management and maintenance. The following summarises some key findings from the interview questions before the interviewee was given the knowledge model;

- 9 out of the 75 initial questions or 12% were answered as “I don’t know”.
- 80% of the interviewees could not offer any initial response when asked how they would know their OSWTS was working.
- 100% of the interviewees were unsure about how often their OSWTS had to be registered.
- 80% were entirely unaware of the legislation that governs OSWTS’s in Ireland.
- 100% of the interviewees were unaware that they had to check if contractors are registered to undertake installation / repair work to an OSWTS.
- 0% of initial responses acknowledged that OSWTS’s need to be de-sludged so that they can function properly.
- 80% of responses were that an OSWTS would need to be full or flowing over for it to be deemed necessary to have it de-sludged.



- Only 20% of initial responses were aware that a contractor needs to be registered to undertake de-sludging.
- None of the interviewees were aware of the need for oxygen to the OSWTS for bacterial operation.
- The adverse affects of discharging excessive grease and fat to the OSWTS was correctly identified in 80% of the initial responses.
- All of the interviewees identified that using excessive detergent and bleach was bad for the environment but 0% stated that this excessive use was back for the bacterial process in the OSWTS.
- 80% of the interviewees associate a broken down system with pipes or services flowing over and 20% with foul odour.
- None of the initial responses by interviewees referred to contacting a registered contractor if their OSWTS has broken down.
- 60% of interviewees believe that in the event of their OSWTS failing an inspection by their local authority that they will have to replace it with a new one. Only 20% referred to remedial action being undertaken to the OSWTS in the event of an inspection failure.
- There was a relatively good initial awareness in relation to record keeping with 60% of interviewees responding that records needed to be maintained in the event of inspection by the local authority.

In the second stage of interview the homeowners were provided with the knowledge model and they were given an opportunity to observe it in some detail. The next stage involved asking the interviewees the same questions as before with the interviewee being afforded the opportunity to refer to the knowledge model as they responded to the questions as discussed in section 4.6.4. Appendix 2 sets out

in tabular form the responses from the interviewees in the before and after scenario and the changes in response are attributable to the knowledge model. While there was some variation in knowledge before the knowledge model was provided to the interviewees the subsequent answers were entirely correct. It was notable however that some interviewees found the knowledge model easier to use and navigate than others. This is attributable to many possibilities however such as;

- Literacy competence
- Ability to distinguish between colours
- Eyesight
- Language

Nevertheless there was a clear and absolute improvement in the level of knowledge of all interviewees regardless of the above factors.

## **7.5 Interaction of Research Methods & Refinement of the Knowledge Model**

The knowledge model has been formulated and refined through the various stages of this research project. The explorative phase of the research identified through the comprehensive literature review in Chapter Two and from the practice based experience workshop which is discussed in section 5.2 the key deficiencies in homeowner knowledge and understanding towards OSWTS's. The research then moved into the validation phase for the content to be contained in the model whereby the knowledge deficiencies identified in the PBE were validated from questionnaires with the wider IOWA membership as outlined in section 6.3. This justification for the adoption of modelling as a mean of knowledge transfer has been outlined in detail in section 3.3.3 with a critical analysis provided on different modelling techniques that can be used. The validation of the structure

and content of the knowledge model was then addressed in the structured interviews with industry experts and homeowners as discussed in sections 7.3 & 7.4 respectively. The recommended refinements to the knowledge model that were identified in the validation phase are presented in this Chapter for content and structure. These refinements are now summarised with the final knowledge model presented in section 7.6.

### **7.5.1 Structure Refinements to the Knowledge Model**

Section 7.3.5.6 outlined the outcome of the structured interviews with the industry experts and a summary of their recommendations is discussed. There was one key structural refinement that was recommended and that related to the removal of some of the arrows from the model. The additional information that is provided for each of the topics is situated on the right hand side of each of the pages. In the initial draft of the knowledge model presented to this expert group as set out in section 6.5.2 there were arrows between these text boxes. It was recommended that these arrows and that the outline from the test boxes be removed so that it was easier to distinguish between the action options of the model and the supplementary information. Section 7.6 contains the revised version with these structural refinements made.

### **7.5.2 Content Refinements to the Knowledge Model**

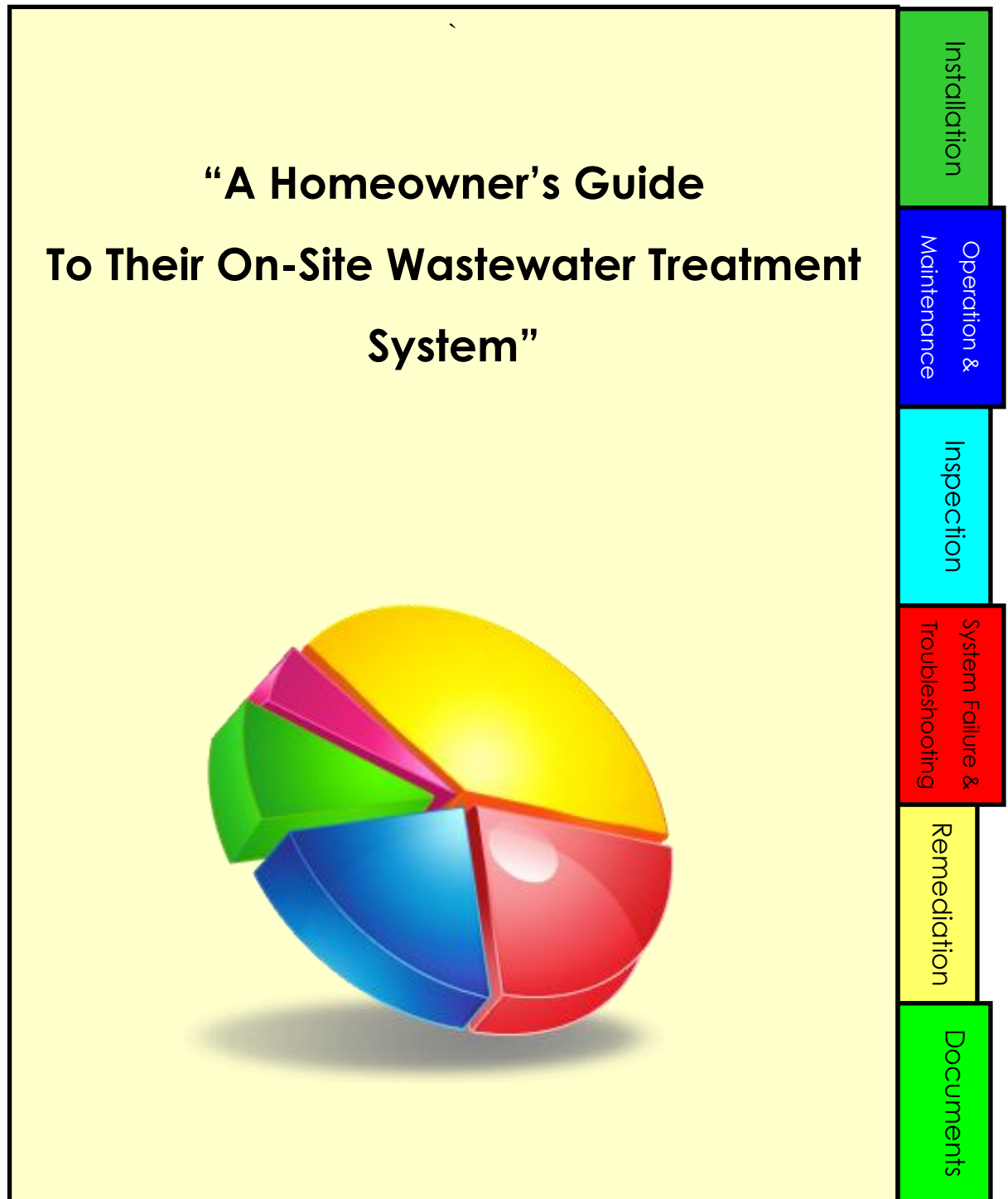
Some recommendations from the industry experts on the contents of the homeowner model are also set out in section 7.3.5.6. The interviewees broadly accepted the contents with some minor additions being referred to as follows;

- i) Reference to the EPA web-site for the benefit of homeowners seeking more information.
- ii) A further reference to the National Inspection Plan (2013) from the EPA.

iii) Additional text on some items.

Some additional text was inserted into the knowledge model to reflect the recommendations of the interviewees as outlined in section 7.6 but a number of items as recommended in section 7.6 have been disregarded. These recommendations relate to the use of photographs and other print media which are deemed to be relevant to the subject area but that would damage the integrity of the concept of a model.

## 7.6 Knowledge Model for Homeowners



**Index:**

**Installation**

**Registration**

**Operation &  
Maintenance**

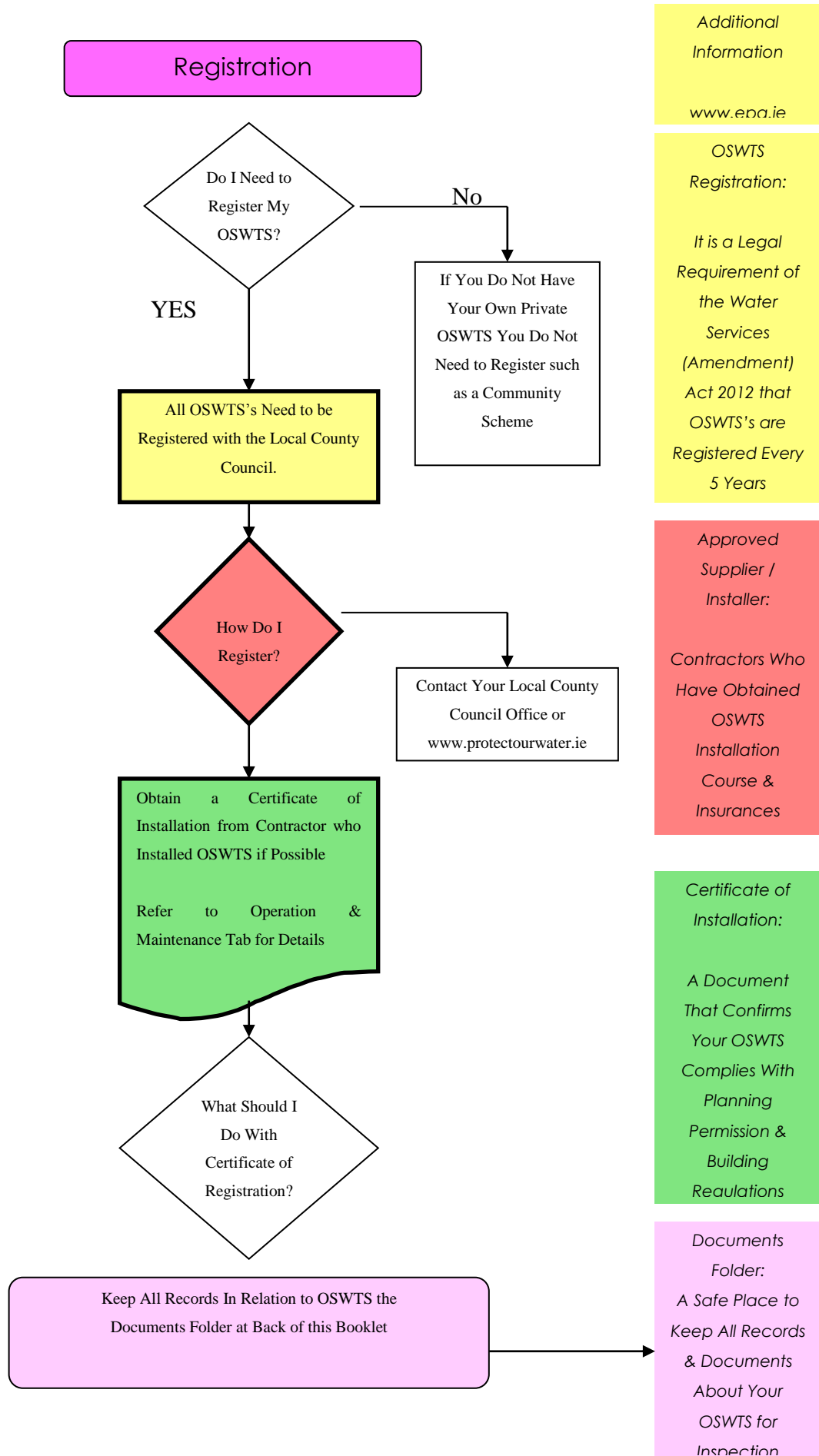
**Inspection**

**System Failure &  
Troubleshooting**

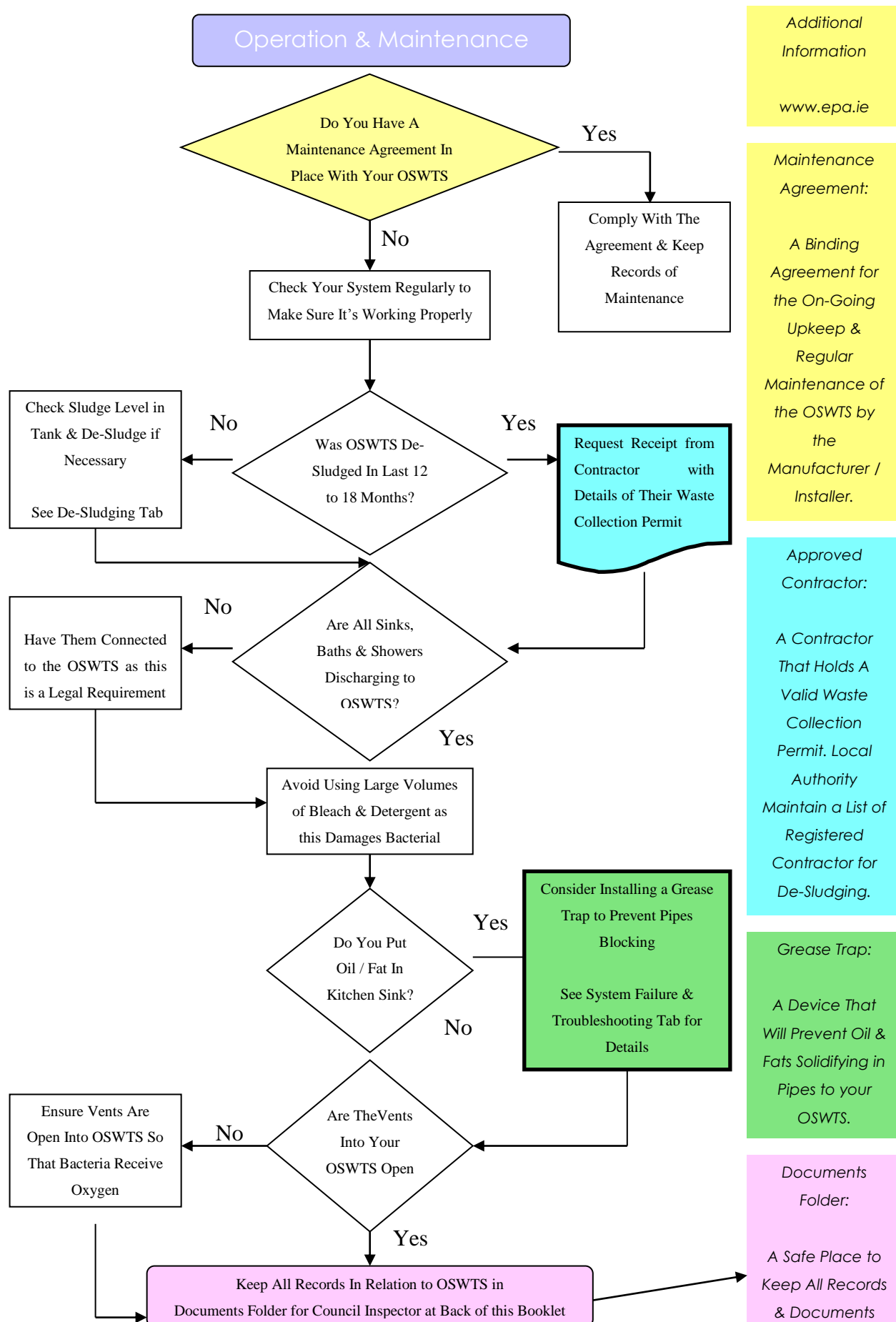
**Remediation**

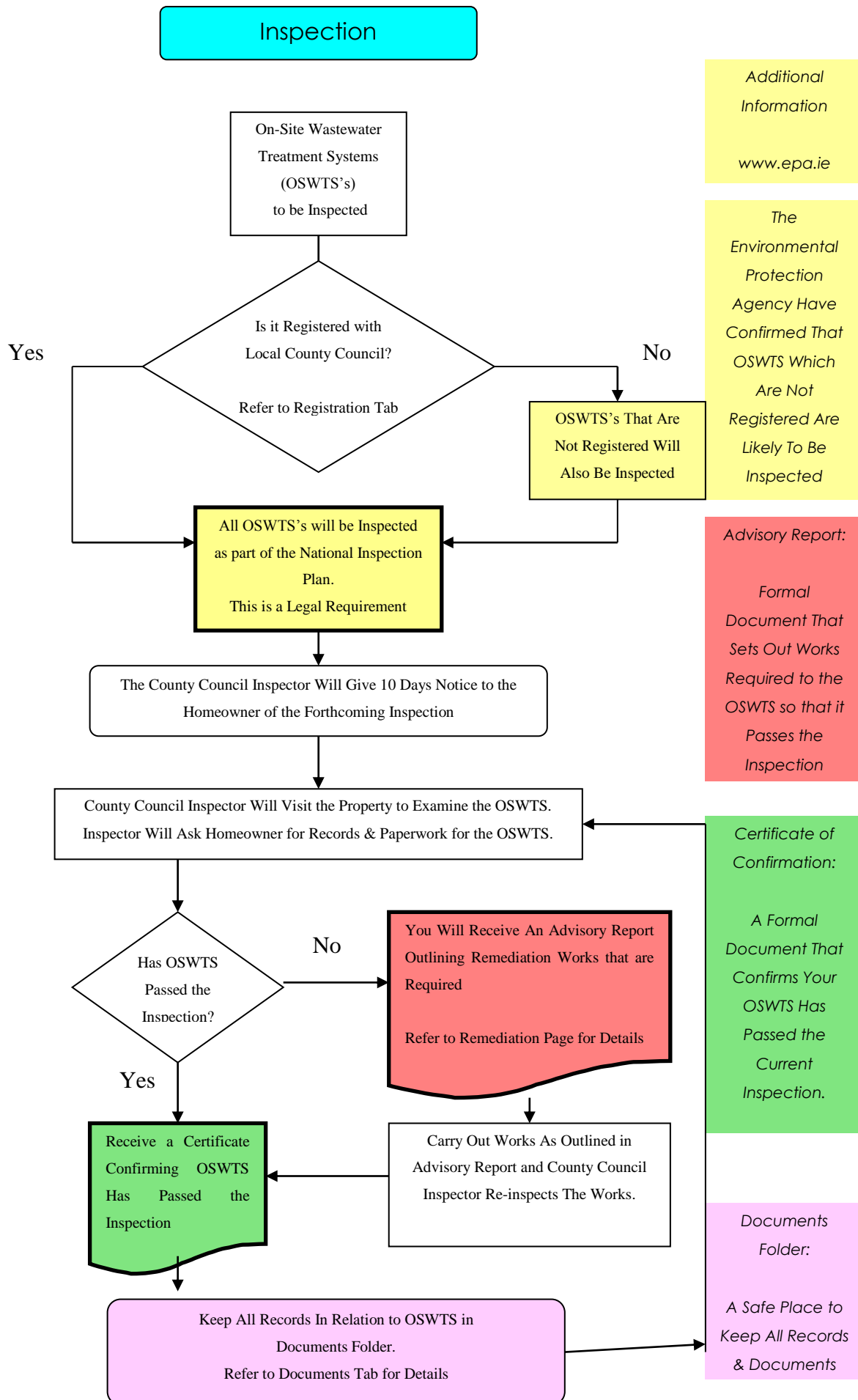
**Documents**











## System Failure & Troubleshooting

Additional  
Information

[www.epa.ie](http://www.epa.ie)

Common  
Problems:

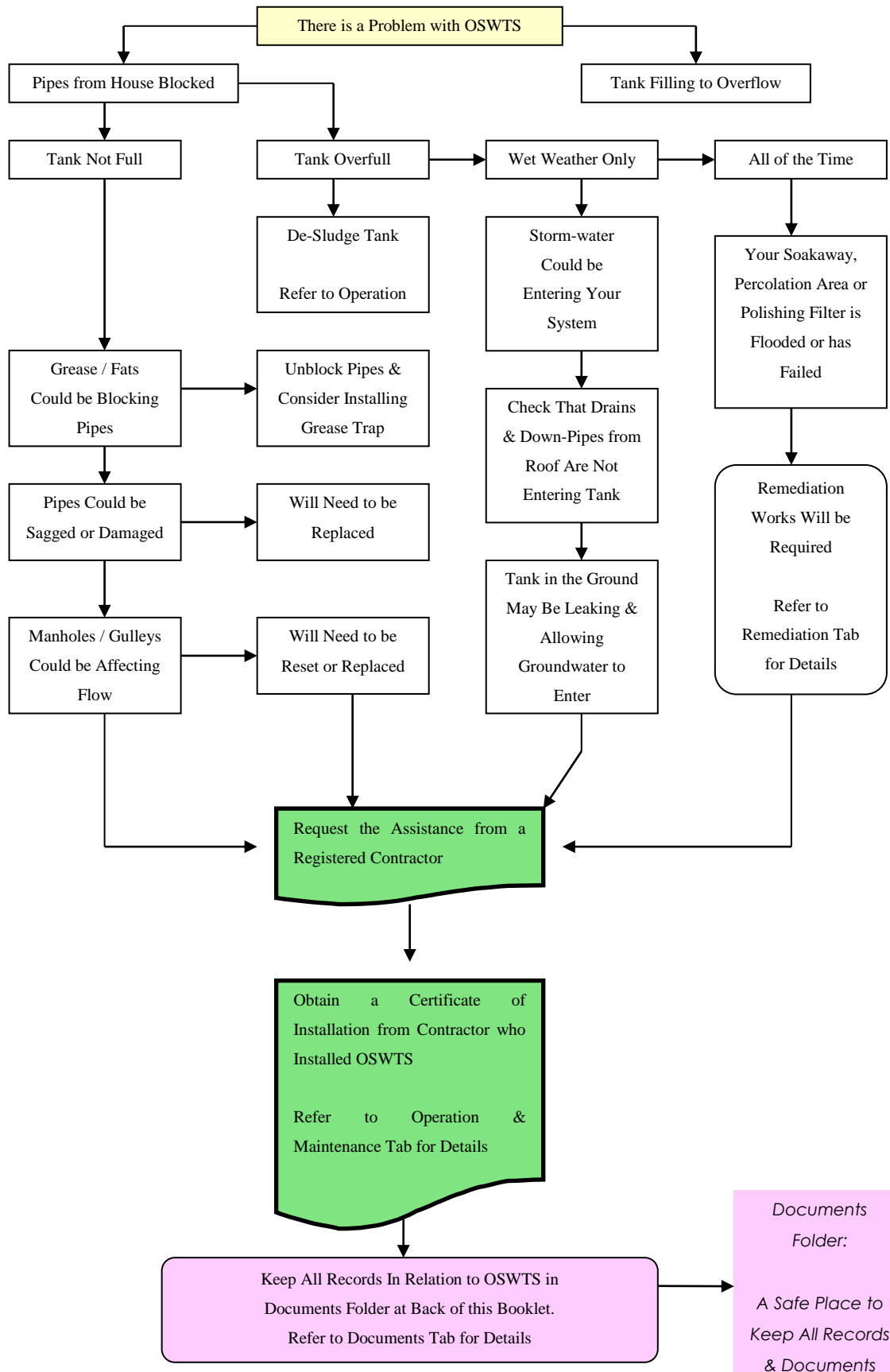
1. Ponding on site
2. Fault light or alarm sounding
3. Bad odours
4. Pipes blocked or overflowing
5. Tank overflowing
6. Toilets / sinks

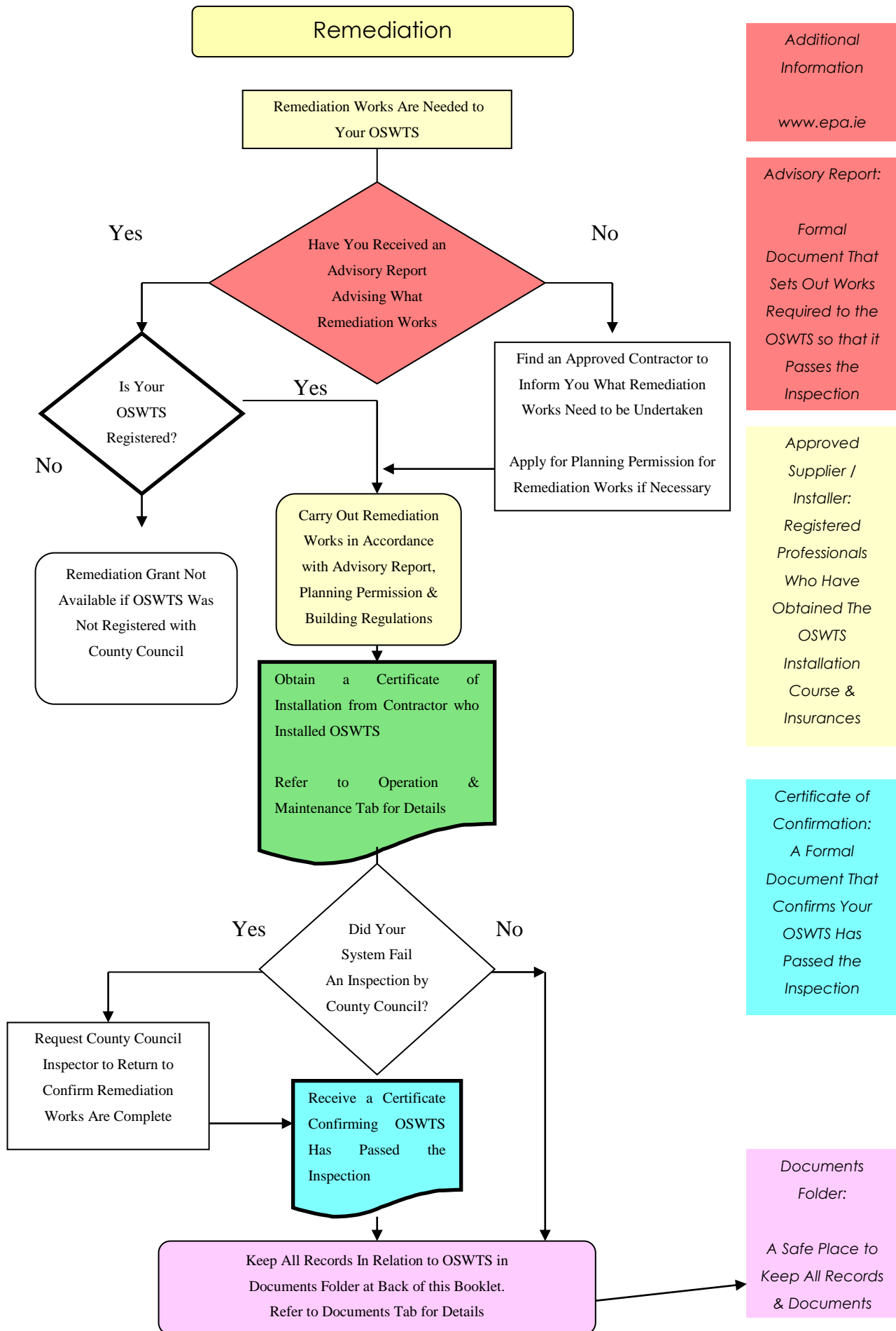
Approved  
Supplier /  
Installer:

People Who  
Have Obtained  
The OSWTS  
Installation  
Course &  
Insurances

Certificate of  
Installation:

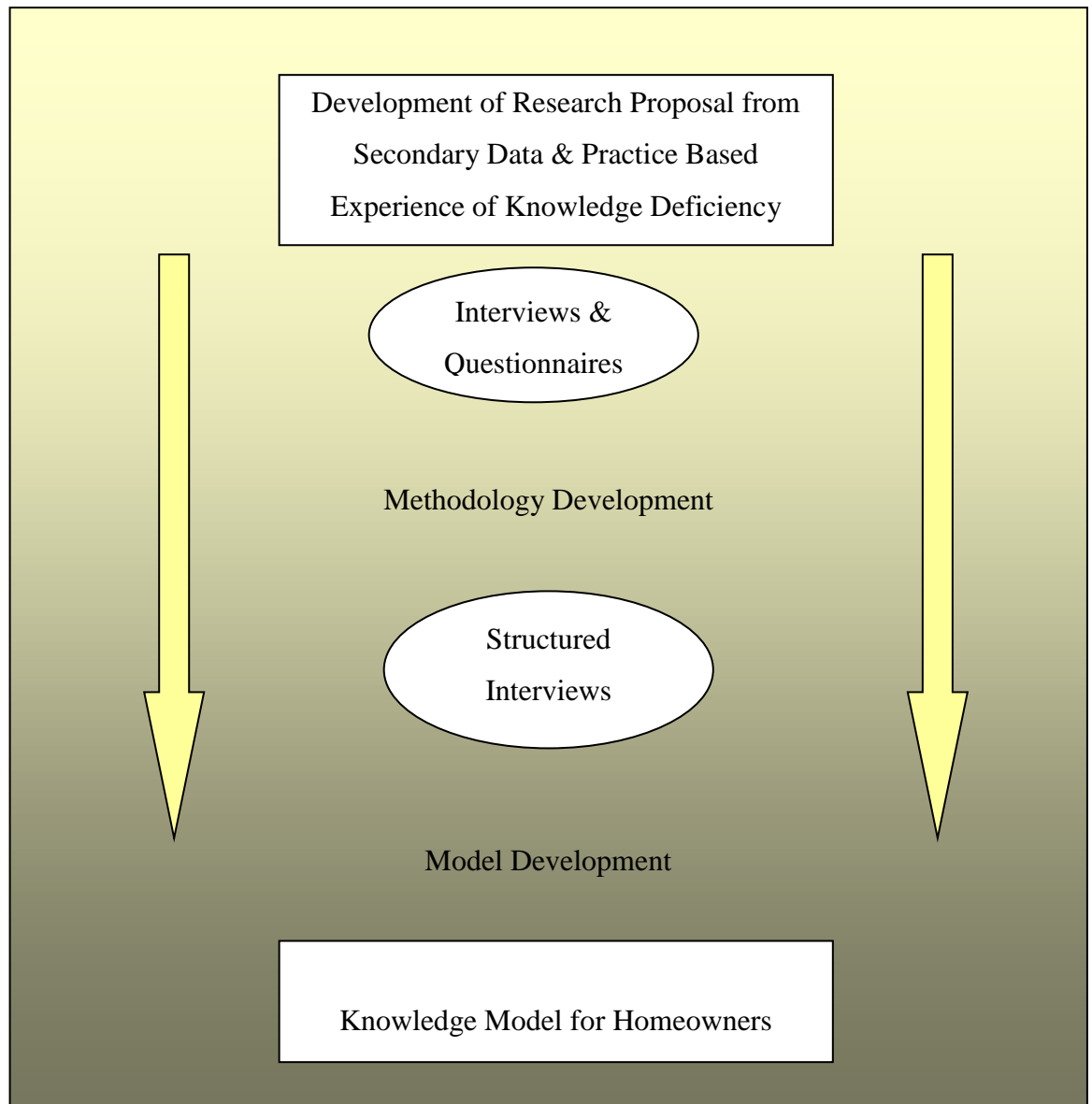
A Document  
That Confirms  
Your OSWTS  
Complies With  
Planning  
Permission &  
Building  
Regulations





## **7.7 Chapter Summary**

This research has developed from the comprehensive literature review undertaken in Chapter Two which identified the precarious position that Ireland finds itself in relation to OSWTS's (Gray, 1994; Daly, 2001; Flynn & Kroger, 2003; Gray, 2004; Gill *et al*, 2005; EPA, 2008; Daly & Craig, 2009 & Gormley, 2009) through to the following Chapter Three which has observed how the use of graphical models have been used as a means of knowledge transfer in other subject areas such as education (Young, 1993; Mylopoulos, 1998; Schreiber & Wielinga, 1998; Schultz, 2002 & Lillehagen & Krogstie, 2008). Chapter Four provided a thorough overview of the methodology and philosophical standpoint of the research which would inform and influence the research and the development of the knowledge model as it was undertaken through Chapters Five and Six. Chapter Seven has brought the knowledge model from conception to reality and has tested the model in a real work scenario with some very positive results. The following diagram summarises how the knowledge model has evolved within the structure of the research;



Chapter Eight will now move on to critically review the key findings of the research as well as considering the limitations that associated with the knowledge model. Finally Chapter Eight will conclude with some recommendations for further research in this subject area.

## **CHAPTER EIGHT – CONCLUSION**

### **8.0 Introduction**

The aim of this study which has been introduced in Chapter One is the following;

‘To develop a knowledge model for homeowners to better manage and maintain their on-site wastewater treatment systems’.

This final chapter summarises the research findings from the literature reviews and the investigations conducted by the researcher as they are presented in this thesis. In doing so, the research methodology undertaken and research novelty is reviewed, and recommendations are made for future research. This chapter will also highlight how the research objectives as discussed in section 1.4 of this investigation were addressed and to summarise these objectives are;

- To examine existing legislation and governance for on-site wastewater treatment systems in Ireland (Chapter Two)
- To review and evaluate wastewater management from OSWTS's to understand where problems exist in their management and maintenance Chapter Two)
- To evaluate the use of modelling for its applicability in an OSWTS context (Chapter Three)
- To develop a knowledge model to improve homeowner understanding of their on-site wastewater treatment systems and their legal responsibilities (Chapters Five & Six)
- To validate the knowledge model that has been developed (Chapter Seven)

## 8.1 Findings from the Literature Reviews

Chapter Two reviewed existing research in the subject area and examined in detail the magnitude and severity of the problem facing Ireland from OSWTS's (Daly, 2003, Gill et al., 2005 & EPA 2009). The need to take urgent action in relation to OSWTS's was also outlined in detail in Chapter Two and to put things in perspective, Ireland has been shown to have E.coli levels seven times that of Northern Ireland and the Netherlands, eighteen times that of Scotland and twenty eight times the levels recorded in England and Wales (Nix, 2010). E.coli occurs where faecal matter exists in water bodies which can be caused by OSWTS contamination of water resources (Gray 1994; Daly, 2001; Flynn & Kroger, 2003; Gray, 2004; Gill *et al*, 2005; EPA, 2008; Daly & Craig, 2009 & Gormley, 2009). Chapter Two also examined the recently enacted Water Services (Amendment) Act 2012, which makes homeowners liable for any contamination caused by their OSWTS. The decline of water quality in Ireland and the pollution of surface and ground waters has been described as the most serious challenge facing Ireland today (OECD, 2000). The continuing decline in Ireland's water quality was highlighted by Lucey et al (1999) and also by Irvine et al (2000) where they recognised that Ireland's responses to water pollution were completely ineffective. According to Daly (2003) there is evidence to suggest that Ireland has among the most microbially polluted groundwater in the EU. This opinion is buoyed by Fairly et al (2002) where they outline that water quality management has had little influence generally on informing the control of polluting land use activities under traditional policy regimes.

The effluent discharged from waste water treatment systems such as septic tanks is highly polluting as it contains faecal bacteria and high levels of nitrogen, phosphorous and other constituents. Therefore, if effluent enters water without being adequately treated it causes pollution. The amount of effluent discharged to the ground in Ireland is considerable, about 80 million cubic metres per year. As much of this effluent ultimately enters groundwater, the risk to human health is obvious (Daly et al, 1993). Crucially the volume of effluent expressed above has



significantly increased in line with the increase in on-site wastewater treatment systems as identified at approximately 500,000 (CSO, 2012).

It is estimated that in Ireland 50 million gallons of effluent from over 1.2 million people is produced from on-site systems daily. This effluent is disposed of in the ground (Daly, 2003). While septic tanks and other on-site wastewater treatment systems are used in other countries their numbers appear to be much lower. For example, according to the Irish Census of Population (CSO, 2012) there are some 500,000 on-site systems in Ireland representing 28% of the overall housing stock compared to an estimated 800,000 in England and 100,000 in Scotland (Gormley 2009). The above comparison with England and Scotland is quite startling when you consider that Ireland has nearly half as many systems as England and Scotland combined but less than 20% of the combined population. The “out of sight, out of mind” problem is suggested by Lenning (1996) is discussed in detail in section 2.6.8 whereby homeowners don’t seem concerned by what happens to the effluent once it leaves the house or that there is a significant deficiency in knowledge and understanding by homeowners (Gill et al, 2005 & GSI, 2009). Moreover, the regulations governing water quality are covered by various Acts and Regulations as discussed in sections 2.5.1 to 2.5.9 which aids the confusion for the homeowner as they become unsure of which regulation to follow.

Chapter Three reviewed various modelling techniques and graphical media which could be used to inform and educate homeowners on their responsibilities and how to improve their behaviour and understand the necessity of properly managing their OSWTS. DeYoung (1993) suggests that changing behaviour is a complex process but is worth the effort as one’s sense of moral obligation is capable of creating powerful feelings of remorse and awaken the conscience, thus affecting and influencing future behaviour. Section 3.3.3 has discussed knowledge modelling in detail and discovered that the main reason why humans have excelled as species is our ability to represent, reuse and transfer knowledge across time and space (Lillehagen & Krogstie, 2008). The knowledge model that has been developed in this research has been shaped from the findings in Chapter Three.

The following is a summary of the key findings from the review of existing literature;

- There currently exists very serious shortcomings in the construction, operation and maintenance of OSWTS's by homeowners in Ireland (Gray 1994; Daly, 2001; Flynn & Kroger, 2003; Gray, 2004; Gill *et al*, 2005; EPA, 2008; Daly & Craig, 2009 & Gormley, 2009)
- The culmination of inadequate policy implementation, poor monitoring and regulation as well as a lack of emphasis on performance led to Ireland's prosecution by the ECJ (Nowlan, 1999 & EPA, 2010)
- Recently enacted legislation in Ireland in the form of the Water Services (Amendment) Act 2012 makes homeowners legally responsible for pollution from poorly performing systems (EPA, 2010)
- There is little or no practical guidance or education for homeowners on how to better operate, manage or maintain their OSWTS's (Gill *et al*., 2005 & Daly & Craig, 2009)

Knowledge modelling has been used in various industries and environments to enhance and improve decision making and behaviour (Chapin, 1971; Andriole, 1989; Harris, 1999; Kaplan, 2001; Irvine, 2005 & Lee, 2011).

## **8.2 Research Methodology Analysis & Key Findings**

According to Philipps and Pugh (2005), research is the process of finding out something you don't know and as a systematic and methodical process that increases knowledge (Amaratunga *et al*., 2002). On the other hand, research methodology is a systematic and orderly approach taken towards the collection and analysis of data (Collis and Hussy, 2003). Any substantial research investigation must be based on a scientific research methodology. Methodology is

at the heart of any research project for it binds together the rationale for the research (Chan, 2004) and means being aware of the way in which you do something and being able to justify why you did it that way (Trafford & Lesham, 2008). The core goal when considering the research methodology is to avoid gross misfits – that is, when you are planning to use one type of method but another is really more advantageous (Yin, 2009). This critical review will illustrate how the research methodology has been adopted for the study and the individual research methods used have successfully fulfilled the research aim of developing a knowledge model for homeowners to better understand, manage and maintain their OSWTS.

Chapter Four detailed that the assumptions that the author brings to the world or the ‘intersection of philosophy’ as defined by Cresswell (2007) is critical to the methodology to be adopted for any research project. In determining the intersection of philosophy the author was confronted with the difficulties as purported by Knight & Ruddock (2008) in that “the problem for researchers in the field of the built environment is that their field of study covers a vast range of subjects and approaches. In this sense, the built environment is clearly not a discrete discipline with its own standard approaches of philosophy”. The post-positivist approach that has been adopted in this research reflects Knight & Ruddock (2008) in the sense that the research aim seeks to address and influence knowledge, behaviour and understanding of homeowners which is a social or interpretive phenomena by the use of a knowledge model which is grounded within a positivist perspective or as referred to Section 4.4 in the Biglan Model (1973) as technological in the applied sciences.

The post-positivist stance of the researcher justified the use of the workshop sessions with the executive committee of the IOWA to identify what knowledge was deficient amongst homeowners in relation to their OSWTS’s and this formed the basis of the practitioner based experience that was identified. The primary data collected from the practitioner based experience was validated by the use of questionnaires with the wider IOWA membership in light of the post-positivist stance. The structured interview technique was adopted at the validation stage as

it provided a focussed and targeted approach within the time and resource constraints of the research project to determine how successful the knowledge model is for homeowners to better understand their OSWTS.

The review of existing research in Chapter Two clearly identified the deficiency in knowledge and the behavioural problems in relation to OSWTS's amongst homeowners. Engaging with homeowners at this point to develop the knowledge model was considered unhelpful as they could not provide any useful insight into what they needed to know and how best to convey the new knowledge. All that could be expected at this point would be for the homeowner to validate the findings of the secondary research of existing literature and the findings of the practitioner based experience from the workshops. The workshops attended by the executive committee of the IOWA were capable of providing the model with the components it needed in relation to subject matter which were verified through the questionnaires with the wider IOWA membership as outlined above. The sample sizes for the workshop sessions, questionnaires and for the structured interviews with the IOWA committee were all dictated by the membership numbers and a limitation of the research is undoubtedly the fact that these numbers were outside of the control of the researcher. Furthermore and as discussed in Chapter Four there is a finite number of professionals that are experienced in the research area and this too is a limitation of the research. The structured interviews with homeowners however at the validation stage of the knowledge model did offer the opportunity for flexibility in participant numbers with five being the sample size.

The justification for this sample size was based on the "snowballing" effect as discussed in section 4.6.4 whereby the respondents provided similar answers and that undertaking additional interviews will not generate new responses. This is what occurred in the research however the opportunity would have been open to undertake further validation interviews with homeowners if the snowballing effect had not been found to be the case. The research flow chart outlined below at Figure 8.1 identified three key stages that were deemed necessary to achieve the aim of the research study. The first stage is the formulation of the research aim,

objectives and methodology. Within this stage the objectives one, two and three have been achieved from the review of secondary research undertaken;

- i) To identify existing legislation and governance for on-site wastewater treatment systems in Ireland.
- ii) To review and evaluate wastewater management from OSWTS
- iii) To evaluate the use of information/ knowledge models for their applicability in an OSWTS context

The second stage of the thesis involved primary research and is referred to at Figure 8.1 as the exploratory stage. The primary research commenced at this point with the IOWA workshop sessions to develop the issues to be addressed in the knowledge model. Within this stage objective four was addressed;

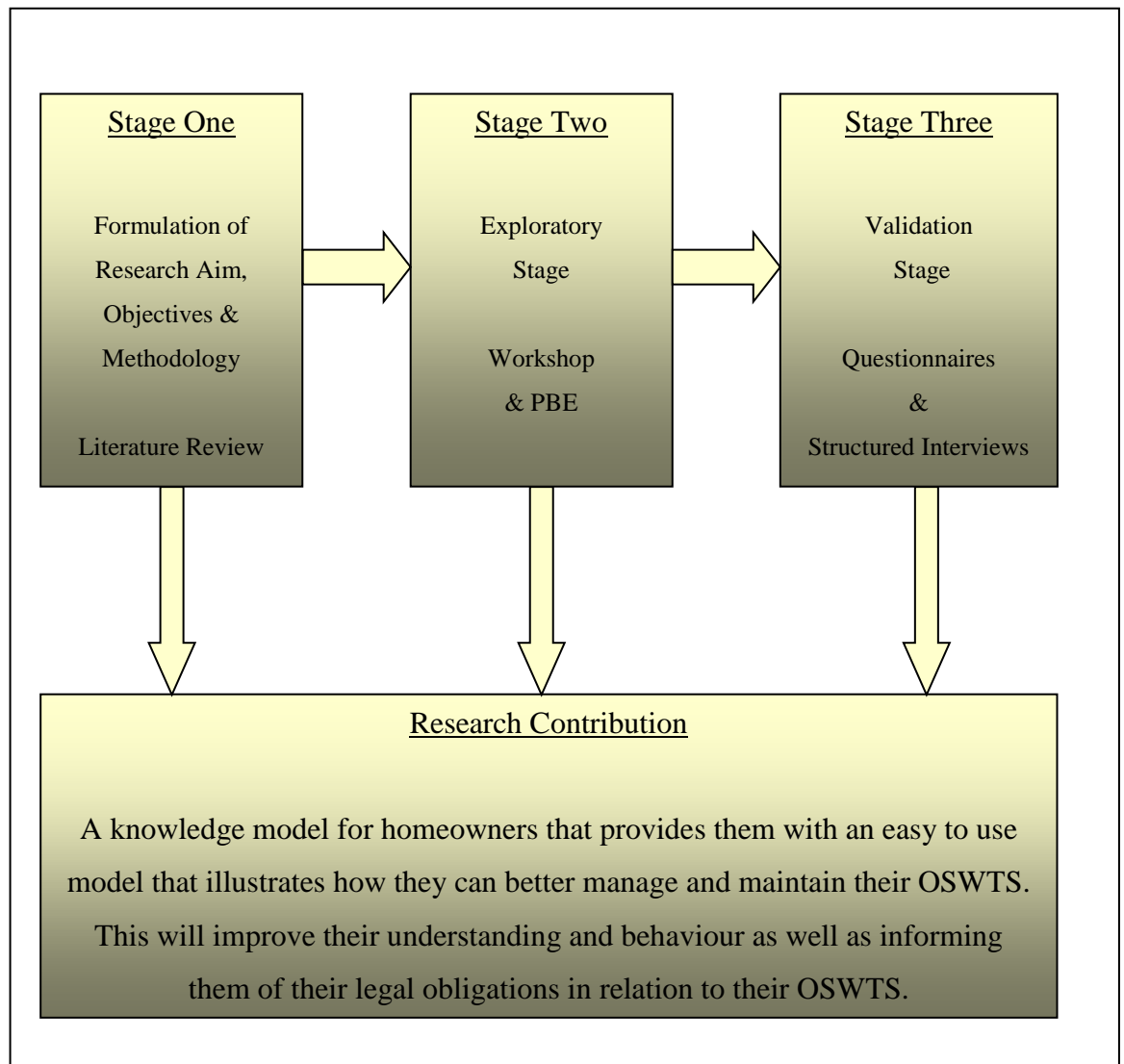
- iv) To develop a knowledge model to improve homeowner knowledge, understanding and behaviour of their on-site wastewater treatment systems and their legal responsibilities.

The third and final stage of the thesis is the validation stage as outlined in Figure 8.1 also and this stage involved the structured interviews with the IOWA committee and the random sample of homeowners. The completion of this stage finalised the structure and content of the knowledge model and has therefore achieved objective five which is as follows;

- v) To validate the knowledge model that has been developed

Figure 8.1 illustrates these three stages and how each of the stages has influenced the knowledge model that has been developed. The key findings for each of the stages will be summarised later in this Chapter and the contribution which has emerged from the comprehensive review of existing literature and research undertaken as well as from the primary research undertaken for this study in the workshops and the structured interviews.

Figure 8.1: Summary of the Research Process & Contribution

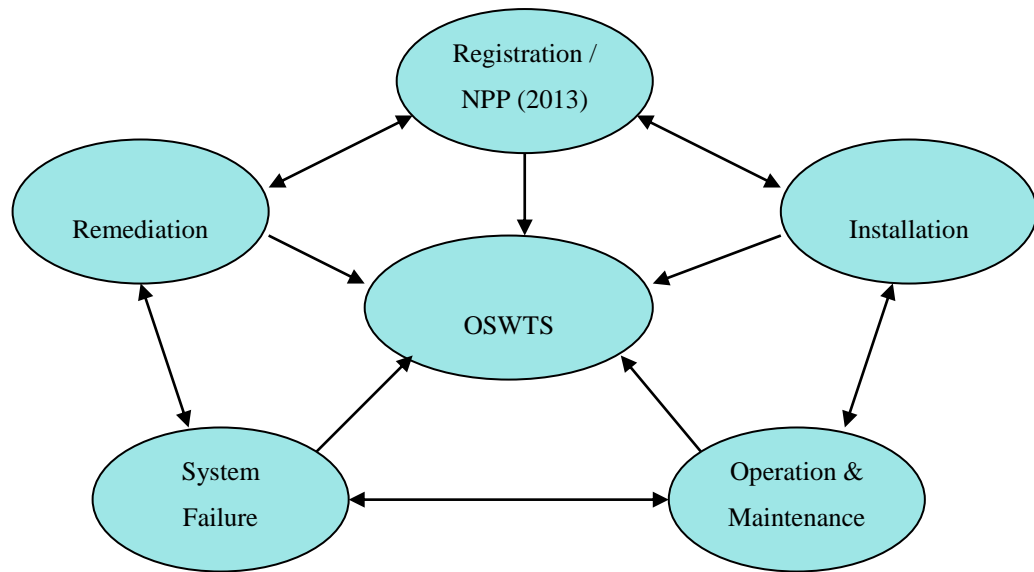


### 8.3 Explorative Findings

The explorative stage of the research commenced with workshop sessions with the IOWA executive committee to identify practice based experience and to discuss the deficiencies that exist in homeowner behaviour, knowledge and understanding in relation to their OSTWS's. The issues identified in the literature review and set out in Chapters Two and Three were used to stimulate the debate on what were the deficiencies amongst homeowners in relation to their OSWTS's.

The topics and issues that were identified from the workshops can be summarised in the following diagram;

Figure 8.2 Graphic illustrating key factors that influence OSWTS's performance from Workshop Session with IOWA Executive Committee



The issues identified in the workshops regarding homeowner knowledge, behaviour and understanding could fit into one of the categories listed above and set out in Chapter Five. The concept of modelling was also developed from the findings of the literature review and a key consideration for participants was the benefit of the “picture painting a thousand words” (Lee, 2011). The findings and topics identified in the workshop sessions and from practice based experience were validated by undertaking a questionnaire with the wider membership of the IOWA. The participants for the questionnaire were also afforded the opportunity to suggest additional items that they felt were relevant for the knowledge model to be developed. This validated information was then used to design the knowledge model for homeowners that would then itself be validated in next phase of the research.

## **8.4 Validation Findings**

As referred to previously the knowledge model was validated in two stages. In the first stage structured interviews were undertaken with four of the five members of the executive committee of the IOWA. These were the same individuals who participated in the workshop sessions in the explorative stage and their comments and subsequent amendments to the model are set out in Chapter Seven. In summary the interview participants felt that the homeowner model was fit for purpose with some general comments for improvement in the following areas;

- It may be too simplified for some homeowners that have some technical knowledge and reference should be made to the EPA website for further reading on the National Inspection Plan (NSS) 2013.
- Some homeowners may benefit from more detailed knowledge and that it may be a counterproductive enterprise if people feel it is too simple
- Remove some arrows in the knowledge model as they may cause confusion
- More text based detail would be beneficial to some homeowners

The second stage of validation involved undertaking five structured interviews with homeowners to test the validity of the model. In this second stage the homeowner was asked fifteen questions in relation to operation, management and maintenance of their OSWTS before they were given the knowledge model. They were then asked the same questions after a copy of the knowledge model was made available and they had an opportunity to familiarise themselves with the model. The general feedback from the homeowners was that the knowledge model was useful and easy to use and the results of these interviews are outlined in section 7.4.5 and illustrate a significant improvement in homeowner knowledge and understanding in relation to OSWTS's.



## **8.5 Research Limitations**

A limitation of this research investigation could be considered to be the number of participants that were involved in the explorative stage which is based on the PBE of the executive committee of the IOWA. Section 5.2.1 has outlined in some detail the background to the IOWA and referred to that fact that this is the only representative of body of industry professionals in Ireland. The pool of practice based experience will broaden in the future as more representative bodies and organisations for on-site wastewater professionals develop and perhaps also as the IOWA develops and the membership committee broadens. Naturally it may therefore make sense to revisit the workshops in the future as referred to in section 8.4. The on-site wastewater industry in Ireland must develop and grow in response to the new Water Services (Amendment) Act 2012 as more emphasis is placed on the management and maintenance of OSWTS's. The ECJ (C188/08) prosecution of Ireland for not having a proper registration and inspection regime for OSWTS's as discussed in section 2.6.10 has resulted in the very swift introduction of new legislation in Ireland and the on-site wastewater industry is currently trying to come to terms with this new legislation. The timing of this research could be perceived to be undertaken during huge change and this could be observed as a limitation in the model that has been developed. Important issues could conceivably be overlooked as the Water Services (Amendment) Act 2013 is still in its infancy and these important issues may not yet have come to the attention of the on-site wastewater industry.

A further perceived limitation is the fact that the researcher is an active member of the IOWA and has been acquainted with some of the members for many years. In the researcher's employment there would be interaction with other IOWA members and this could be perceived to create bias or threaten the validity of the research as there may be a question of impartiality on the part of the researcher. It could also be conceived for instance that interviewees would not engage freely in light of being acquainted with the researcher or they may have a reluctance to speak openly and freely. Mitigation measures such as researching practice based

experience from individuals that the researcher was not acquainted with was not possible due to the limited number of industry experts as outlined in section 4.6.1.

The knowledge model has been developed as a graphical tool which encompasses a visual flow of actions using colours and text as a means of educating the homeowner on how to better manage and maintain their OSWTS. The need and justification for this model are outlined in Chapters Two and Three with Chapter Four examining the methodology for achieving the aim of the research. Undoubtedly a limitation of the research relates to homeowners that may be illiterate, colour blind or that may speak alternative languages. In any of these cases the usefulness of the knowledge model will be compromised.

## **8.7 Research Novelty**

The author has acknowledged that there are limitations in the research but nevertheless the research findings are both novel and valuable in that they address very serious problems for both homeowners and the wider public in Ireland by seeking to address the lack of understanding of OSWTS's and the legal implications of owning a poorly maintained OSWTS (Gray, 1994; Daly, 2001; Flynn & Kroger, 2003; Gray, 2004; Gill *et al*, 2005; EPA, 2008; Daly & Craig, 2009; Gormley, 2009, IOWA, 2013; Kelly, 2014 & GSI, 2014). The knowledge model identifies the responsibilities that the homeowner has from when their OSWTS is being registered or installed and also in the everyday operation and maintenance. There is a clear outline of the legal requirements for homeowners to have their OSWTS serviced and properly maintained with a special emphasis on ensuring that contractors undertaking the work are properly registered and that the documentation that relates to the OSWTS is retained in the event of inspection under the Water Services (Amendment) Act 2012 and the subsequent national inspection plan for OSWTS's.

A further aspect of the novelty of this research is the use of modelling in the education of homeowners on their OSWTS's. The review of existing literature in

Chapters Two and Three has identified that modelling is widely used for information and education purposes in other industries but not previously within the realm of domestic wastewater disposal for homeowners. In essence, this research has not reinvented the wheel, it has simply applied the use of a wheel where one was not used before and measured its effectiveness.

## **8.8 Contribution to Knowledge**

One of the key criteria for a piece of research work to be considered as a PhD is that it is an original piece of work that makes a significant contribution to knowledge. The making of a significant contribution to knowledge provides evidence to substantiate a conclusion that's worth making. Research is about the articulation and analysis of phenomena observed and investigated through a variety of techniques. It's about making sense of a particular phenomenon and not just describing it while also analysing and explaining it. As more evidence is presented, the analysis and explanations are re-evaluated.

In this research the concept of knowledge modelling has been applied in the context of homeowners who have legal and moral responsibilities to ensure that their OSWTS's operate effectively and to ensure that they are not the cause of nuisance or pollution. The review of existing literature and research in Chapter Two has underlined and affirmed the serious problems that exists in relation to OSWTS's in Ireland presently. The contribution to knowledge of this research is therefore the re-contextualisation of an existing technique, theory or model (applying a technique in a new context, testing a theory in a new setting, showing the applicability of a model to a new situation): showing it works - or that it doesn't - and why (Creswell, 2008).

## **8.9 Future Research**

This section summarises some specific areas where the author believes further research would be useful;

1. Further research would be useful to determine if the knowledge model has an impact over an extended period of time on the performance of individual OSWTS's. While the validation phase of this research identified that homeowners were better informed through the use of the knowledge model, it is not known if this will influence the homeowner's behaviour towards their OSWTS over an extended timeframe.
2. The research undertaken has identified that in some cases homeowners are aware of their legal responsibilities towards their OSWTS's and that they do understand that they require on-going maintenance and management. Nevertheless they choose the 'out of sight out of mind' principle (Gray, 2004) and make little or no effort to ensure that their OSWTS's are functioning properly. Further research in this area could provide an understanding of why people see pollution from their OSWTS as being acceptable and may provide a basis for improving homeowner behaviour.
3. This research study has been undertaken while Ireland is in the depths of an economic crisis. This crisis has resulted in significant numbers of people having their homes repossessed with many others being at the mercy of mortgage lenders to stay in their homes. The behaviour of people towards their OSWTS and their property in general will naturally be influenced by their financial circumstances and it would be useful to research the possibility of some form of assistance for those who cannot afford to manage their OSWTS properly.
4. The National Inspection Plan for OSWTS's which has been developed in response to the enactment of the Water Services (Amendment) Act 2012 is a very new piece of legislation in Ireland. Accordingly as time progresses

there may be issues that will arise for homeowners that are not addressed in the knowledge model developed for this research and refinements may be necessary.

5. The knowledge model developed for homeowners in this research is paper based and further research on the viability of an electronic version would be considered useful. This could encapsulate some form of application whereby notifications are sent to remind homeowners about regular maintenance for instance. Furthermore future research could also examine the use of other graphic means and methods to convey knowledge to homeowners.

## **8.10 Chapter Summary**

This concluding Chapter has summarised the aim and objectives of the research and has provided a broad overview of how the thesis has developed from inception through to its completion and publication. A summary of the research need, justification and methodology have been presented in addition to a brief overview of the findings from the explorative and evaluative phases of the research. The research limitations have been acknowledged in the Chapter as well as a summary of the novelty of the research and the subsequent contribution to knowledge. Finally the Chapter has discussed the opportunities for future research work on this subject area. The on-site wastewater industry is currently experiencing huge transition and development and it is hoped that this work will provide a basis for which to move forward to address issues relating to the management and maintenance of OSWTS's.

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## **APPENDICES**

### **Appendix 1 – IOWA Questionnaire Form**

### **Appendix 2 – Homeowner Responses to Interview Questions**

### **Appendix 3 – Process of Model Development**



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## **Appendix 3 – Process of Model Development**