WASTE MANAGEMENT

A Strategy for Dublin

FEASIBILITY STUDY

FOR

THERMAL TREATMENT OF WASTE

FOR THE

DUBLIN REGION

Report on Siting and Environmental Issues

This project is grant aided by the European Cohesion Fund

AN ROINN COMHSHAOIL AGUS RIALTAIS ÁITIÚIL
DEPARTMENT OF THE ENVIRONMENT AND LOCAL GOVERNMENT

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EXECUTIVE SUMMARY

1. INTRODUCTION

The Dublin Waste Management Strategy Study completed by the MCCK Consultancy Group in December 1997 recommended thermal treatment of waste as part of an integrated solution to waste management in the Dublin region over the next 15- 20 years. The Study also recommended that a feasibility study be undertaken to investigate further the possibilities for thermal treatment in terms of available technologies, siting of a facility and public involvement. The Dublin Region for the purposes of the Study consists of the administrative areas of Dublin Corporation, Fingal County Council, South Dublin County Council and Dun Laoghaire Rathdown County Council and had a combined population of 1,056,666 in the 1996 Census.

In 1998/99 the four Dublin local authorities adopted the Dublin Waste Management Plan which was broadly based on the 1997 strategy. The adopted plan is an integrated approach to waste reduction, recycling, thermal treatment with energy recovery and residual landfill. Following Plan adoption, this report on thermal treatment siting is a further stage in Plan implementation following the technical report presented last September.

The Study Brief stated that the study should address the following issues:-

- Waste streams, volumes, and characteristics
- Technological options
- Environmental impacts
- Life cycle analyses
- End market use for energy and residual products
- Siting
- Examination of representatives facilities in other countries
- Procurement procedures
- Public consultation and involvement

The study was undertaken in two parts as follows:-

- Phase 1 Technical Issues Report (September 1999) Report on technological options, end market, procurement and preliminary environmental/siting issues.

- Phase 2 Siting and Environmental Issues Report (November 1999) Report on further development of environmental siting issues leading to selection of possible sites for thermal treatment with public involvement

2. TECHNOLOGICAL OPTIONS

Thermal treatment is a term covering several energy recovery concepts including the more traditional methods of waste combustion with energy recovery, and also the available non-incineration technologies such as pyrolysis, and gasification.

Waste Combustion (Incineration) with Energy Recovery
Waste combustion reduces the bulk of waste and recovers surplus energy as heat (hot water or steam) or electric power or a combination of these. All combustible materials in solid waste from households, commerce and industry can be treated by waste combustion. Co-combustion, for example in combination with sludges, can also be carried out. Combustion has a proven track record in Europe, with the technology being developed and improved in terms of energy efficiency and atmospheric emissions. The two alternative systems for combustion of municipal solid waste (MSW) are Grate Combustion and Fluidised Bed Technology. The former is a 50-year-old technology while fluidised bed system has been in place principally in Sweden for over 20 years. Both systems require a degree of mixing and shredding of the waste before entering the incineration chamber.

Grate Combustion
Waste is placed on a moving grate which moves slowly towards the combustion chamber allowing waste to be dried out before combustion at a temperature range of 950-1200 °C. Flue gasses are passed through an after-combustion chamber for at least 2 seconds at > 850 °C to ensure complete burning, and then passed to a boiler where steam or hot water are generated from the energy in the flue gases.

Fluidised Bed
The principal differences as compared to the grate combustion is that the waste moves on a sand bed fluidised by blowing air beneath it. More power is consumed in the process and there are differences in the quantity and type of residues produced.

The end products from either system of incineration are as follows (expressed as a proportion of the weight of incoming waste).

- fly ash and flue gas cleaning products 2 - 5 % (by weight)
- ferrous metals 2 - 3 % (by weight
- clinker (bottom ash) 15 - 25 % (by weight).

There is therefore approximately 20% - 30% residue by weight. Expressed as volume the result is a reduction to approximately 5-10% of the waste input. The options for these by-products are recycling (e.g. magnetic sorting of any metals, incorporation of clinker into road building etc.) and disposal to landfill. The surplus energy produced can be recovered through production of electricity and heat, for example for industry, drying of materials, district heating schemes for households.

Flue gas cleaning involves scrubbing to remove particulates, heavy metals, acid gases and dioxins. In terms of emissions to the environment, modern plants will comply with the (Draft) EU Directive on Incineration of Waste (December 1998). The emission limits set out by this legislation are more onerous than national legislation in many states and are quite stringent. Much of the recent development in technology has been in the refinement of processes and flue gas cleaning systems in order to meet the strict requirements on emissions.

Pyrolysis
Pyrolysis is a thermal pre-treatment method, which transforms waste into a gas, liquid and char fraction. It is generally followed by a combustion step. This technology is relatively new. Municipal wastes and other specific waste streams can be dealt with by the process.

The process requires waste to be shredded, before it enters a reactor. It is transformed in the absence of oxygen at a temperature of 500-800°C by a thermo-chemical process. The pyrolysis process will typically result in the following end products as a percentage of the incoming waste quantity:

char (carbon & ash)	30-40 % (by weight)
gases and liquids	50-60 % (by weight)
residuals	10 % (by weight)

The residuals include inorganic non-degradable materials. The gas can be used as a fuel for kilns (e.g. cement industry) or to generate steam for electricity production. The char can be used as a fuel (similar to coal) but would need a flue gas scrubbing system, or as a filter material (activated carbon).

The system has merits which include less flue gas production, and better retention of contaminants in the ash. The disadvantages include a high processing cost, and requirements for finding end users for by-products.

Gasification
This process is similar to pyrolysis in some ways. With gasification, the pre-treated waste is fed into a reactor where carbonaceous material reacts with a gasifying agent (e.g. air, oxygen, or CO2) at temperatures of 800-1100°C or higher. A series of chemical reactions form a combustible gas with traces of tar. The ash residue becomes vitrified (glass-like) at these high temperatures and is separated as a solid residue. The gas can be burned to generate heat or steam. Typically up to 90 % by weight of the waste input is transformed to gases and liquids, with solid residuals making the balance.

Advantages include a manageable solid fraction with low leaching characteristics, and efficient energy recovery. Disadvantages are the high cost of processing and the traces of tar in the gas which may contaminate the quench water which must then be treated. The gasification process is less well developed in terms of municipal solid waste than waste combustion with energy recovery. However a proprietary process called Thermoselect offers promise. The first full scale facility was commissioned in Karlsruhe in Germany in 1999 and recently the company has opened a second plant in Japan.

3. END MARKET USE

End market use is an important factor in the practicality and economics of running a thermal waste treatment facility. End market use refers to how the various output products from a thermal plant can be used beneficially. The principal end products from a thermal treatment are energy products, recyclable materials and residuals requiring further treatment. The main product of thermal waste treatment is energy.

Energy may be produced directly in the form of heat or indirectly in the form of a gaseous or liquid fuel which may be used later or even elsewhere. Generally, best use of this fuel will be made on site for the generation of either heat or electricity. It is possible to produce electricity from each of the thermal waste treatment processes under consideration i.e. waste combustion with energy and Thermoselect. Power generation can have a large impact on plant economics but this depends on contracts for the supply of electricity to a consumer. The potential revenue from sales of electricity for a modern WTE facility treating MSW ranges from IR£12.50 per tonne to IR£20.00 per tonne. This is based on a range of electricity prices of 2.5 – 3.6 p/kWh, a calorific value for the waste of 9-10 MJ/kg and a net electrical efficiency of 20%.

Alternative thermal technologies such as Thermoselect have reduced potential in this regard due to lower electrical efficiencies and increased operating costs. Dry saturated steam can be supplied to a nearby industry for process heating applications provided that there is a market. Steam is normally needed at pressures of 6-10 bar and cannot be transported over long distances due to pressure and heat losses in the piping system. It is relevant to note that the decision to locate a thermal treatment facility in a particular location may act as a significant 'draw' to manufacturing industry if process heat can be provided at a low cost as a by-product of the waste treatment process.

4. ENVIRONMENTAL APPRAISAL

The environmental impacts of the thermal treatment of municipal solid waste were evaluated based on the two technologies under serious consideration namely waste combustion with energy recovery and the Thermoselect process. The most important environmental impacts relate to air quality, including global warming potential and toxicity to humans; energy/electricity production; and solid waste production. It is necessary to point out that the capacity and number of thermal treatment plants does not affect the magnitude of the environmental impacts shown as these have been assessed independently of location. Only the impacts related to transport, which are site-specific and assumed to be the same regardless of the thermal treatment process selected, are influenced by the capacity and number of plants.

The main advantage of waste combustion with energy recovery is the high quantity of electricity generated compared to the Thermoselect process, which helps reduce the need to use conventional energy sources. As a result, the global warming (and acidification) impact potential is lower for waste combustion compared to Thermoselect, despite the lower atmospheric emissions from the Thermoselect process itself.

The main advantage of using the Thermoselect process is the lower emissions from the process itself, which will lead to a better air quality in the area surrounding the plant. However, from a life cycle perspective, Thermoselect results in higher impacts associated with the significantly lower amount of electricity generated. Environmental benefits may be associated with the residual solid waste produced by the Thermoselect process, as it may be easier to recover different fractions (e.g. salt, sulphur, metal compounds) and therefore easier to reuse them. In addition, residual solid waste produced by conventional power plants (17-22 kg/tonne of waste treated) also requires disposal to landfill. Another advantage of the Thermoselect process relates to the absence of wastewater produced.

In summary, both combustion and gasification are processes which need to be considered further. Combustion or incineration has a longer track record and is more efficient in energy recovery and therefore more economical. Gasification has lower emissions, its solid residues are most recyclable and has little or no wastewater residue. While combustion has been replicated at the required scale for the Dublin Region in many other European and other cities, gasification is currently being proven as roughly half the scale being required for Dublin (200,000 tonnes / annum unit in Karlsruhe Germany).

5. PUBLIC INVOLVEMENT

A four strand approach to public involvement was adopted based on knowledge of local issues and the experience of successful and unsuccessful siting studies of thermal treatment plants elsewhere.

- Strand 1: Presentation and briefing to Elected Members of the four local authorities on the Dublin Waste Plan Implementation, biological treatment and thermal treatment studies
- Strand 2: Establishment of Community Focus Groups within the four local authority areas
- Strand 3: Public opinion surveys on proposed waste management strategy options, facility siting criteria and scoping of key environmental issues associated with thermal treatment plants in Dublin.
- Strand 4: Proactive public information campaign involving national and local media, public displays and other suitable consultation fora.

A presentation to the Elected Members took place on 14th September, 1999 in the Gresham Hotel. This took the form of a briefing in which the progress to date the implementation of the Dublin Waste Management Plan was outlined. Presentations were given by representatives from Dublin Corporation and the consultants. Technical feasibility studies on thermal and biological treatment were explained and reports were made available which are now in all the Dublin libraries.

Community Focus Groups (2 in each local authority area) were established to inform the siting process. In general the groups indicated that the public are generally accepting of thermal treatment as part of an integrated waste management solution. Concerns were expressed however, with regard to emissions, safety standards, cost and appearance of the plant.

The public opinion survey was conducted consisting of 506 interviews spread across the four Dublin local authority areas during October/November 1999. The purpose of the surveys was to inform further the siting process and to gain a better understanding of public opinion on waste issues in general and thermal treatment of waste in particular. Preliminary findings of the survey are as follows:-

- 1 in 4 Dubliners admit that they know nothing about what happens to their waste once it has been collected. Most of the remainder concede that they know very little.
- Over half of Dublin adults expressed some concern about disposal of household waste in landfills.
- When presented with an illustration of an integrated approach to the disposal of household waste, more than 7 in 10 felt it was a good idea. Only 4% reacted negatively, leaving the remainder undecided.
- The primary concerns were impact of families health, emissions and smell with a variety of secondary concerns such as noise, traffic, effect on house prices, the environment and safety standards.
- The main criteria with choosing a site should be based on how dangerous emissions are, siting it away from residential areas, and from children/playgrounds/schools, smells and volume of emissions.

The next stage in public involvement will be a proactive approach involving press releases, newsletters, local liaison groups etc. The Environmental Awareness Officers employed by the local authorities will play a key role in assisting public information on waste reduction and waste management options.

6. SITING

The need for thermal treatment as a means of maximising diversion from landfill was adopted in the Dublin Waste Management Plan. The identification of areas suitable for a treatment plant needs to be undertaken according to a systematic selection having regard to technical, environmental, social and economic criteria.

Legislation and Official Guidelines

As thermal treatment of municipal waste is not an established technology in Ireland there are no national guidelines regarding the selection of areas suitable for the location of thermal treatment facilities. There are however Draft EPA Guidelines for Landfill Site Selection. In the absence of specific documents guidance must be taken from relevant legislation. The primary pieces of legislation are:-

- 89/369/EEC Air Pollution from New Municipal Waste Incinerators
- Proposal for a Council Directive on the Incineration of Waste 1998
- The Waste Management Act, 1996

Selection Methodology

The general procedure for the Study commenced with a sieving process whereby exclusionary factors are first examined. These are factors, which preclude the siting of a Thermal Treatment plant and include the following:

- City and County Development Plans
- Proposed Natural Heritage Areas
- Airport Exclusionary Areas
- Areas of High Amenity or Archaeological Interest

Having taken account of the above exclusionary factors, ten areas were identified as potential sites. These sites were visited and a preliminary assessment was carried out of their suitability for development as a thermal treatment facility. The sites are listed by local authority below.

Dublin Corporation:

A. The Poolbeg Peninsula
B. The former Semperit factory at Killeen Road, Ballyfermot

Dun Laoghaire/Rathdown:

C. The Cherrywood area of Loughlinstown
D. Agriculturally zoned area of Glenamuck
E. The Tibradden section of Rockbrook

Fingal:

F. Industrial area west of Balbriggan
G. The Belcamp Area west of the Malahide Road
H. Agriculturally zoned land in Deanestown

South Dublin:

I. Vacant sites in the Walkinstown Industrial Park
J. Vacant industrial site in Newlands

The sites were then subject to a detailed assessment on the following criteria:

- Road Access
- Traffic
- End-Market Use
- Site Size and Current Land Use
- Proximity to Residential Areas
- General Planning and Environmental Considerations

A matrix of the ten potential sites was created in order to perform a qualitative evaluation of the individual site suitability. Through this process the following 4 most suitable sites for development of a thermal treatment facility were obtained.

- Cherrywood
- Newlands
- Poolbeg
- Robinhood

These were then subject to a much more detailed assessment of the above stated criteria as well as general planning and environmental issues surrounding the site. This assessment resulted in the following preferential ranking of the four sites:

1. Poolbeg
2. Robinhood
3. Cherrywood
4. Newlands

Selected Site and Siting Conclusion

The Poolbeg Site has been identified as the preferred site through a systematic assessment of areas suitable for thermal treatment development in City/County Dublin. Preliminary assessment of available land in the Poolbeg Peninsula shows suitable land available adjacent to the existing sewage treatment works at Ringsend. The site offers potential for end market use, is not in close proximity to residential areas, and the new road developments will make the area very accessible from every part of the Region. The site currently contains a large amount of existing power industry with chimney stacks so the facility should not be visually intrusive on the landscape. It's location within the waste production centre of gravity for the region supports the proximity principle. However, all of these aspects together with issues raised in the public consultation process need to be carefully examined, as part of a complete Environmental Impact Assessment and having regard to the alternative sites.

In the next phase of development should take special note of the areas of ecological concern in close proximity to the site. The facility planning will need to satisfy the public concerns with ecologically sound engineering and development. In order to achieve success in siting any waste facility it is important to involve the public in the process, engender their trust and convince those most affected by the proposal that it is the best solution to the problem.

7. COST AND PROCUREMENT ISSUES

The approximate cost of a thermal treatment facility for 400,000 tonnes/annum is IR£120 million. Options for funding include EU financial support and/or application of the "Polluter Pay Principle" through waste producer charges as part of a Public Private Partnership arrangement currently favoured by government policy.

The plant should be procured using the Design, Build, Operate (DBO) procedure with the site owned by the four Dublin local authorities (similar to Dublin Bay Project) provided that EU Cohesion funding is secured. Otherwise, the Design Build Finance Operate (DBFO) route must be chosen. An EU procurement process should request proposals for "thermal treatment" to meet the most recently published Draft EU Directive on the Incineration of Waste (December 1998). An EIS will have to be carried out as part of the planning process together with an appropriate public involvement process where all issues concerning the public will be fully addressed in an open manner.

1. INTRODUCTION

1.1 BACKGROUND TO STUDY

The Dublin Waste Management Strategy Study completed by the MCCK Consultancy Group in December 1997 recommended thermal treatment of waste as part of an integrated solution to waste management in the Dublin region over the next 15- 20 years. The Study also recommended that a feasibility study be undertaken to investigate further the possibilities for thermal treatment in terms of available technologies, siting of a facility and public involvement. The Dublin Region for the purposes of the Study consists of the administrative areas of Dublin Corporation, Fingal County Council, South Dublin County Council and Dun Laoghaire Rathdown County Council and had a combined population of 1,056,666 in the 1996 Census.

1.2 WASTE MANAGEMENT PLAN FOR THE DUBLIN REGION

The Waste Management Plan was developed based on studies carried out for the Dublin Waste Management Strategy. The Waste Strategy Report was produced in December 1997 and presented to the Dublin Local Authorities in January 1998. The Strategy Study recommendations were accepted by each of the four Authorities in January 1998 who agreed to make a common Dublin Waste Management Plan. The Draft Plan was subsequently published for public consultation in July 1998. The final Plan incorporated revisions following the two-month consultation period. The Plan has now been adopted by Dublin Corporation, Dun Laoghaire Rathdown County Council, South Dublin County Council and Fingal County Council.

The Plan covers a five year period and will be reviewed after this period in accordance with the Waste Management (Planning) Regulations, 1997. These Regulations require that a Plan shall set out the present position regarding waste management and anticipated trends and developments over the period of the Plan. The Regulations also require an evaluation of Waste Policy Options in relation to the provision of services, the management of individual wastes, the achievement of waste hierarchy objectives and the enforcement/implementation of up to date legislation. Each of these aspects was considered in detail during the preparation of the Plan.

In formulating an integrated solution to waste management in the Dublin region a number of waste management scenarios were modeled to enable the Best Practical Environmental Option to be chosen. The chosen solution had to meet various EU and national recycling targets by increasing recycling and reducing dependence on landfill. These scenarios were as follows:-

Scenario 1: To meet Mandatory Recycling Targets and comply with Draft EU Landfill Directive.

Scenario 2: To achieve Maximum Realistic Level of Recycling.

Scenario 3: To meet Mandatory Recycling Targets, comply with EU Draft Landfill Directive and achieve efficient bulk waste reduction through thermal treatment.

Scenario 4: To achieve Maximum Realistic Level of Recycling to comply with EU Draft Landfill Directive and achieve bulk waste reduction through thermal treatment.

These four scenarios were compared on the basis of meeting strategy requirements in terms of technical capacity, environmental acceptability and cost. A detailed modelling exercise was carried out to determine the cost and environmental impact of each scenario. The environmental assessment had regard to factors such as global warming, acidification, nitrification and photochemical ozone formation, heavy metals and dioxins.

Scenario 4 was chosen as the Best Practicable Environmental Option in that it minimises landfill as far as possible, maximises recycling, meets all legal requirements and is the most robust and secure option for the future. The new approach includes thermal and biological treatment of waste. Both these treatment options were recommended for further study to determine the best available technological options not entailing excessive cost.

1.3 NATIONAL WASTE POLICY

National waste policy in Ireland is now governed by the Waste Management Act, 1996 which is being brought into law through a series of Regulations. The Waste Management Act is guided by the European hierarchical approach as follows:-

- Prevention/Minimisation
- Reuse / Recycling
- Energy Recovery
- Environmentally Sustainable Disposal of residual waste which cannot be prevented, recycled or recovered

The recent Policy Statement on Waste Management published by the Minister for the Environment and Local Government on 1st October, 1998 gives expression to the Irish Government's desire to cut our dependence on landfill by dealing with waste on a regional basis. It also advocates the need for an integrated approach funded by the "polluter pays principle".

This new national policy sets ambitious targets for waste diversion and recycling as follows:

- Diversion of 50% of overall household waste from landfill
- A minimum 65% reduction in biodegradable waste consigned to landfill
- 35% recycling of municipal waste
- The development of waste recovery facilities employing environmentally beneficial technologies as an alternative to landfill including composting
- Recycling of at least 50% of Construction & Demolition waste within a 5 year period with a progressive increase to at least 85% over 15 years

The Dublin Waste Management Strategy (1997) was developed before these targets were set. However the recommended strategy solution with maximum recycling and thermal treatment will enable the Dublin local authorities to meet the above targets. These targets and objectives have also been transposed into the Regional Waste Management Plan which has been adopted by all four Dublin authorities.

Figure 1.1 Dublin Waste Management Plan Implementation Thermal Treatment Study Area

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1.4 OBJECTIVES OF THE STUDY

The objective of the study is to carry out a feasibility study of thermal treatment of waste in the Dublin region as recommended in the Dublin Waste Management Strategy Study. The Study Brief states that the study should address the following issues:-

- Waste streams, volumes, and characteristics
- Technological options
- Environmental impacts
- Life cycle analyses
- End market use for energy and residual products
- Siting
- Examination of representatives facilities in other countries
- Procurement procedures
- Public consultation and involvement

1.5 CONTENT OF STUDY

The study team having reviewed the objectives and technical requirements carried out the study according to the following study programme:-

- Phase 1 Technical Issues Report on baseline studies, technological options, end market, procurement and environmental/siting issues.

- Phase 2 Siting and Environmental Issues Report on further development of environmental siting issues leading to selection of possible sites for thermal treatment with maximum public involvement.

This Report is intended to address Phase 2 of the study. The Phase 1 report was published at a press launch in the Gresham Hotel on 14th September, 1999 and the report is available in local libraries in the Dublin area.

The studies leading to this Report are the subject of EU Cohesion Fund Aid through the Department of the Environment and Local Government and it is hoped that this EU aid will extend to the Public Involvement Process also.

1.6 STRUCTURE OF REPORT

The main purpose of this report is to recommend sites which are suitable for the development of thermal treatment. These sites are recommended following a systematic siting process which involved the development of siting criteria and shortlisting of potential sites. A comprehensive public involvement programme was conducted to inform the siting process. An environmental evaluation of thermal treatment was also conducted in addition to a review of health issues.

2. ENVIRONMENTAL IMPACTS

2.1 INTRODUCTION

The environmental impacts associated with the incineration of municipal solid waste are considered for two types of thermal treatment plants, based on the recommendations in the "Feasibility Study on Thermal Treatment Options for the Dublin Region" dated September, 1999. The technologies include waste combustion with energy recovery, which is considered to be a reliable and well-known technology with a proven track-record, and Thermoselect, an emerging integrated pyrolysis/gasification technology.

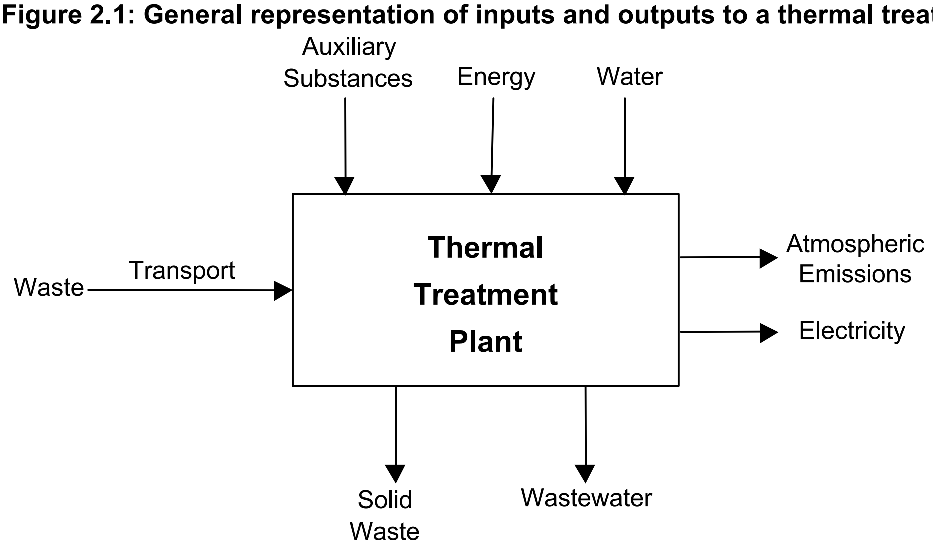
Environmental impacts related to waste combustion with energy recovery (waste combustion plants) are assessed based mainly on information obtained from a modern plant in Denmark (I/S Vestforbrænding) with a wet flue gas cleaning system and SNCR system (Selective Non-Catalytic Reduction). Since the new line (Anlæg 5) started operating in 1998, I/S Vestforbrænding has a capacity of up to 500,000 tonnes per annum of municipal solid waste.

The use of a waste combustion plant with a wet flue gas cleaning system as opposed to a dry or semi-dry system is used for illustrative purposes only and does not represent a technological choice, which may be made at a later stage. However, in Denmark waste combustion plants with wet flue gas cleaning systems are generally favoured because the quantity of residual waste produced by wet flue gas cleaning systems is approximately half and two-thirds less than that produced from dry and semi-dry systems respectively. In addition, emissions from plants with wet flue gas cleaning systems (WTE, see Table 2.1) are generally lower, particularly with respect to emissions of SO_2, HCl, NOx and dioxin. Wet flue gas cleaning systems are favoured despite the fact that wet systems cost at least 10% more than dry or semi-dry systems, and that no wastewater is generated from dry and semi-dry systems.

Environmental impacts related to the Thermoselect process are assessed based on information available from a plant with a steam turbine in Karlsruhe, Germany. The plant, with three lines of 10 tonnes/hour and a design capacity of 225,000 tpa, is now operating at close to full-capacity for the first time.

Although the sequence of unit processes within each thermal treatment process differ, the overall inputs and outputs that are most relevant are shown in Figure 2.1.

Figure 2.1: General representation of inputs and outputs to a thermal treatment plant.



Environmental impacts associated with the inputs and outputs to thermal treatment plants are shown in Figure 2.2. For each impact category shown the nature of the impact and an evaluation of the differences between the two types of thermal treatment plants under consideration are presented (Section 2.2). In addition to the environmental impacts, the risk of accidental and sudden occurrences is described. A screening life cycle analysis is then carried out and an overall comparison made between the environmental impacts of the waste combustion and Thermoselect processes (Section 2.3). Finally, the costs for both plants are estimated (Section 2.4). It is should be emphasised that all industrial processes and other waste treatment processes will result in environmental impact.

2.2 ENVIRONMENTAL IMPACTS

2.2.1 Emission Limits

Air quality associated with atmospheric emissions from thermal treatment plants is an important issue. New, more stringent emission standards that are similar to the current German standards (17. BImSch V) have been through a first reading in the European Parliament. However, the proposed limits still require final approval (a second reading) before replacing the existing Directive on Emissions from the Incineration of Municipal Waste 89/369/EEC, which according to the Danish EPA may take up to 2 years.

Table 2.1 below shows the emissions guaranteed for a modern waste combustion plant compared to a Thermoselect plant, as well as the proposed EU Limits. The type and quantity of the emissions depend on the nature of the municipal solid waste. For the purposes of this report, municipal solid waste treated is assumed to be the same regardless of the technology and type of thermal treatment system used. The main groups of pollutants from thermal treatment plants are micropollutants such as dioxins/furans, heavy metals, particulates (dust), acid gases (SO_2, HCl, HF) and nitrogen oxides. As a result of the fact that more flue gas is produced per tonne of waste from waste combustion plants compared to the Thermoselect process, the absolute emissions from WTE plants are significantly higher than from the Thermoselect process, except for emissions of HF (hydrogen fluoride). This is emphasised by e.g. emissions of carbon monoxide (CO) that indicate the degree to which waste is incinerated; lower carbon monoxide emissions are a sign of more complete combustion and cleaner flue gas.

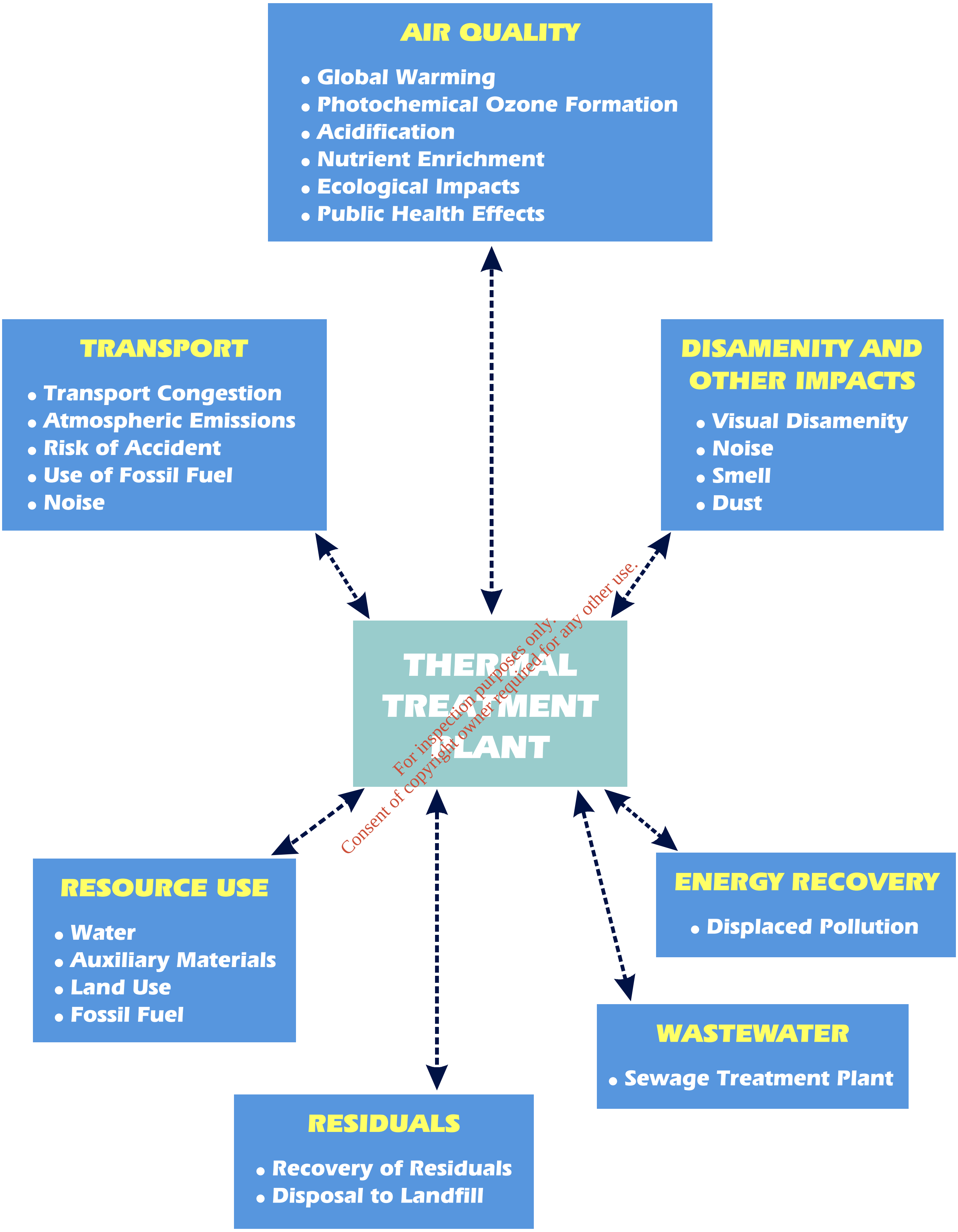


Figure 2.2 Environmental Impacts associated with Thermal Treatment Plants

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Table 2.1: Atmospheric emissions guaranteed for a modern WTE and Thermoselect plant per tonne of waste incinerated, and the proposed EU Limits for thermal treatment plants. Emissions are in mg/Nm^3 unless otherwise stated.

Pollutant	Proposed EU Limits	Emissions from Thermoselect	Emissions from WTE
Dust	10	3	3
CO	50	10	25
SO_2	50	10	25
NO_2	200	100	100
HCl	10	2	2
HF	1	0.2	0.1
(Cd + Tl) *	0.05	0.005	0.025
Hg	0.05	0.005	0.025
Heavy metals **	0.5	0.05	0.25
Dioxin (PCDD/F)	0.1 μg/Nm^3	0.01 μg/Nm^3	0.05 μg/Nm^3
Organics (TOC)	10	2	5

**Assumed emitted in ratio 1:1.*
*** Sum of Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V, Sn. Assume emitted in equal fractions.*

2.2.2 Air quality

In addition to meeting the EU limits for atmospheric emissions from the chimney or stack, planned thermal treatment plants are required to predict air pollution concentrations to document that their (future) impact on air quality is acceptable. Air quality standards set by the Irish EPA (shown in Table 2.2) must be met, including immediately down wind of the plant.

Table 2.2: Air quality standards and thresholds set by the Irish EPA

Pollutant	Averaging period	Limit value	Measured values
SO_2	Annual median of daily mean values	40-60 μg/m^3	23 μg/m^3
	98-percentile of daily mean value	100-150 μg/m^3	60 μg/m^3
Smoke	Annual median of daily mean values	40-60 μg/m^3	9 μg/m^3
	98-percentile of daily mean value	100-150 μg/m^3	39 μg/m^3
NO_2	Annual median of daily mean values	50 μg/m^3	Depends on e.g. traffic emissions
	98-percentile of hourly mean value	200 μg/m^3	
Ozone	Threshold for human health (8-hr mean)	110 μg/m^3	Comply
Pb	Annual median of daily mean values	2 μg/m^3	< 0.4 μg/m^3
CO	WHO Guidelines: 1 hour	26 ppm	1.60 ppm
	8 hours	8.7 ppm	1.59 ppm

WHO Guidelines are listed for CO; no Irish or EU standards exist for this pollutant. Measured values are also shown (Data from EPA Annual Report, 1997).

Although the level of air quality monitoring in Ireland is limited, Table 2.2 indicates that the measured values (for 1997) for urban areas are in general much lower than the existing air quality standards (EPA Annual Report, 1997). Air quality monitoring focuses on SO_2 and smoke (particulates), and the measured values as shown above from the Dublin corporation network, are well below the limit values. Monitoring for NO_2 occurs at two stations in Dublin and large differences exist between the values recorded, influenced by the physical siting of the monitors and the NO_2 emissions from local traffic, but are thought to be similar to the limit values. Finally, the measured ozone levels at the 6 stations in Ireland was mostly below the threshold limit for the protection of human health, and concentrations of Pb and CO measured in Dublin were well below the air quality standards. The measured air quality suggests that the contribution of atmospheric emissions from a thermal treatment plant in the Dublin area will probably not lead to air quality standards being exceeded.

Once a site has been chosen for the thermal treatment plant, site-specific air quality levels will have to be predicted. Different types of models are available to predict air pollution concentrations, ranging from complex physical models to the use of expert opinion. Numerical dispersion models, particularly Gaussian models, are the most frequently used to predict air pollution levels. The most relevant predictions relate to long-term (mean daily values) and short-term (maximum hourly values) ground-level concentrations. Required inputs to Gaussian models include local meteorological data, typically wind speed, wind direction, atmospheric stability, and emission data such as emission rate, stack height, stack diameter and flue-gas temperature. For example, prevailing winds in the Dublin area (as measured at Dublin airport in 1998) are south-westerly winds (220 to 270°) with typical wind speeds of 7 to 16 knots/hour. Models can also be used to determine the contribution of atmospheric emissions to aquatic toxicity including the sediments in the Irish Sea, and the potential effects.

Gaussian models can also be used to predict the necessary stack height to disperse pollutants and obtain a particular ground-level concentration. Certain pollutants can be decisive in determining the stack height, depending on the quantity emitted and the toxicity of the pollutant. For example, an EIA of a modern waste combustion plant in Denmark identified heavy metals including arsenic, cadmium and mercury as being most important for meeting air quality standards.

An overview of the impacts associated with atmospheric emissions from thermal treatment plants is given in the Table 2.3 below. Section 2.3 presents the results of an Life Cycle Assessment where the impacts are described in more detail and the relative magnitude of the (site-independent) impacts are compared. The impacts include global warming, photochemical ozone formation, acidification, nutrient enrichment and public health effects/toxicity (also discussed in Chapter 3). "Ecological impacts" in Table 2.3 comprise ecological impacts not already covered e.g. acidification, and typically refers to the toxic effects pollutants may have on fauna and flora. Once a site has been selected, an evaluation of these impacts must be carried out e.g. the previously mentioned contribution, if any, to aquatic toxicity in the Irish Sea, as well as the other impacts that have regional and local effects (all except global warming).

Table 2.3: Overview of impacts associated with atmospheric emissions (HM = heavy metals).

Impact	Pollutant(s)	Description
Global warming	CO_2, CO	Greenhouse effect causing climate change
Photochemical ozone formation (O_3)	VOCs, NOx	O_3 is a secondary pollutant formed from VOCs and NOx. Causes decrease in agricultural yield.
Acidification	SO_2, HCl, HF, NOx	Decline in coniferous forests, fish mortality, metal corrosion, damage to buildings
Nutrient enrichment	NOx	Aquatic ecosystems - eutrophication; terrestrial ecosystems - disappearance of e.g. heathland
Public health effects	O_3, HM, dioxins, particulates etc.	See Chapter 3 and Section 0 (toxicity to humans)
Ecological impacts	HM, dioxin etc.	Pollutants having toxic effects on fauna/flora

2.2.3 Wastewater

The amount of wastewater generated from thermal treatment plants is generally relatively small. Thermoselect claim that no wastewater is generated from the thermal treatment process as the wastewater is cleaned and reused or evaporated. At modern waste combustion plants, approx. 0.1 m^3 wastewater/tonne waste is usually discharged into the sewage system after chemical treatment. As much of the treated wastewater as possible is reused, which reduces the need to use drinking water, as well as the amount of treated wastewater discharged.

In addition to more stringent limits for atmospheric emissions from thermal treatment plants, EU limits have also been proposed for wastewater emissions from thermal treatment plants, in connection with the new Directive which is to replace the existing Directive on Emissions from the Incineration of Municipal Waste 89/369/EEC (see Section 2.2.1). The proposed EU limits for wastewater are shown in Table 2.4. The proposed EU limits are thought likely to be finally approved within the next two years.

The toxic effects of discharging treated wastewater to a sewage treatment plant are thought to be relatively limited, although the high concentrations of salts, can exceed the limits set by the environmental protection authorities, particularly for waste combustion plants with wet flue gas cleaning systems.

Table 2.4 Proposed EU Limits for wastewater discharged (to the sewage system) from thermal treatment plants, in mg/l of wastewater.

Parameter	Proposed EU limit
Suspended solids	45 mg/l
As	0.15 mg/l
Pb	0.2 mg/l
Cd	0.05 mg/l
Cr	0.5 mg/l
Cu	0.5 mg/l
Hg	0.03 mg/l
Ni	0.5 mg/l
Tl	0.05 mg/l
Zn	1.5 mg/l
2,3,7,8-TCDD	0.3 mg/l

2.2.4 Residual solid waste

The total amount of solid waste produced per tonne of waste treated is similar for both waste combustion and Thermoselect plants (see Table 2.5), and can be categorised into waste that can potentially be reused and hazardous waste that requires disposal at a controlled landfill site.

Table 2.5 Quantities of solid waste produced from thermal treatment plants (in kg/tonne of waste treated) and their estimated value based on current prices (in IR£/kg of solid waste produced).

Solid waste	Waste Combustion with Energy Recovery (kg/tonne waste)	Thermoselect (kg/tonne waste)	Estimated value (IR£/kg solid waste)
Residual waste	42		- 0.03 IR£/kg
Heavy metal compounds		8	- 0.03 IR£/kg
Total waste to landfill	***42***	***8***	**-**
Metal	30	30	0.02 IR£/kg
Vitrified granulate		345	0.0015 IR£/kg
Bottom ash	320		0 IR£/kg
Sulphur		2	0 IR£/kg
Mixed salts		12	0 IR£/kg
Total reusable waste	***350***	***389***	**-**
Total solid waste	***392***	***397***	**-**

2.2.5 Potentially reusable waste

Bottom ash from waste combustion plants can be used for e.g. road construction as an aggregate in road base material, although further processing may be required depending particularly on the concentrations of heavy metals and dioxin in the bottom ash. However, bottom ash does not have much value (possibly two orders of magnitude less than vitrified granulate). However there is considerable debate at present as to whether the environmentally preferred solution for bottom waste is reuse, as opposed to disposal to landfill, considering the uncertainties involved regarding the quantities of pollutants e.g. heavy metals in the bottom ash, which may eventually be released (over 1000s of years). The range in concentration of various heavy metals in bottom ash from waste combustion plants, which varies depending on the composition of the waste treated, is given in Table 2.6. I/S Vestforbrænding (1998) state that the content of dioxin in bottom ash is <5 ng/kg waste treated, and the content of TOC is <1% of the weight of bottom ash produced.

Table 2.6 Typical ranges in the total quantities of various heavy metals found in bottom ash, based on data from different countries (IAWG, 1997).

Heavy metal	Typical range (mg/kg solid waste)
Fe	4,100 - 150,000
Cu	190 - 8,200
Cr	23 - 3,200
Ni	7 – 4,300
Cd	0,3 - 71
As	0,12 - 190
Pb	98 – 14,000
Zn	610 - 7,800
Hg	0,02 - 7,8

Metals with high boiling points (well over 1,500°C) including Fe, Cu, Cr and Ni, tend to be preferentially concentrated in bottom ash whereas metals that are relatively volatile such as As, Cd, Hg and Pb, are typically found in higher quantities in fly ash and flue gas cleaning residues. Metal can be recovered from bottom ash from waste combustion plants and can potentially be sold on the scrap market e.g. to a steel works. The composition of this "metal" waste (in Table 2.5) is not known precisely, but will contain metals such as Fe.

Bottom ash and vitrified granulate make up the bulk of solid waste produced from the waste treatment process. In addition, both processes generate the same amount of recoverable metal waste. The vitrified granulate produced from the Thermoselect process may have a higher (economic) value than bottom ash produced from waste combustion plants. Thermoselect maintain that vitrified granulate can be used as an aggregate for concrete (the value of which is shown in Table 2.5), as well as in road construction, like bottom ash. However, it is uncertain whether the granulate is being used to produce concrete at the present time and no information is available about the total quantities of pollutants in the granulate. Furthermore the stability of the metals in the granulate over the long term is unknown. Recovered metal from the waste treatment process at the Thermoselect plant can be sold on the scrap market e.g. to a steel works.

Solid waste products from the wastewater treatment systems include sulphur (70-80% dry matter) removed from the synthesis gas via the sulferox system, which can be sold to the chemical industry but is not thought to be of much value, and mixed salts (90-97% dry matter) composed of 90% natrium chloride.

2.2.6 Waste to landfill

Residual waste arising from waste combustion plants (see Table 2.5) includes fly ash and flue gas cleaning residues (sludge), as well as gypsum produced from the SO_2 removal system. Residual waste is regarded as hazardous and in general needs to be treated (stabilised) prior to disposal at a controlled landfill site. Major environmental impacts associated with the disposal of residual waste include transport to the landfill site and the production of leachate containing high concentrations of pollutants, such as heavy metals, salts and organic compounds.

The Thermoselect process also produces a waste that requires landfilling ("heavy metal compounds" in Table). The composition of the heavy metal compounds is not clear, but it will probably contain most of all Zn, Cd, Tl, Sb and Pb in the original waste. Thermoselect maintain that the heavy metal waste is composed of 20-30% Zn.

2.2.7 Impact of solid waste

The amount of potentially reusable waste that can be reused in practice depends on the existence of a market for the different waste types. However, even if the possibility of reusing the waste exists, the environmental benefits of reusing the waste and therefore the most "sustainable solution" is unclear. For instance, in the short-term the reduction in the amount of waste to be landfilled may be reduced by using e.g. bottom ash or vitrified granulate as road fill, but in the long-term (on the order of thousands of years) the impacts of leachate generated on the soil and groundwater may be the same or more significant than impacts from disposing of the waste at a landfill site.

Concerning waste to landfill, an apparent environmental advantage of the Thermoselect process is the lower quantity of hazardous waste requiring landfill compared to the waste combustion process. However, the quantities of residual waste produced from a waste combustion plant depend largely on the composition of the waste treated, e.g. the amount of fly ash produced is 20 ±10 kg/tonne.

Comparing the environmental impacts associated with both the hazardous and potentially reusable wastes produced by waste combustion and Thermoselect (shown in Table 2.5) is not straightforward. The amount and composition of different waste types from WTE, and probably also Thermoselect, depends on the nature of the waste treated. Further comparison is not possible without more detailed knowledge of the composition of the waste generated by the Thermoselect process, particularly the total concentration of heavy metals in different waste types. Finally, establishing a special system for the collection of metals and hazardous waste prior to thermal treatment is crucial (as part of an integrated, overall waste management system), since such material entering a thermal treatment plant is either emitted via the stack, or accumulates in the solid waste.

2.2.8 Energy recovery

Energy can be recovered from the thermal treatment of waste, both in the waste combustion process and via the burning of synthesis gas in the Thermoselect process. Table 2.7 shows the net amount of electricity produced after accounting for the electricity consumption of the plant, which for the Thermoselect process includes the additional energy required to produce oxygen (refer to Table 2.7). Energy produced from both types of thermal treatment processes is assumed to be used to generate electricity (not heat, although selling heat to industry could be a possibility depending on the location of the plant). The electricity generated for both plants is calculated for waste with a lower heat value (LHV) of 9.1 and 11 MJ/kg, which is the range typically expected for municipal solid waste.

In addition, two different efficiencies for the steam turbine at the Thermoselect plant are compared including 27% and 32% efficiency. The dimensions of the steam turbine influence the efficiency of the energy generation process, and 27% corresponds to the most realistic efficiency obtainable. A higher efficiency (32%) is also used, as the highest realistic efficiency for plants with higher capacities e.g. on the order of 400,000 tpa.

Table 2.7 Net electricity produced from energy recovered during thermal treatment in kWh/tonne of waste.

LVC	WTE*	TST (27%)	TST (32%)	Units
9.1 MJ/kg	560	51	120	kWh/tonne
11 MJ/kg	677	193	289	kWh/tonne

*Waste Combustion with energy recovery

Electricity produced from the thermal treatment of waste displaces pollution, particularly atmospheric emissions and the use of fossil fuels, which would otherwise have occurred from an alternative source of electricity such as a coal-fired power station. As can be seen in Table 2.7, the electricity generated (and hence pollution displaced) from waste combustion is significantly higher than from a Thermoselect plant, even with a high LHV and a highly efficient steam turbine. This difference is primarily due to the low energy efficiency of the Thermoselect process (heat loss prior to electricity generation), together with the energy required to produce oxygen and run the plant.

2.2.9 Disamenity and other impacts

Disamenity will be used as a general term to refer to the nuisance caused as a result of the existence of thermal treatment plants including noise, dust, odours, and visual disamenity.

Noise

The impact of a thermal treatment plant on the level of noise in the area surrounding the plant should be assessed, and models exist for this purpose. Sources of noise considered are the thermal treatment plants and internal transport; noise from the traffic associated with waste deliveries is not usually determined. If the noise from the plant is likely to exceed the regulatory limits, mitigation measures should be taken.

The noise pollution from waste combustion plant (I/S Vestforbrænding) meets the Danish noise limits for residential areas: 45/40/35 dB(A) during the day/evening/night-time. The closest residential areas are approximately 150-300 meters east/south east from the edge of the plant, where measurements are taken to ensure compliance with the noise limits. Noise emitted from the Thermoselect plant at Karlsruhe is thought to be similar to that emitted from the waste combustion plant. The closest residential area to Thermoselect is approx. 500 m from the plant.

Dust

In addition to being emitted from the stack, dust can also be produced when the waste is delivered to the thermal treatment plant. Emissions of dust can be minimised by unloading waste in a closed building and extracting the air from the unloading area into the furnace, thereby burning the dust. In addition, the unloading area and waste silos are fitted with sprinklers that can be used to minimise dust emissions when necessary. Finally, internal transport of dust-emitting auxiliary materials and waste products occurs indoors to reduce the risk of fugitive dust emissions.

Odours

Odours can arise when waste is delivered to the thermal treatment plant, and, just as for dust emissions, odours can be minimised by unloading waste in a closed building and sucking the air from the unloading area into the furnace, thereby burning any odorous emissions. Internal transport of odorous auxiliary materials and e.g. waste sludge from the wet scrubber system or cleaning of wastewater, should occur indoors to reduce the risk of odorous emissions.

Visual disamenity

The thermal treatment plant will have a visual impact on the landscape, particularly the plant buildings, stack and plume. The land area requirements for both thermal treatment plants is similar, but the physical appearance of the buildings may differ. The stacks of thermal treatment plants in Denmark are typically between 70-120 m (Christensen, 1998) e.g. the stack height of a waste combustion plant with a capacity of 500,000 tonnes/year (I/S Vestforbrænding) is 105 m. As a result of the lower atmospheric emissions from the Thermoselect plant, the stack height required may be lower than for the waste combustion.

2.2.10 Transport

The presence of a thermal treatment plant gives rise to impacts related to waste deliveries. Predicting these impacts requires determining the number of deliveries and when they occur, the type of vehicle used, and the route(s) taken. For example, 209-365 waste deliveries/day would be expected to a thermal treatment plant with a capacity of 380,000 tonnes/year assuming that 4-7 tonnes of waste transported/delivery and that deliveries occur 5 days/week. This information can then be used to assess the resulting environmental impacts including traffic congestion, noise and vibration, accidents and safety, use of fossil fuel (oil), as well as atmospheric emissions and resulting impacts compared to the impacts from the existing traffic levels.

The impacts related to waste deliveries to and from a thermal treatment plant in the Dublin region will be similar regardless of the type of plant chosen, although the magnitude of certain impacts such as traffic congestion will be site-specific.

2.2.11 Resource use

A resource refers to a primary raw material used in the thermal treatment process, including both renewable or non-renewable resources. Resources used include water, fossil fuel, land and auxiliary materials.

Table 2.8: Resources used in the WTE and Thermoselect thermal treatment processes. Water used at the Thermoselect process is reused at the plant.

Resource	WTE	Thermoselect
Water	0.25 m^3/tonne	1.36 m^3/tonne
Fossil fuel	0.5 l fuel oil/tonne	15 Nm^3 natural gas/tonne
Land use	2-4 ha	2-4 ha

Water use

The quantity of water used for both types of thermal treatment plants is relatively low (see Table 2.). The water consumed is typically of secondary quality i.e. not drinking water and the impacts on the environment occur at the local scale.

Fossil fuels

Fossil fuels such as fuel oil are used to start up and shut down WTE plants, whereas the Thermoselect process requires fossil fuel to burn with the synthesis gas in the boiler. The amounts of fossil fuels used are relatively low, with Thermoselect requiring higher quantities than WTE.

Auxiliary materials

Auxiliary materials used in the flue gas cleaning processes are listed in Table 2.9. Cleaning the flue gases at waste combustion plants is necessary before the gases are emitted to the atmosphere and involves electrostatic precipitation of suspended solids, followed by washing of the gases in a scrubber using a mixture of water and reagents. Reagents include $CaCO_3$ that removes HCl/HF, and NaOH to neutralise SO_2. Removal of NOx and dioxins occurs by injecting activated carbon into the flue gas stream (SNCR process). Additional substances e.g. flocculating agents are used to clean the wastewater produced during the flue gas cleaning process.

The synthesis gas produced at Thermoselect plants is cleaned before being burnt to generate electricity. Synthesis gas is shock cooled by passing the gas through a series of cold water jets. Subsequently, sulphur is removed from the synthesis gas (sulpherox system) and activated coke is used to remove dioxins and heavy metals. Condensed pollutants in the wastewater are removed in sedimentation tanks. Among other things, reverse osmosis is used to clean the wastewater, which is then reused at the plant or evaporated.

Table 2.9 Quantities of auxiliary materials (in kg/tonne of waste) used in the WTE and Thermoselect thermal treatment processes.

Auxiliary substance	WTE (kg/tonne)	Thermoselect (kg/tonne)
CaCO3	14	
NaOH	4	12
TMT (100%)	0.2	
Polymer (100%)	0.01	
Iron	0.05	0.75
Activated carbon	0.5	1.3
NH3-water (25%)	3	
O2 (95%)		500
HCl	0.1	6
H2O2		0.05
Glycerine		0.15
Ion exchanger		0.07

**Activated coke is used for Thermoselect.*

One of the most notable differences in the auxiliary materials used in the thermal treatment processes (Table 2.9) is the use of oxygen as opposed to air in the Thermoselect process. Producing oxygen requires a relatively high amount of energy and is also partly responsible for the low amount of energy recovered from the Thermoselect process (see Section 2.2.8).

Auxiliary materials used during thermal treatment processes are transported to the plant in sealed containers and handled indoors, so that the risk of spill or emissions of e.g. dust, noise and smell are expected to be minimal. However, the impacts on the working environment are a possibility and appropriate safety precautions should be taken when handling the materials (esp. the hazardous substances).

2.2.12 Accidental and sudden occurrences

Waste Combustion with Energy Recovery

A waste combustion plant consists of the following main components/systems:

- Receiving silo with crane and shredder
- Incinerator grate and back-up burners
- Steam boiler and turbine
- Ammonia injection system
- Electrostatic-filter
- Scrubbers
- Lime injection system
- Dioxin filter
- Slag handling system
- Flue-gas residue handling system
- Various support installations

All components are based on well proven technology and when designed and operated according to regulations the operation of such a plant is very safe.
There are of course certain operational risks, as at any other industrial plant. The main risks relate to:

1 Fire in the silo
2 Fire in the dioxin filter
3 Leaks of high pressure feed-water and steam system
4 Overheating
5 Explosive matter in the waste
6 Leak of ammonia
7 Contact with flue-gas residuals

Mitigation measures

Fire in the silo occurs relatively frequently and is extinguished using water canons permanently installed in the silo.

Fire in the dioxin filter may occur if glowing particles reach the filter. If the dioxin filter of a line at the plant catches fire, fine contaminated carbon particles will be emitted (on the order of a few tonnes), requiring a new filter to be installed. For waste combustion plants with wet flue gas treatment systems this is very unlikely to happen as the flue gas has passed 2 wet scrubber stages and is cooled before reaching the dioxin filter.

Leaks from high pressure water and steam systems are dangerous for operation personnel, but these systems are very well known in industrial applications and in industry, and work has to be carried out in accordance with strict regulations. If well maintained, these systems do not cause unacceptable risks for personnel.

Overheating of the boiler may cause damage and steam outlets in the boiler. The main reason is lack of feed water. Therefore, dual feed-water pumps should be installed together with an UPS system (Uninterruptable Power Supply), and a dual water level control system.

Waste may contain explosive matter such as gas bottles. Due to the large volume in the grate-fired boilers, the boilers can normally withstand the shock-waves caused should an explosion occur. Explosions may also occur in the silo or shredder. Therefore windows in the concrete silo are made of safety glass and explosion vents are installed.

A sudden leak of ammonia, used to remove NOx, is acutely dangerous. However, even small leaks are very easily detected by smell long before dangerous concentrations are reached. In addition, filling stations and tanks are normally located outdoors.

Contact with flue-gas residuals should be avoided due to long term, toxic effects of heavy metal compounds. Residuals are normally handled when moist i.e.65% dry matter, reducing the risk of fugitive dust emissions. Appropriate safety equipment is necessary.

Thermoselect

A Thermoselect plant consists of the following main components/systems:

- Receiving silo with crane, shredder and waste conveyer
- Pyrolysis unit
- Oxygen blown gasifier and back-up burners
- Gas cleaning system

- Activated coke filter
- Steam boiler and turbine
- Slag handling system
- Flue-gas residue handling system
- Various support systems.

A Thermoselect plant is not much different from a waste combustion plant. The main difference is that the product gas is cleaned and combusted instead of burning the fuel and cleaning the flue-gas. The main risks relate to:

- Fire in the silo
- Fire in the activated coke filter
- Leaks of high pressure feed-water and steam system
- Overheating
- Explosive matter in the waste
- Leak of synthesis gas
- Contact with flue-gas residuals
- Internal explosion in the gas bearing equipment

Mitigation measures

Similar to a waste combustion plant however at a Thermoselect plant the risk of fire is further reduced by the fact that the silo and conveyers are closed vessels covered by inert (non-flammable) N_2 gas.

Similar to a waste combustion plant. The gas passes quench and wet scrubbers and is cooled before reaching the activated coke filter that removes dioxin. The filter has to be emptied 4 times per year, and appropriate clothing including mask should be worn.

Mitigation measures concerning leaks of high pressure feed waste and stream system are similar to waste combustion plants.

Mitigation measures concerning overheating are similar to waste combustion plants.

Mitigation measures concerning explosive matter in the waste are similar to waste combustion plants. All waste passes though the shredder, which retains any explosive matter before it enters into the incinerator.

Leak of synthesis gas: The synthesis gas is poisonous and explosive in small concentrations due to the concentrations of CO and H_2 respectively. To reduce the risk of a gas leak, the gas system is operated under slight low pressure. In case of high pressure the gas is led to a flare for safe combustion and outlet to the atmosphere. To reduce the risk of explosion in case of a leak, all electric installations are Ex-proof and the building is well ventilated and built with a hinged roof.

Mitigation measures concerning contact with flue gas residuals are similar to waste combustion plants.

Internal explosion in the gas bearing equipment: There is a small potential risk of internal explosion in the gas bearing equipment as oxygen is added to the high temperature gasifier reactor. The danger only normally arises when there a certain mixture of gas and oxygen/air occurs. However, under normal operating conditions there will only be an internal flame around the oxygen inlet, as ignition will take place instantaneously at the high temperatures inside the reactor, and critical gas mixtures are avoided (oxygen reacts to form CO_2 and H_2O.
Furthermore the gas bearing equipment is designed for the deflagration pressure. In the event of an internal explosion, pressure release capsules and water seals will be blown out.

Occurrences at the Thermoselect plant in Karlsruhe

During commissioning of the Karlsruhe plant, 3 main problems have been reported:

A) Problems with the control of the waste crane (normal during initial "running in")

B) Leaking synthetic membrane in the sedimentation basins (2 no's 20m long 4m deep have been repaired)

C) Explosion in the cooling water pipe due to a closed shut-off valve (procedure fault). It is claimed that the one of three pumps overheated.

All problems have now been rectified and Thermoselect emphasise that the accident was not related to the key technology. The accident was caused by human error - closing a valve that must be open during operation. The accident could have happened at any plant with a steam cycle, including traditional WTE plants.

Safety analysis

According to EU directives it is compulsory to carry out an HAZOP analysis (HAZard and OPerability analysis) for new industrial plants as part of the approval procedure, including a technology such as the Thermoselect process. An HAZOP analysis identifies potential deviations from normal operating conditions and their consequences and possible reasons for the deviations are studied assisted by an impartial risk assessment specialist. Depending on the expected frequency of deviations and potential consequences, a certain number of barrier points may be needed and can be defined to ensure a certain level of safety at the plant. Existing and planned barriers are studied and where barrier points are missing, extra barriers are introduced until the required demand for safety is reached (typically a calculated value of 1 deadly accident per 1000 years is acceptable or 1 deadly accident per specific person in critical areas per 10,000 years)
An HAZOP analysis according to the German Standard 12.BIm Sch V was carried out for the Karlsruhe plant for approval of the plant during the planning stage, but the analysis should be repeated/revised for all new plants, as control philosophy and plant details normally vary from plant to plant.

Although no formal requirements exist for a HAZOP analysis to be carried out for waste combustion plants, it is recommended that an analysis be performed for some of the systems at the plant, such as the dioxin filter.

2.3 LIFE CYCLE ASSESSMENT

2.3.1 Goal definition

A screening life cycle assessment (LCA) was carried out to obtain an indication of the magnitude of the environmental impacts arising from the thermal treatment of municipal solid waste using the two processes mentioned previously including:

- Waste combustion process with wet flue gas cleaning system (WTE)
- Thermoselect process (integrated pyrolysis/gasification) with steam turbine.

The LCA is essentially a simplified version of a Danish LCA method (EDIP - Environmental Design of Industrial Products) where emphasis is placed on the environmental impacts related to atmospheric emissions.

LCA methods cannot, at present, assess the environmental impacts resulting from e.g. the disposal of waste to landfill associated with thermal treatment. In view of this limitation, impacts related to solid waste produced, together with other impacts associated with thermal treatment discussed in the previous section are summarised separately in Table 2.10 below.

2.3.2 Scope definition

The functional unit is the thermal treatment of 1 tonne of municipal solid waste.

Assessment criteria

A simplified version of an LCA method (EDIP) is used to assess the (site independent) effects related to atmospheric emissions from thermal treatment plants. In particular, the impact categories global warming, photochemical ozone formation, acidification, nutrient enrichment, and human/persistent toxicity are considered.

The amount of displaced pollution resulting from energy produced from the combustion of waste is also considered. Energy from the combustion of waste is assumed to be used to generate electricity only (not heat). Benefits are associated with generating electricity, and atmospheric pollutants emitted from a conventional coal-fired power plant are attributed to the thermal treatment plant producing the least amount of electricity, in an amount equivalent to the difference in electricity produced by the two plants.

Environmental impacts related to the construction and decommissioning phases of the thermal treatment plants (including for example energy, materials, transport, noise and dust) are not considered although there may be differences depending on the plant type, especially with respect to the energy and material requirements during the construction phase. Environmental impacts are examined for thermal treatment plants under normal operating conditions i.e. excluding accidental and sudden occurrences (discussed in Section 2.2.13).

Technological scope

Environmental impacts are assessed based mainly on information obtained from I/S Vestforbrænding (WTE) in Denmark, for waste combustion, and Thermoselect process in Karlsruhe, Germany. Both these thermal treatment plants are described in more detail in the Feasibility Study for Thermal Treatment of Waste for the Dublin Region (Draft Report, September, 1999).

It is assumed that the outputs (and inputs) for both thermal treatment plants are independent of the plant capacity; only the energy generated varies depending on the lower heat value (LHV) of the waste. The electricity generated for both plants is calculated for waste with a LHV of 9.1 and 11 MJ/kg, as well as two different efficiencies for the steam turbine at the Thermoselect plant (27% and 32% efficiency). The highest and lowest differences between the electricity generated at the two different plants are used to obtain a range of values. This corresponds to an LHV of 11 MJ/kg and Thermoselect with an efficiency of 32%, and an LHV of 9.1 MJ/kg and Thermoselect with an efficiency of 27% respectively.

Time scale

No time scale is defined during which the environmental impacts of thermal treatment are to be considered. A default value of 100 years is used for assessing the global warming potential.

Inventory

The inventory phase involves the collection and presentation of environmental information relating to the functional unit. An inventory of the most important outputs from thermal treatment plants are the atmospheric emissions for which EU limits have been proposed (listed in Table 2.1). In addition, emissions related to displaced pollution are taken into consideration (see Appendix A.).

Impact assessment

The information collected during the inventory is interpreted at the impact assessment stage. Interpretation of the inventory results occurs in three steps:

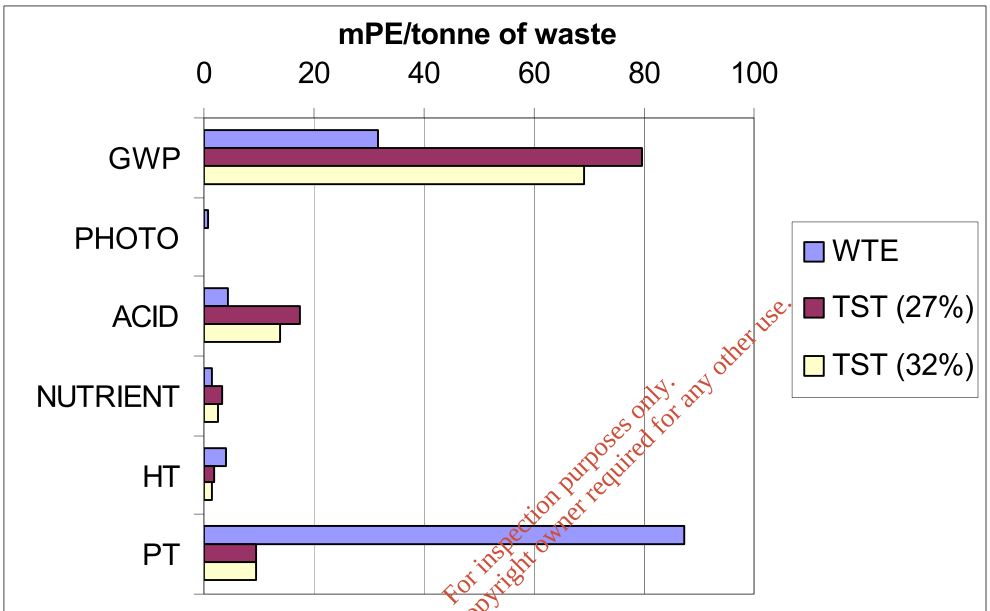
1. The first step involves classification of environmental information into impact categories and conversion to impact potentials.

2. In the second step, impact potentials are normalised by comparison with a background impact.

3. In the final step the relative importance of the impact potentials are weighted.

The normalised impact potentials are presented in Figure. The final step (weighting) is not performed, as this typically involves comparison to e.g. politically targeted reduction goals. Normalised impact potentials relate impact potentials to a background impact expressed as an average impact per person, and are therefore expressed in person equivalents (PE), to enable comparison of the alternative thermal treatment processes. For each impact category in Figure, the nature of the impact is briefly described and the most environmentally desirable process (WTE vs. TST) is discussed.

Figure2.3: Normalised environmental impacts (in milli PE) resulting from the thermal treatment of 1 tonne of municipal solid waste using WTE (waste combustion) and TST (Thermoselect). Percentages in parentheses refer to the steam turbine efficiency for TST.



Global warming potential (GWP)

Emissions of e.g. CO_2 and CO contribute to global warming, also known as the greenhouse effect. The global warming potential for the thermal treatment plants includes an estimate of the amount of CO_2 (in this case the amount of CO is negligible in comparison) emitted from the combustion of waste, since an equal amount of the waste with similar lower heat value and carbon content is assumed to be treated at both plants. In particular, the waste contributing to global warming is waste from non-renewable materials such as plastics; other combustible waste made from renewable material such as paper and waste food is considered to be CO_2-neutral. The global warming potential also includes emissions related to the combustion of fossil fuels (fuel oil and natural gas).

For the Thermoselect process, which generates less electricity than WTE, the global warming potential also depends on the amount of CO_2 (and CO) resulting from the production of extra electricity from a coal-fired power station.

As a result of the thermal treatment of non-renewable material, the global warming potential is one of the two most important impact categories. The difference in electricity produced by the two thermal treatment processes additionally means that the global warming potential is significantly higher for the Thermoselect process than WTE.

Photochemical ozone formation (PHOTO)

Photochemical ozone is a secondary pollutant formed from volatile organic compounds (VOCs) and NOx in the presence of sunlight. Ozone increases the frequency of asthma and problems with the respiratory tract in humans, and is particularly associated with smog in cities. Ozone is also responsible for reductions in agricultural yield.

In this case, photochemical ozone formation can be neglected. The emissions of carbon monoxide and volatile organic compounds are not high enough to bring the value of the normalised impact potential over 1 mPE per tonne. The ozone levels recorded in Ireland are generally low, due to the limited emissions of precursor pollutants and prevailing weather conditions (EPA Annual Report, 1997).

Acidification (ACID)

Once deposited onto soil or water, atmospheric emissions of acidic compounds can result in a decrease in pH which is contributes to e.g. the widespread decline of coniferous forests. Acidification also leads to the corrosion of metals and disintegration of the exterior of buildings.

The most significant sources of acidifying compounds are combustion processes associated with electricity and heat production, and transport. Both the emissions from the thermal treatment plant and, for Thermoselect, the emissions from a coal-fired power plant used to generate electricity contribute to acidification. The Thermoselect process contributes significantly more to acidification than WTE.

Nutrient enrichment (NUTRIENT)

Nutrient availability is typically a growth limiting factor in ecosystems, and compounds containing nitrogen and phosphorous can cause eutrophication in aquatic ecosystems, and the disappearance of nutrient-poor terrestrial ecosystems such as raised bogs and heathland. The use of fertilisers in agriculture is a considerable source of nutrients to aquatic ecosystems, but combustion processes also contribute to nutrient enrichment of both aquatic and terrestrial ecosystems.

The emissions of nitrogen oxides from thermal treatment and electricity generation are slightly higher for Thermoselect, although compared to the other impact categories nutrient enrichment is not an important impact.

Toxicity to humans (HT and PT)

Atmospheric emissions that are harmful can contribute to human toxicity via exposure through the air, but also soil and water. Two impact categories are concerned with toxicity including human toxicity and persistent toxicity (HT and PT respectively in Figure).

Human toxicity (HT) represents the potential for toxicity via the atmosphere on a predominantly local scale. If the concentrations of harmful substances emitted are sufficiently high, toxic effects can occur a short time after human exposure, in this case via inhalation of air. Potential human toxicity is significantly higher for WTE than Thermoselect and are approximately twice as high if emissions corresponding to the proposed EU limits are assumed as opposed to the emissions that are typically measured. The higher value for WTE is obtained mainly because of the higher emissions of lead, cadmium and dioxin from the stack. Nonetheless human toxicity is not as important as persistent toxicity.

Persistent toxicity (PT) is assumed to represent toxicity to humans on a predominantly regional scale via exposure to soil and water. A certain fraction of atmospheric emissions of pollutants with a lifetime in the atmosphere of more than one day are assumed to reach the water and soil compartments after dispersion, and can cause longer term toxicity compared to exposure via the air. Along with the global warming potential, persistent toxicity is one of the most important impact categories. The high value obtained for WTE is a result of emissions of pollutants that are harmful, not readily degradable and have a tendency to bioaccumulate, and include dioxin, and to a lesser extent mercury. Therefore, the amount of dioxin (and mercury) emitted from the thermal treatment plants has a crucial influence on the reliability of the normalised results. For example, assuming emissions for WTE correspond to the proposed EU limits (i.e. varying the emissions by 50%) increases the impact potential for persistent toxicity by 100%.

The very low values obtained for Thermoselect compared to WTE may in fact be higher, because emissions of heavy metals and dioxin from displaced pollution (emissions from coal-fired power plant) associated with Thermoselect have not been considered. Data are not readily available and no emission limits exist for these pollutants at EU level. However, emissions of heavy metals and dioxins are thought to be approximately one order of magnitude less than the corresponding emissions from thermal treatment plants, and will therefore not influence the overall results.

2.3.3 Summary of environmental impacts

The environmental impacts associated with the inputs and outputs to WTE and Thermoselect plants are listed in Table 2.10 below, and the most environmentally favourable thermal treatment process for each impact is indicated.

Table 2.10: Comparison of environmental impacts associated with thermal treatment processes WTE and Thermoselect.

Environmental Impact	WTE	Thermoselect
Air quality:		
GWP	✓	
PT/HT		(✓)
ACID	✓	
Wastewater		✓
Residual solid waste		(✓)
Energy recovery	✓	
Disamenity		(✓ visual disamenity)
Transport	-	-
Resource use	(✓)	

A tick mark indicates the process with the lowest environmental impact. A tick mark in parentheses indicates that the process may have the lowest environmental impact, and a dash shows that the processes have impacts of equal magnitude.

The most important environmental impacts relate to air quality, including global warming potential and toxicity to humans; energy/electricity production; and solid waste production. It is necessary to point out that the capacity and number of thermal treatment plants does not affect the magnitude of the environmental impacts shown as these have been assessed independently of location. Only the impacts related to transport, which are site-specific and assumed to be the same regardless of the thermal treatment process selected, are influenced by the capacity and number of plants.

The main advantage of waste combustion with energy recovery is the high quantity of electricity generated compared to the Thermoselect process, which helps reduce the need to use conventional energy sources. As a result, the global warming (and acidification) impact potential is lower for waste combustion compared to Thermoselect, despite the lower atmospheric emissions from the Thermoselect process itself.

The main advantage of using the Thermoselect process is the lower emissions from the process itself, which will lead to a better air quality in the area surrounding the plant. However, from a life cycle perspective, Thermoselect results in higher impacts associated with the significantly lower amount of electricity generated. Environmental benefits may be associated with the residual solid waste produced by the Thermoselect process, as it may be easier to recover different fractions (e.g. salt, sulphur, metal compounds) and therefore easier to reuse them, although not enough information is available concerning the composition of the residual solid waste to be able to draw any definite conclusions. In addition, residual solid waste produced by conventional power plants (17-22 kg/tonne of waste treated) also requires disposal to landfill. Another advantage of the Thermoselect process relates to the absence of wastewater produced.

2.4 COSTS

The costs are calculated for the thermal treatment processes under consideration, namely waste combustion with energy recovery (WTE) and Thermoselect. In order to give an impression of how costs vary according to the capacity of the plant, costs have been calculated for both WTE and Thermoselect thermal treatment plants assuming capacities of approximately 200,000 tpa and 380,000 tpa. In addition, to lower heat values are assumed for the municipal solid waste including 9.1 and 11 MJ/kg, which represent the realistic range expected.

As for the environmental assessment, the costs calculated for WTE are for a plant with a wet flue gas cleaning system, which costs at least 10% more than dry or semi-dry systems.

Costs of treating 380,000 tpa

Table 2.11 shows the costs of thermal treatment plants with a capacity of 380,000 tpa. For WTE, 380,000 tpa corresponds to having e.g. 3 lines each capable of treating 16 tonnes/hr, and for Thermoselect, 4 lines treating 12.5 tonnes/hr (which is the standard capacity of a line). Costs are shown for municipal solid waste with lower heat values (LHV) of 9.1 and 11 MJ/kg, which primarily influence the income from the sale of electricity, but also the total operating costs for WTE plants.

The costs of investment for a WTE plant are between 11 and 16% less than for a Thermoselect plant, which gives an annual cost that is at least 1.5 mIR£ lower for WTE, although using e.g. 15 years and 6% p.a. (as opposed to 12 years, 5% p.a.) would lower the annual cost of a Thermoselect plant. Total operating costs per year are also less for WTE (about 11 to 15% compared to Thermoselect). The resulting overall cost per year is between 36 and 40% cheaper for WTE.

Table 2.11: Costs (in millions of IR£) associated with thermal treatment of approx. 380,000 tpa for a 3 x 16 tonnes/hr WTE plant and a 4 x 12.5 tonnes/hr Thermoselect plant (27% efficiency). Costs are shown for two different lower heat values (LHV).

Item	WTE		Thermoselect (27%)	
	9.1 MJ/kg	11 MJ/kg	9.1 MJ/kg	11 MJ/kg
Cost of investment	102	108	121.6	121.6
Annual cost (12 years, 5% p.a.)	11.5	12.2	13.7	13.7
Total operating costs	6.2	6.4	7.3	7.3
Income from sale of electricity	5.3	6.4	0.5	1.8
Income from sale of residues	0.2	0.2	0.4	0.4
Resulting overall cost per year	12.2	11.9	20.0	18.7

As well as the lower heat value, the steam turbine efficiency at Thermoselect plants also influences the income from the sale of electricity. Table 2.12 shows the variation in overall costs per year assuming an efficiency of 27%, and a higher efficiency of 32%, which represents the highest realistic efficiency for plants with capacities on the order of 400,000 tpa. Despite a higher efficiency of 32%, the overall costs per year for WTE are still 33 to 37% cheaper than for Thermoselect.

Table 2.12: Overall costs per year (in millions of IR£) associated with thermal treatment of approx. 380,000 tpa for a 4 x 12.5 tonnes/hr Thermoselect plant. Costs are shown for different lower heat values (LHV) assuming steam turbine efficiencies of 27% and 32%.

LHV	Thermoselect (27%)	Thermoselect (32%)
9.1 MJ/kg	20.0	19.4
11 MJ/kg	18.7	17.7

Costs of treating 200,000 tpa

Table 2.13 shows the costs of thermal treatment plants with a capacity of 200,000 tpa, corresponding to 2 lines each treating 12.5 tonnes/hr for both WTE and Thermoselect. Costs are shown for municipal solid waste with an LHV of 9.1 MJ/kg. The efficiency of the Thermoselect steam turbine is assumed to be 27%, which is the most realistic efficiency for a plant with a capacity of 200,000 tpa.

When the capacity of the thermal treatment plant is on the order of 200,000 tpa, the costs of investment and annual cost for a WTE plant are only 4% less than for a Thermoselect plant, which is less than the difference for a plant with twice the capacity. However, as a result of lower operating costs and income from the sale of electricity, the overall cost per year is still cheaper for WTE compared to Thermoselect (by about 25%).

Table 2.13: Costs (in millions of IR£) associated with thermal treatment of approx. 200,000 tpa with an LHV of 9.1 MJ/kg, for a 2 x 12.5 tonnes/hr WTE plant and a 2 x 12.5 tonnes/hr Thermoselect plant (27% efficiency).

Item	WTE	Thermoselect (27%)
Cost of investment	70	73
Annual cost (12 years, 5% p.a.)	7.9	8.2
Total operating costs	4.6	4.9
Income from sale of electricity	2.8	0.3
Income from sale of residues	0.1	0.2
Resulting overall cost per year	9.5	12.6

Although the costs for WTE and Thermoselect plants with a capacity of 200,000 tpa are similar, comparing Table 2.11 and Table 2.13 suggests that the costs associated with a Thermoselect plant of 200,000 tpa are similar to the costs of a WTE plant with twice the capacity.

3. REVIEW OF HEALTH ISSUES

3.1 INTRODUCTION

Thermal treatment of waste in particular incineration is an established waste management technique in Europe. It began in the last century as a method of improving sanitary conditions in cities. Its use grew rapidly after the Second World War and by the 1980's there were over 400 incinerators treating municipal waste in Europe. For many years this growth in the technology was not matched by improvements in operating standards and most incinerators had only minimal control on emissions. This lead to public concern about thermal treatment of waste following the discovery of dioxins in fly ash from municipal waste incinerators in 1977.

This prompted the European Commission to take action and by 1989 two Directives were introduced applying new standards for emissions to the atmosphere from municipal waste incineration. The first of these Directives set out limits for acid gases, dust and heavy metals to be achieved by all new incinerators and the second applying to all existing facilities set lower standards but required that all existing plants should achieve the standards by 1 December 1996. Any plant unable to comply would be required to close. Many older plants especially smaller facilities were unable to meet these new standards and had to be closed. The standards are set to become even more stringent with the introduction of the Draft Directive on the Incineration of Waste (December 1998) which will set a limit value for dioxins/furans which were not covered in the previous Directive.

In reviewing the health issues associated with thermal treatment it was found that most of the published literature relates to occupational or accidental levels of exposure to higher levels of pollutants than expected from waste incineration. In general the data on effects of low level exposure of pollutants either singly or in combination is lacking. Furthermore many of these chemicals are already present in the environment from a variety of other sources making it difficult to evaluate the effect if any of additional exposure resulting from emissions from a thermal treatment plant.

3.2 SELECTED POLLUTANTS

The atmospheric pollutants from waste combustion processes fall into six principal categories:-

- Products of incomplete combustion
- Fine particulate matter (dust)
- Trace organic substances e.g. .dioxins/furans
- Acid gases
- Nitrogen oxides
- Heavy metals
- Greenhouse gases

These pollutants originate both from within the waste itself and from the combustion process. The pollutants of most concern in terms of public health are dioxins/furans, heavy metals and dust. Sophisticated pollution abatement equipment now exists to deal with these pollutants and removal efficiencies in excess of 99% can now be attained for most of these substances. The new Directive will now ensure that all plants control emissions within very strict limits. In terms of human health the principal exposure route to these pollutants are inhalation and ingestion.

3.3 DIOXINS

Dioxin is a generic name used to describe a family of compounds known as chlorinated dibenzo-p-dioxins. Dioxins can have between one and eight chlorine atoms and the number of chlorine atoms and their position on the molecule determine the physical and chemical properties and the toxicity. There are as many as 210 closely related organic compounds among which 17 have been identified as demonstrating high toxicity. These compounds are divided into two groups:-

- Polychlorinated dibenzo-para-dioxins (PCDDs)
- Polychlorinated dibenzofurnas (PCDFs)

Furans are structurally similar to dioxins and elicit similar toxic and biochemical responses in animals. In general dioxins and furans are highly persistent compounds with a strong affinity for soil and sediment. The two groups are usually referred to as dioxins and furans and the term dioxin is often used to describe both in less technical circles. They are ubiquitous in the environment and have been found in all media i.e. air, water, soil, sediments, animals and food.

Dioxins do not occur naturally nor are they intentionally manufactured by industry except in small amounts for research purposes. They occur as by-products of other processes where chlorinated compounds are formed such as with some herbicides, bactericides and wood preservatives. They are also produced in small quantities in a wide range of combustion processes (within a temperature range of 250-400^{o}C) where organic materials and chlorine compounds are burned together. Such sources can include incineration of waste, metallurgical operations such as smelting and scrap metal recovery furnaces and the burning of fuels such as coal, wood and petroleum products. Other significant sources are believed to be motor vehicle emissions (mainly from leaded fuels) and emissions from domestic fires, particularly when domestic waste is used on these fires (Concannon, 1996).

The United Nations produced a report in May 1999 which summarises the findings in dioxin research and technology and is the first attempt to compile dioxin and furan inventories. From existing inventories a number of conclusions were drawn including the following:-

- The best coverage exists for municipal solid incineration for both stack emission measurements and activity rates. As this sector undergoes the most dramatic changes in technology, emission factors and PCDD/PCDF emissions change rapidly. As a consequence strong downward trends are recognised in countries with modern technology or rigid legislation.

- The sector of hazardous waste incineration is relatively homogeneous and does not present a major source in any country.

- There is only limited information available from the iron and steel producing sector. Some European countries have identified this sector as the major contributor to national dioxin inventories.

- From some countries the inventory should be updated to improve estimates of the present situation, especially when more stringent regulation has been established.

Due to the improvements in emission control technology the dioxin inventory is declining and the WHO have recommended a tolerable daily intake of 1 to 4 picograms per kilogram body weight per day. While the population is exposed to small amounts of dioxins about 98% of this intake is from dietary sources such as food and milk with inhalation only accounting for a minor intake (ATSDR, 1992).

The health effects of dioxins have been extensively studied in animals and have been shown to have some adverse effects at high dose levels. There is no evidence however, to show that the average daily dioxin exposure of between 1-3pg/kg/day poses any cancer risk in humans (ATSDR, 1992).

3.4 HEAVY METALS

Heavy metals are metals with a high atomic number and include elements such as cadmium, mercury and lead. Cadmium occurs naturally in the environment predominately in the form of chloride, sulphide and oxide. Industry is a larger user of cadmium principally in the production of alkaline batteries and industrial pigments but also in welding and electroplating operations. A large proportion of persons living in industrial nations are exposed to cadmium due to its ubiquitous nature. Exposure is largely through food but cigarette smoking also exposes individuals to high levels of cadmium. Occupational exposure can result in respiratory illness, kidney dysfunction and increased risk of lung cancer. There is no evidence that such illnesses occur from environmental exposure.

Mercury is a naturally occurring metal which has several forms. Metallic mercury is a shiny silver white odourless liquid and if heated is a colourless gas. Mercury combines with other elements such as chlorine to form inorganic salts and with carbon to make organic compounds of which the most common is methylmercury which is produced mainly by small organisms in soil and water. Metallic mercury is used to produce chlorine gas and caustic soda and also used in dental fillings, thermometers and batteries. Mercury salts are used in skin lightening creams and antiseptic creams and ointments. The sources of inorganic mercury in the environment include air emissions from mining ore deposits, manufacturing plants, and the burning of coal and waste. It enters soil and water from natural deposits, disposal of wastes and volcanic activity. Merthylmercury or organic mercury bioaccumulates in larger organisms such as fish. The nervous system is very sensitive to all forms of mercury. Merthylmercury and mercury vapours are more harmful than other forms. Exposure to high levels of metallic, inorganic mercury can permanently damage brain, kidneys and developing foetus. Short term exposure to high levels of mercury vapour may cause effects such nausea, vomiting and diarrhoea. The WHO has no guideline for mercury in ambient air due to lack of quantitative information on the consequences if any of the deposition of mercury from outdoor air.

Lead occurs naturally in the environment as a blue/grey metal found in small amounts in the earth's crust. It is ubiquitous in the environment and comes from human activities such as mining, manufacturing and combustion activities such as the burning of fossil fuels and waste. The health effects of lead have been well publicised for the past twenty years or so and lead from petrol, paint and ceramic products, pipe solder etc have been dramatically reduced in recent years. While lead can affect almost every organ and system in the body it is particularly known to affect the central nervous system and infants and young children are most at risk. These effects are most common after high exposure to lead and the effects if any of low exposure to lead is uncertain. The contribution of thermal treatment to lead related illnesses is likely to be negligible compared to other sources.

3.5 DUST

Dust is present in the atmosphere from a number of industrial and natural sources. Inhalation is the main exposure route to dust airborne particles and it is the particles less than 10 microns that are of greatest concern as these can reach deep into the lungs. Exposure to these particles is most associated with cardiopulmonary symptoms over a long term. However these effects are more likely to predominate in susceptible populations, smokers, and those with existing pulmonary or cardiovascular disorders. Pollution abatement equipment can achieve very high removal efficiencies of dust up to 99.8 %. Consequently the contribution of thermal treatment to these illnesses will be negligible compared to all the other possible contributors.

3.6 EPIDEMIOLOGICAL STUDIES

There is a scarcity of information concerning the human health effects of exposure to the low levels of pollutants associated with thermal treatment facilities as many of the studies relate to much higher exposure levels related to occupation or accidents. Some examples of epidemiological studies investigating the health of populations living close to thermal treatment facilities are described herein.

The Small Area Health Statistics Unit in the UK (Elliot et al 1996) carried out a study entitled cancer incidence near municipal solid waste incinerators in Great Britain. The study area was chosen to be within 7.5 km of municipal waste incinerators in Britain. In total 72 such incinerators were found dealing with household, commercial and/or industrial waste. All the facilities included in the study were build prior to 1976 and therefore lacked modern flue gas cleaning systems. The study was conducted in two phases the first phase related to persons living within 3 km of an incinerator which resulted in 20 incinerators being included in the first phase of the study. The second phase of the study included the remaining 52 facilities and thus was based on a larger sample size. In summary the study involved observations on over 14 million people for up to 13 years. The study found no evidence overall for decline in risk with distance from incinerators for a number of cancers including non-Hodgkin lymphomas and soft tissue sarcomas. There were some significant findings for all cancers combined, stomach, colorectal, liver and lung cancer. However the authors highlighted that this was more likely explained by difficulties with the data interpretation such as assumptions made to account for socio-economic factors in addition to a substantial level of misdiagnosis of primary liver cancers. It is also particularly noteworthy that this study was based on very old facilities none of which would be operating to the current high level of emission standards.

An earlier study also conducted by the Small Area Health Statistics Unit in the UK (Elliot et al 1992) found no evidence to suggest excess risk of cancers of the larynx or lung among residents living near incinerators of waste solvents and oils of the type found at Charnock Richard near Coppull in Lancashire. This conclusion was based on a study of 20 incinerators with a feedstock of mainly waste oils, solvents or both. The purpose of the study was to investigate an alleged disease excess near an industrial site using routine sources of data and to extend the inquiry to other similar sites. The study also concluded that the apparent cluster of cancer of the larynx previously observed at Charnock Richard was unlikely to be due to its former incinerator. It should be noted this study was based on facilities treating industrial wastes none of which would be capable of meeting the current emission standards.

4 PUBLIC INVOLVEMENT

4.1 INTRODUCTION

A public involvement programme was conducted during the siting phase of the study. It was recognised that there was a need to involve the public at an early stage in the siting process to assist with the scoping of issues such as site selection and criteria for assessing acceptability of impacts. The programme was designed with the advice of Dr. Judith Petts Risk Communications Consultant and EIA specialist who is Professor of Environmental Risk Management at the University of Birmingham.

A four strand approach to public involvement was adopted based on knowledge of local issues and the experience of successful and unsuccessful siting studies of thermal treatment plants elsewhere.

- Strand 1: Presentation and briefing to Elected Members of the four local authorities on the Dublin Waste Plan Implementation, biological treatment and thermal treatment studies
- Strand 2: Establishment of Community Focus Groups within the four local authority areas
- Strand 3: Public opinion surveys on proposed waste management strategy option, facility siting criteria and scoping of key environmental issues associated with thermal treatment plants in Dublin.
- Strand 4: Proactive public information campaign involving national and local media, public displays and other suitable consultation fora.

4.2 PRESENTATION AND BRIEFING TO ELECTED MEMBERS

A presentation to the Elected Members took place on 14th September, 1999 in the Gresham Hotel. This took the form of a press briefing whereby the progress of the Dublin Waste Management Plan was outlined. Presentations were given by representatives from Dublin Corporation, M.C. O'Sullivan & Co. Ltd. and Tobin Environmental Services Ltd. The feasibility studies on thermal and biological treatment were outlined and reports were made available which are now in all the Dublin libraries.

4.3 ESTABLISHMENT OF COMMUNITY FOCUS GROUPS

A research exercise was carried out with the assistance of Lansdowne Market Research to establish and facilitate meeting with community focus groups. The main objectives of the research were as follows:-

- To understand the public attitudes and behaviour towards waste management
- To identify the public's criteria for selecting sites for Thermal Treatment Plants

The groups were selected to reflect the demographic breakdown of the Dublin population based on Census figures. The breakdown of the groups was as follows:-

Table 4.1: Composition of Community Focus Groups

Group	Age	Social Class	Sex	Local Authority
1	20-24	ABC1	Male	Dun Laoghaire Rathdown
2	20-24	C1C2	Female	Fingal
3	25-34	ABC1	Mixed	South Dublin
4	25-34	C2DE	Mixed	Dublin Corporation
5	35-49	ABC1	Mixed	Dun Laoghaire/Rathdown
6	35-49	C1C2	Mixed	South Dublin
7	50-64	ABC1	Mixed	Dublin Corporation
8	65+	C2DE	Mixed	Fingal

The groups reflected the broad socio-economic breakdown of the Region and included housewives, full and part time employed, retired, students and unemployed. One meeting of 2 hour duration was held with each group in a local hotel.

4.3.1 Research Findings

The information obtained from the groups can be summarised under the following heading:-

- Attitudes towards waste disposal
- Reaction to different waste treatment methods
- Attitude towards thermal treatment
- Siting Criteria

Attitudes towards Waste Disposal

It was found that people fell into three groups with regard to their attitudes towards waste disposal. These groups of people can be described as active disposers, responsive disposers and dismissers. The active disposers take responsibility and would be more conscious of environmental issues and feel they have a role to play in the future of the environment. Such people are likely to recycle as much as possible and may have a home compost heap. The responsive disposers are people who are prepared to take some responsibility and will participate in local authority initiatives such as Christmas tress recycling or kerbside collection. However these people are not highly motivated and are likely to lapse when it becomes difficult. The remaining group are those who currently take no responsibility and rarely give consideration to environmental issues.

In general the collection of household waste is taken for granted by most people and once collected few really give any consideration to what happens next. The majority were aware that it went to landfill and some thought it may be burnt. Some thought that waste may be treated prior to disposal and that some waste is segregated for recycling. It was also considered that recycling may be a viable business however some recognised that paper recycling is not presently viable. While waste is not high on the agenda it was considered that awareness of waste as an environmental issues is increasing due to difficulties of siting landfills and provision of kerbside collection of recyclables in some localities.

It was concluded that Irish people are less concerned than their European neighbours about waste disposal and this lack of concern about waste is exacerbated by the fact that waste disposal is a low priority for the Irish government reflected through lack of awareness of waste disposal issues, lack of facilities for recycling and lack of enforcement of policies. The absence of enforcement of policies means that only those who feel strongly about the issues feel any onus to take responsibility or initiative. There is also no doubt that much of the current apathy towards waste disposal is caused by the fact that the domestic waste collection service is currently free.

Reaction to different waste treatment methods

The different options for managing waste were presented to the groups to ascertain their opinions. The options presented included recycling banks, kerbside collection, composting, recycling of construction/demolition waste, collection of harmful hazardous waste, thermal treatment and landfill. There are many factors influencing attitudes towards waste treatment options and to gain acceptance there must be awareness and familiarity of the treatment method, understanding of the level of personal effort required and the impact on people and the environment. Ultimately everybody is concerned about the impact on them personally and their families. The focus and factors that motivate people to accept a particular treatment will vary with active disposers more likely to be concerned about environmental matters, the responsive disposers concerned about the level of personal effort involved and the dismissive people needing more information to increase level of motivation.

Attitudes towards Thermal Treatment

Thermal treatment was discussed with the groups in order to obtain initial impressions, reaction following provision of some facts, siting criteria, information needs and information providers. The initial reactions to thermal treatment is one of uncertainty as the term is not generally associated with waste treatment/disposal. It therefore in most peoples mind refers to incineration as other thermal treatment options would not be known to the general public. The more informed people appreciated that incineration was commonly used in other European countries to treat municipal waste and is an option that must be considered in Ireland. However incineration in general had a negative image and was associated with large chimneys, health implications and environmental implications such as smog.

When presented with some facts about incineration there was an appreciation of the possible benefits as follows:-

- The bulk reduction of waste by as much as 90% was seen to be very positive
- The generation of electricity was seen as very positive in addition to the possible use of ash residual for road construction. However there was speculation regarding the electricity production in cost/benefits terms.
- A key benefit was the lack of effort required from the individual in that waste would continue to be collected from their homes.
- It was considered important that thermal treatment is part of an integrated solution in conjunction with better recycling initiatives.

There were also a number of concerns expressed about thermal treatment as follows:-

- Level of emissions and how these are prevented
- What waste will be thermally treated. Will any hazardous waste be treated and will this result in toxic emissions.
- Likely impact of emissions on public health

There was however comfort taken from the fact that the emissions are no worse than from other industries, the emissions must meet EU standards and actual emissions are less than EU limits. A number of issues arose regarding the safety of the facility in the context of well publicised incidents such as the recent nuclear explosion in Japan. There was concern over who would run the plant and monitor the safety standards. It was concluded that strict monitoring of the facility by an independent body is essential. There was concern that if the facility was privately owned profit motivation might compromise safely standards.

Concern was also expressed regarding the cost of the plant and whether thermal treatment would be financially viable in Ireland due to the low population density compared to the rest of Europe. The appearance of the plant is also critical to its public acceptance and it was considered essential that the plant be in keeping with current Irish industrial architecture for new facilities.

In summary the benefits and concerns can be summarised as follows:-

Benefits	**Drawbacks/Concerns**
• Waste Reduction	Emissions
• Energy Creation	Safety Standards
• Recycling waste (recycling ash)	Cost Implications
• Limited personal effort	Appearance

Siting Criteria

The criteria considered essential to siting a facility relate to people, environment and financial/business considerations. It was felt that the site should be located away from densely populated residential areas and schools. The reasoning behind this was based on possible health implications and impact on property values. There was also a desire that the siting process be fair and that the burden is shared with some resistance to the idea of solving other local authorities problems. There was concern that areas that hold less clout for example council areas may end up victims.

Environmental criteria related to transportation in particular with a good road network considered critical given Dublin's current road congestion problems. There was also concern as to whether there would be any noise or smell implications given that the plant may be running for 24 hours. The appearance of the plant should be in keeping with other industries and blend in with the existing industrial environment. There was a small number of people concerned about the cost of transporting waste to the site and also the ease of transferring energy to the national grid or other potential energy users. The groups concluded that in choosing possible sites for thermal treatment consideration need to be given to the following:-

- Population density
- Good road network
- Safety
- Financial viability
- Energy usage
- Appearance of the Plant

Other Findings

A very useful aspect of the research was that it gave some indication of the type of information the general public need to be provided with in order to gain a better appreciation of the waste management issues in Dublin. In particular information is needed on current waste management, future options and to be educated on the thermal treatment concept, siting criteria and the management, ownership and monitoring of the plant. Public trust in the system is critical to the successful implementation of the Plan as there has been a lack of trust in the past of both central and local government.

4.4 PUBLIC OPINION SURVEY

A public opinion survey was conducted for the study team by Lansdowne Market Research to provide more information about the public attitude to waste management including thermal treatment. This survey was designed by Lansdowne Market Research in association with the study team and is included in Appendix B of this document. The survey consisted of 506 interviews spread across the four Dublin local authority areas. The purpose of the surveys was to inform further the siting process and to gain an understanding of public opinion on waste issues and thermal treatment of waste.

The preliminary results of the survey indicate the following:-

- Lack of awareness
- About 56% of respondents expressed concern about landfill sites
- Only 18% of respondents have heard of thermal treatment as a means of treating municipal waste
- 69% of respondents don't have an opinion on thermal treatment (based on the fact that they haven't heard of it)
- 25% of respondents think thermal treatment is a good idea
- 72% of respondents think an integrated waste management solution including thermal treatment is a good idea
- the main concerns expressed with regard to thermal treatment are emissions, family health and smell
- the criteria considered important in siting a thermal treatment plant were away from residential areas and schools, playgrounds, etc, emissions, noise, smell and road network.

4.5 PROACTIVE PUBLIC INVOLVEMENT CAMPAIGN

Now that the short-list of sites for thermal treatment, biological treatment and the residual landfill are known it is likely that there may be specific reaction in the communities directly affected by the proposed developments. There is also a likelihood that some environmental organisations may disagree with elements of the integrated Waste Plan.

Maximum public information on the true nature of the proposals needs to be given using the following approaches:-

- Press Releases
  The integrated approach of the Plan should be highlighted in all news released to the media. The choice between thermal treatment and less landfill and the fact that cutting down on landfill is directly related to thermal treatment being available, needs to be highlighted on

every occasion. The message that recycling on its own will be insufficient to meet the national targets for diverting waste from landfill needs to be emphasised.

- Newsletter
  A newsletter on the integrated approach to waste management in Dublin should be produced and circulated early in the New Year to all Dubliners in the four local authority areas. The content should include general information on all elements of the Plan; recycling and factors likely to hinder its development such as current recycled paper market. In terms of thermal treatment both sides of the argument will have to be outlined. This should be complimented with information on thermal treatment plants in Europe, examples of countries closing down old incinerators and replacing them with new ones or with new thermal technologies.

- Local Liaison Groups
  It will be essential to set up a forum for meeting with local residents to discuss their concerns. Also the option to provide additional facilities needs to be explored.

- Study Tour
  Once the proposed site locations are known, representatives of the local community should be invited to visit existing plants. Representatives of the local community where the plant is in operation should also be invited to Dublin to meet the local community and tell them about their experience of living with a thermal treatment plant.

- National Debate
  The proposed Study Tour for the Elected Members of Dublin Corporation will attract national publicity, particularly since the environmental correspondents of the national media will be invited along and will be reporting on the trip. The national media should be encouraged to debate the issues involved in the Waste Plan.

- Environmental Educational Officer
  A campaign to broaden awareness of the work being undertaken by the Environmental Educational Officer recruited by Dublin Corporation should form an important part in the implementation of the Dublin Waste Plan. Any initiatives undertaken by any of the four local authorities relating to waste minimisation and recycling should be promoted throughout the region.

- Use of New Logo
  The new logo, representing the new way forward for managing waste in the Dublin region needs to be displayed prominently on all new facilities or on any existing facilities that have been upgraded and improved. This is already being done in Dublin Corporation's area and should be extended to show good practice in action throughout the Region.

5. DEVELOPMENT OF SITING CRITERIA

5.1 SITE SELECTION GUIDELINES

The need for thermal treatment as a means for maximising landfill diversion has already been established in the Dublin Waste Management Plan. As with all waste management facilities the identification of areas suitable for a thermal treatment plant needs to be undertaken according to a systematic selection process having regard to technical, environmental, social and economic criteria. The aims of the selection process are as follows:-

- To minimise environmental impacts
- To protect the health and well being of the local community
- To minimise the cost of the development

5.1.1 Legislation and Official Guidelines

As thermal treatment of municipal waste is not an established technology in Ireland there are no national guidelines regarding the selection of areas suitable for the location of thermal treatment facilities. There are however Draft EPA Guidelines for Landfill Site Selection. In the absence of specific documents guidance must be taken from relevant legislation. The primary pieces of legislation are:-

- 89/369/EEC Air Pollution from New Municipal Waste Incinerators
- Proposal for a Council Directive on the Incineration of Waste 1998
- The Waste Management Act, 1996

The Waste Management Act is an enabling piece of legislation being brought into law through a series of Regulations. There is no specific guidance regarding siting of thermal facilities, however the broad thrust of the Act supports thermal treatment in that it supports the EU waste hierarchy of reduction, reuse, recovery including energy recovery and finally landfill of residual wastes. The proposal for a Directive on the Incineration of Waste aims to reduce as far as possible negative effects on the environment. In particular the effects on air, soil, surface water and groundwater and the resulting risks to human health from the incineration and co-incineration of waste, and to that end to set up and maintain appropriate operating limit values for waste incineration and co-incineration plants within the community.

The site selection process has been made using all available guidelines and information within the parameters of the legislation. A proactive public involvement process outlined in Chapter 4 informed the process and was instrumental in the formulation of guidelines for future site selection processes.

5.2 SELECTION PROCESS

5.2.1 Methodology

The general procedure for the Study is a sieving process whereby exclusionary factors are first examined. These are factors, which preclude the siting of a Thermal Treatment plant and include the following:

- Proposed Natural Heritage Areas
- County Development Plans

- Areas of High Amenity or Archaeological Interest

These factors are classed as "*Group 1*" criteria. By excluding these, generally suitable areas emerge. "*Group 2*" criteria are then considered. These are more significant criteria, which may have serious financial implications for the development of a Thermal Treatment Plant and include the following:

- Road Access
- Traffic
- End-Market Use
- Site Size and Current Land Use
- Proximity to Residential Areas
- General Planning and Environmental Considerations

Using this set of criteria the generally suitable areas were narrowed down to 4 generally suitable/possible sites. The suitability of 4 shortlisted sites was further assessed resulting in a preferential ranking for the siting of a Thermal Treatment facility.

5.3 GROUP 1 CRITERIA – EXCLUSIONARY ZONES

5.3.1 City & County Development Plans

The siting of a Thermal Treatment Plan in the Dublin Region should have regard to local development policy as outlined in the following Development Plans:

- Dublin City Development Plan 1999
- Dun Laoghaire/Rathdown County Development Plan 1998
- Fingal County Development Plan 1999
- South Dublin County Development Plan 1998

These are legal documents prepared by each local authority to provide a framework for the guidance and control of development within the Dublin Region. The site selection process should have regard to the Plans as existing and future landuse in the vicinity of proposed sites needs to be determined. Population trends, development plan zoning, designated industrial areas, end market users and proposed changes in the transportation network need to be evaluated.

Development plan zoning objectives may vary between local authority areas. Objectives may be included to provide for natural assets or amenities specific to that area such as the protection of the Dublin Mountains or areas of urban renewal.

5.3.1.1 Dublin City Development Plan 1999

The siting of a Thermal Treatment Plant in the Dublin City area would have to have regard to the Dublin City Development Plan (1999). The plan is one of a number of corporate policy documents, which have key influence on the control of development in the City. The Plan deals with the comprehensive planning of the city for the next five years while taking account of longer term trends and objectives. The City Development Plan divides the city into a number of zones listed from Z1-Z15 each having a zoning objective, as listed in Table 5.1 and illustrated in Figure 5.1. This table also illustrates the acceptability of the siting of a Thermal Treatment plant in the various zones.

The Plan addresses the most commonly encountered activities within the City and indicates the acceptability or otherwise of the proposed land use. The guidelines as suggested in this plan are as follows:

- **Permissible Use**
  Is one which is generally acceptable in principle in the relevant zone, but which is subject to normal planning consideration including policies and objectives outlined in the Plan.

- **Open for Consideration Use**
  Is one which may be permitted where the Planning Authority is satisfied that the proposed development would be compatible with the overall policies and objectives for the zone, would not have undesirable effects on the permitted uses, and would otherwise be consistent with the proper planning and development of the area.

Thermal Treatment is accounted for in the Plan under the landuse, 'Incineration.' This use is classed as 'permitted in principle' in objective Z7, while this land use is not permitted under any other zoning objective.

Table 5.1 Land Use Zoning Objectives in Dublin City

Zone	Zoning Objective	Thermal Treatment Acceptability
Z1	To protect and/or improve residential amenities	Not Permitted
Z2	To protect and/or improve the amenities of residential conservation areas	Not Permitted
Z3	To provide for and improve neighbourhood facilities	Not Permitted
Z4	To provide for and improve mixed-services facilities	Not Permitted
Z5	To consolidate and facilitate the development of the central area, and to identify, reinforce, strengthen and protect its civic design character and dignity	Not Permitted
Z6	To provide for the creation and protection of enterprise, and facilitate opportunities for employment creation	Not Permitted
Z7	**To provide for the protection and creation of industrial uses and facilitate opportunities for employment creation**	**Permitted in Principle**
Z8	To protect the existing architectural and civic design character, and to allow only for limited expansion consistent with the conservation objectives of the Development Plan of primarily residential and compatible office and institutional uses	Not Permitted
Z9	To preserve and provide recreational amenity and open space	Not Permitted
Z10	To be developed in accordance with approved mixed-use action area plans	Not Permitted
Z11	To protect and improve canal, coastal and river amenities	Not Permitted
Z12	To ensure that existing environmental amenities are protected in any future use of these lands	Not Permitted
Z13	To seek the social, economic and physical rejuvenation of an area	Not Permitted
Z14	To seek the social, economic and physical rejuvenation of an area with mixed use, of which residential and 'Z6' would be the predominant uses	Not Permitted
Z15	To provide for institutional and community uses	Not Permitted

Source: Dublin City Development Plan (1999)

It is the high level of urbanisation and its associated high residential population, which particularly distinguishes this local authority area from the other three study areas. This factor is reflected in the zoning objectives and land use designations.

The zones Z1, Z2 and Z8, the main residential zoned areas, create exclusionary zones for a vast area of the City. The amenity potential of the area is protected by the zoning objectives Z9 and

Z11, which provide for the preservation and improvement of waterways and open space. These areas are also exclusionary to Thermal Treatment development.

The main areas that create exclusionary zones are objectives Z1, Z2, Z3, Z4, Z5, Z6, Z8, Z9, Z10, Z11, Z12, Z13, Z14, and Z15 (Figure 5.2). These zones include the greater plan of Dublin Corporation area. Areas that contain sections of land not in an exclusionary zone include:

- Ashtown
- Coolock
- Darndale
- Dublin Port/Docklands Area
- Inchicore
- St. James's Gate

5.3.1.2 Dun Laoghaire-Rathdown County Development Plan 1999

The Development Plan consists of a number of zoning objectives, which are illustrated in Figure 5.3 and listed in Table 5.2. The table also illustrates the acceptability of 'Industry Special' which is the use class under which Thermal Treatment would fall.

This local authority is distinguished from the other study areas by its maritime association. This link is mirrored in the zoning objectives where categories are in place to protect both coastal and harbour related activities.

The Development Plan addresses the most commonly encountered activities within the county and indicates the acceptability or otherwise of the proposed land use. The guidelines are as follows:

- **Permitted in Principle**
  Is subject to compliance with relevant policies, standards and requirements set out in the Development Plan

- **Open for Consideration**
  Uses which could not be considered acceptable in principle in all parts of the relevant use zone. They will only be accepted where the Council is satisfied that the use would not have undesirable consequences for the permitted uses. Uses, which are temporary by nature, are open for consideration in all zones.

- **Not Permitted**
  Activities which are not indicated as "Permitted in Principle" or "Open for Consideration" will not be considered.

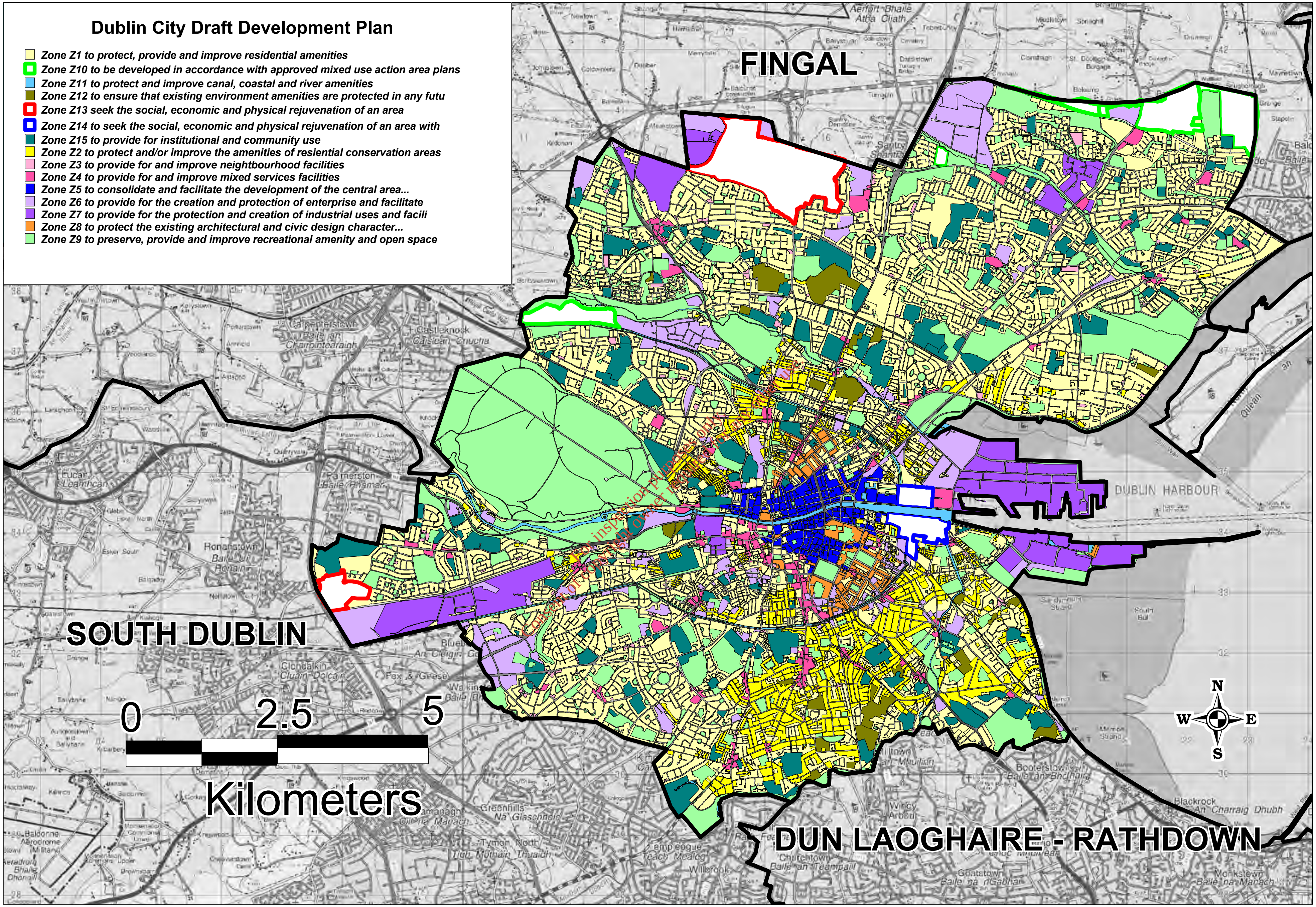


Figure 5.1 Dublin City Development Plan Zoning

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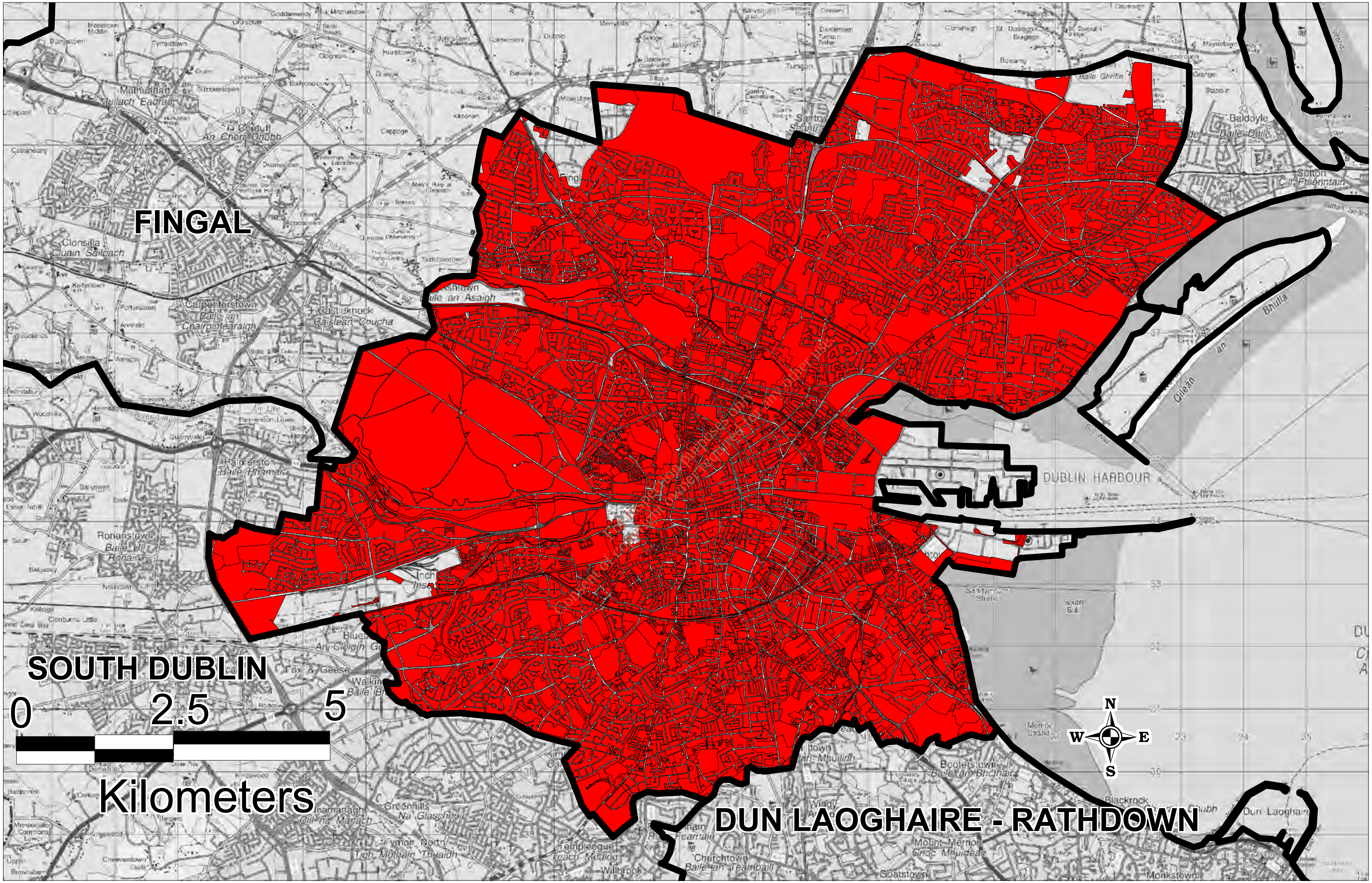

Fig. 5.2 Dublin City Thermal Treatment Exclusionary Areas

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Table 5.2 Land Use Zoning Objectives for Dun Laoghaire-Rathdown

Zone	Zoning Objective	Thermal Treatment Acceptability
A	To protect and/or improve residential amenity	Not Permitted
A1	To provide for new residential communities in accordance with approved action area plans	Not Permitted
B	**To protect and improve rural amenity and to provide for the development of agriculture**	**Open for Consideration**
LC	To protect, provide for and/or improve local centre facilities	Not Permitted
DC	To protect, provide for and/or improve district centre facilities	Not Permitted
TC	To protect, provide for and/improve town centre facilities	Not Permitted
E	**To provide for industrial and related uses**	**Permitted in Principle**
E1	**To provide for the development of a science and technology park**	**Open for Consideration**
F	To preserve and provide for open space and recreational amenities	Not Permitted
G	To protect and improve high amenity areas	Not Permitted
GB	To protect and enhance the open nature of lands between urban areas	Not Permitted
H	To provide for harbour related amenity, recreational, light industrial and commercial development	Not Permitted
J	To protect and improve coastal amenities	Not Permitted

Source: Dun Laoghaire-Rathdown County Development Plan (1998)

The main areas which create exclusionary zones come under zones A, A1, LC, DC, TC, F, G, GB, H and J(Figure 5.4). These zones include the areas of:

Ballinteer	Ballybrack	Blackrock	Booterstown
Cabinteely	Carrickmines	Churchtown	Corklittle
Cornelscourt	Dalkey	Dun Laoghaire	Foxrock
Galloping Green	Glasthule	Glencullen	Glendoo
Goatstown	Killiney	Kill of the Grange	Kilmashogue
Loughlinstown	Marley	Milltown	Monkstown
Mount Merrion	Newtown	Old Connaught	Sallynoggin
Shankill	Stepaside	Stillorgan	Tibradden
Ticknock	Windy Arbour		

Areas that contain small sections of land not in these zones include:

- Churchtown
- Deans Grange
- Jamestown
- Kingston
- Loughlinstown
- Leopardstown
- Marlay
- Milltown
- Old Connaught
- Sandyford

5.3.1.3 Fingal County Development Plan 1999

The County Development Plan aims to achieve the sustainable development of Fingal County. The Plan consists of a number of zoning objectives, which are illustrated in Figure 5.5 and listed in Table 5.3. The table also illustrates the acceptability of the siting of a Thermal Treatment facility in the various zonings. In order to achieve sustainable development in Fingal, the County provides guidelines for development in both its urban and rural communities. The guidelines are as follows:

- **Acceptable**
  Uses that will be considered acceptable

- **Open for Consideration**
  The use is generally acceptable except where indicated otherwise and where specific factors which may be associated with the use (e.g. scale) would result in the proposed use being contrary to the zoning objective

- **Not Acceptable**
  Uses that will not be acceptable

Table 5.3 Development Plan Zoning Objectives for Fingal

Zone	Zoning Objective	Thermal Treatment Acceptability
A	To protect and improve residential amenity in established residential areas	Not Acceptable
A1	To provide for new residential communities in accordance with approved action area plans and subject to the provision of the necessary social and physical infrastructure	Not Acceptable
NC	To protect, provide for and/or improve local/neighbourhood centre facilities	Not Acceptable
NCB	To protect, provide for and/or improve neighbourhood/local centre facilities in Ballymun	Not Acceptable
MVC	To protect and enhance the special physical and social character of major village centres and provide and/or improve village facilities	Not Acceptable
C4	To provide for the County Hall and ancillary uses	Not Acceptable
D	To provide for major town centre activities in accordance with approved action area/structure plans and subject to the provision of the necessary physical infrastructure	Not Acceptable
E	**To facilitate opportunities for general industrial employment and related uses in established industrial areas**	**Open for consideration***
L1	To facilitate opportunities for light industrial employment in a high quality landscaped environment in accordance with approved action area plans and subject to the provision of the necessary physical infrastructure	Not Acceptable
ST	To facilitate opportunities for science and technology based employment in a high quality landscaped environment in established science and technology parks	Not Acceptable
ST1	To facilitate opportunities for science and technology based employment and associated and complimentary uses in a campus style environment in accordance with approved action area plans and subject to the provision of the necessary physical infrastructure	Not Acceptable

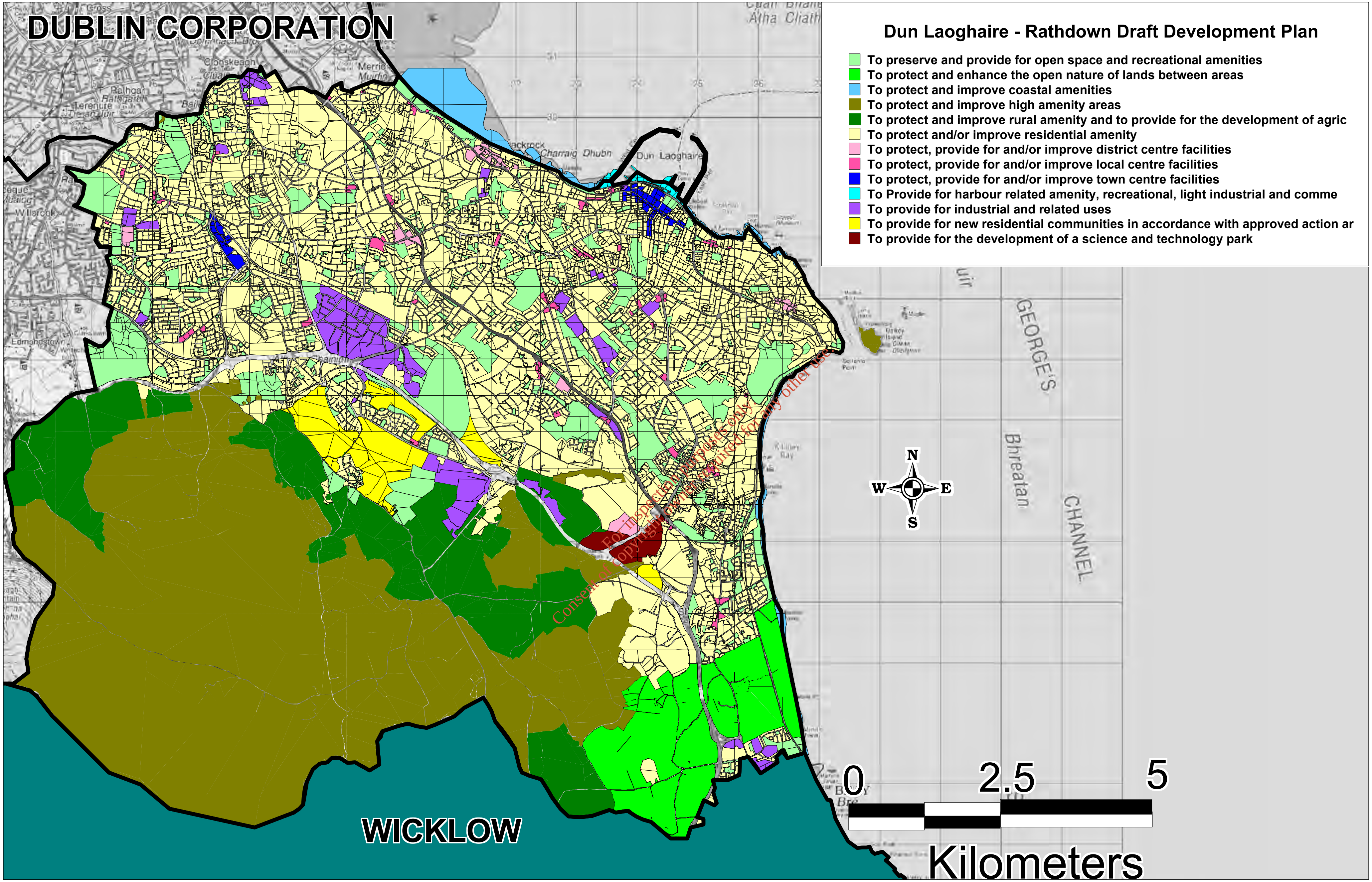

Figure 5.3 DLRCC Development Plan Zoning

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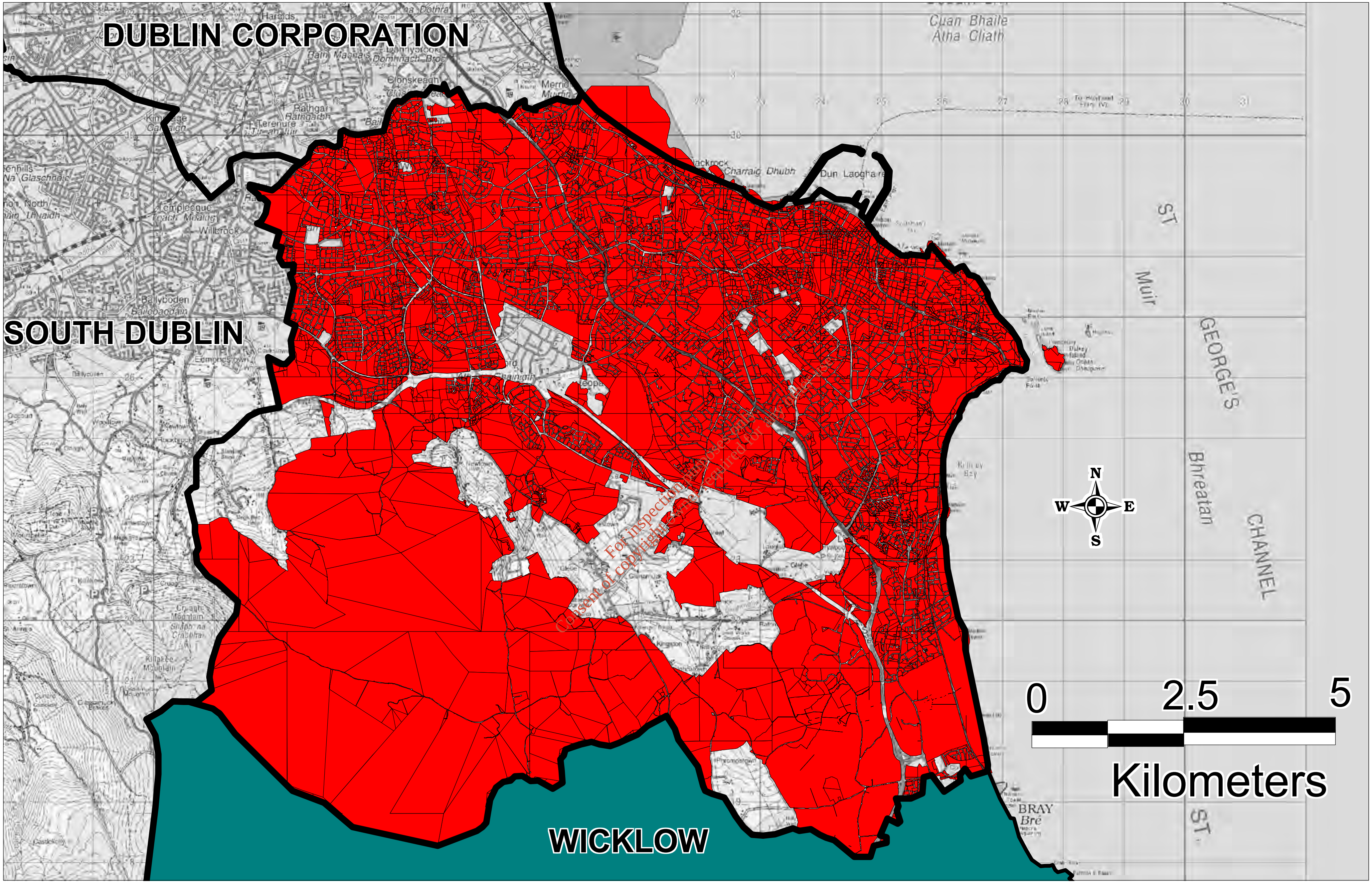

Figure 5.4 DLRCC Thermal Treatment Exclusionary Areas

Zone	Zoning Objective	Thermal Treatment Acceptability
MU1	**To provide for an appropriate and compatible mixture of uses in accordance with approved action plans and subject to the provision of the necessary social and physical infrastructure**	**Open for consideration***
RV1	To protect and enhance the special physical and social character of rural villages and provide and/or improve village facilities to serve local needs in accordance with approved action area plans and subject to the provision of the necessary social and physical infrastructure	Not Acceptable
B	**To protect and provide for the development of agriculture and rural amenity**	**Open for consideration****
B1 (Rush only)	To protect and provide for the development of horticulture and to provide for the housing needs of persons native to the area in accordance with an approved action area plan	Not Acceptable
F	To preserve and provide for open spaces and recreational amenities	Not Acceptable
G	To protect and improve high amenity areas	Not Acceptable
H	To provide for a Green Belt and to provide for urban and rural amenities	Not Acceptable

Source: Fingal County Council Draft Development Plan 1998

* *Where the use is subject to the overall zoning objective and specific objectives within that zone*

** *Where the use is subject to the overall zoning objective and specific objectives within that zone and not to be permitted in areas designated as Sensitive Landscape Areas*

The main areas in Fingal which create exclusion zones come under zoning objectives A, A1, NC, NCB, MVC, C4, D, L1, ST, ST1, RV1, B1, F, G, and H(Figure 5.6). These zones include the areas of:

Baldongan	Baldoyle	Blanchardstown	Carpenterstown
Clonsilla	Corduf	Donabate	Flacketstown
Garristown	Howth	Knockbrack	Lusk
Malahide	Malheney	Mulhuddart	Portmarnock
Portraine	Rush		

Areas not entirely classed as exclusionary zones include:

- Baldoyle
- Balbriggan
- Clonsilla
- Santry
- Swords

5.3.1.4 South Dublin County Development Plan 1998

The County Development Plan sets out the aims of the Council for the future planning and development of the County and provides guidelines on its development and conservation. The guidelines suggested are as follows:

- **Permitted in Principle**
  Land uses designated under each zoning objective as "Permitted in Principle" are, subject to compliance with the relevant policies, standards and requirements set out in the Plan, generally acceptable

- **Open for Consideration**
  This includes uses which may or may not be acceptable depending on the size or extent of the proposal and to the particular site location. Proposals in this category will be considered on their individual merits and may be permitted only if not materially in conflict with the policies and objectives of the Development Plan and if they are consistent with the proper planning and development of the particular area

- **Not Permitted**
  Uses listed as 'Not Permitted' are, except in exceptional circumstances as determined by the Planning Authority, not acceptable

The zoning objectives listed in the County Development Plan are illustrated in Figure 5.7 and presented in Table 5.4. The table also illustrates the acceptability of 'Industry Special' which is the use class under which the siting of a Thermal Treatment facility would fall.

Table 5.4 Development Plan Zoning Objectives for South Dublin.

Zone	Zoning Objective	Thermal Treatment Acceptability
A	To protect and/or improve Residential Amenity	Not Permitted
A1	To provide for new Residential Communities in accordance with approved Action Area Plans	Not Permitted
B	**To protect and improve Rural Amenity and to provide for the development of Agriculture**	**Open for Consideration**
LC	To protect, provide for and/or improve Local Centre facilities	Not Permitted
DC	To protect, provide for and/or improve District Centre facilities	Not Permitted
TC	To protect, provide for and/improve Town Centre facilities	Not Permitted
E	**To provide for Industrial and related uses**	**Permitted in Principle**
F	To preserve and provide for Open Space and Recreational Amenities	Not Permitted
G	To protect and improve High Amenity Areas	Not Permitted
GB	To preserve a Green Belt between Development Areas	Not Permitted
H	To protect and enhance the outstanding natural character of the Dublin Mountain Area	Not Permitted

Source: South Dublin County Development Plan 1998

The South Dublin County Council area is different to the other study areas in that quite a high proportion of the County is made up of mountainous terrain. Provision as been made in the County Development Plan to protect this resource by granting the Council control of any development above the 350m contour line. The objective of this development control is to retain the open natural character of the mountains and enhance outdoor recreational potential of the area while protecting and sustaining the environmental capacity of the upland landscape. The

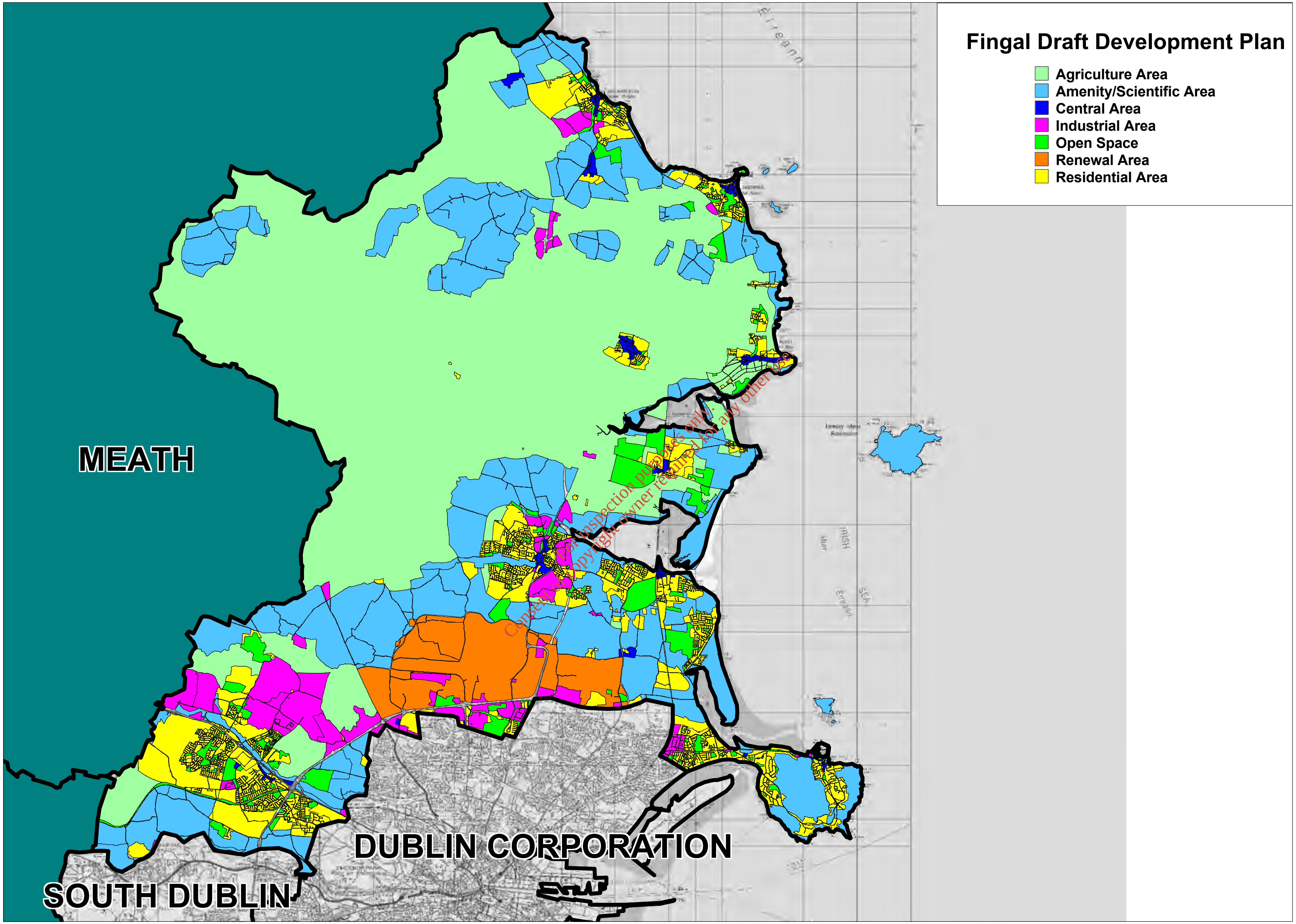

Figure 5.5 Fingal Development Plan Zoning

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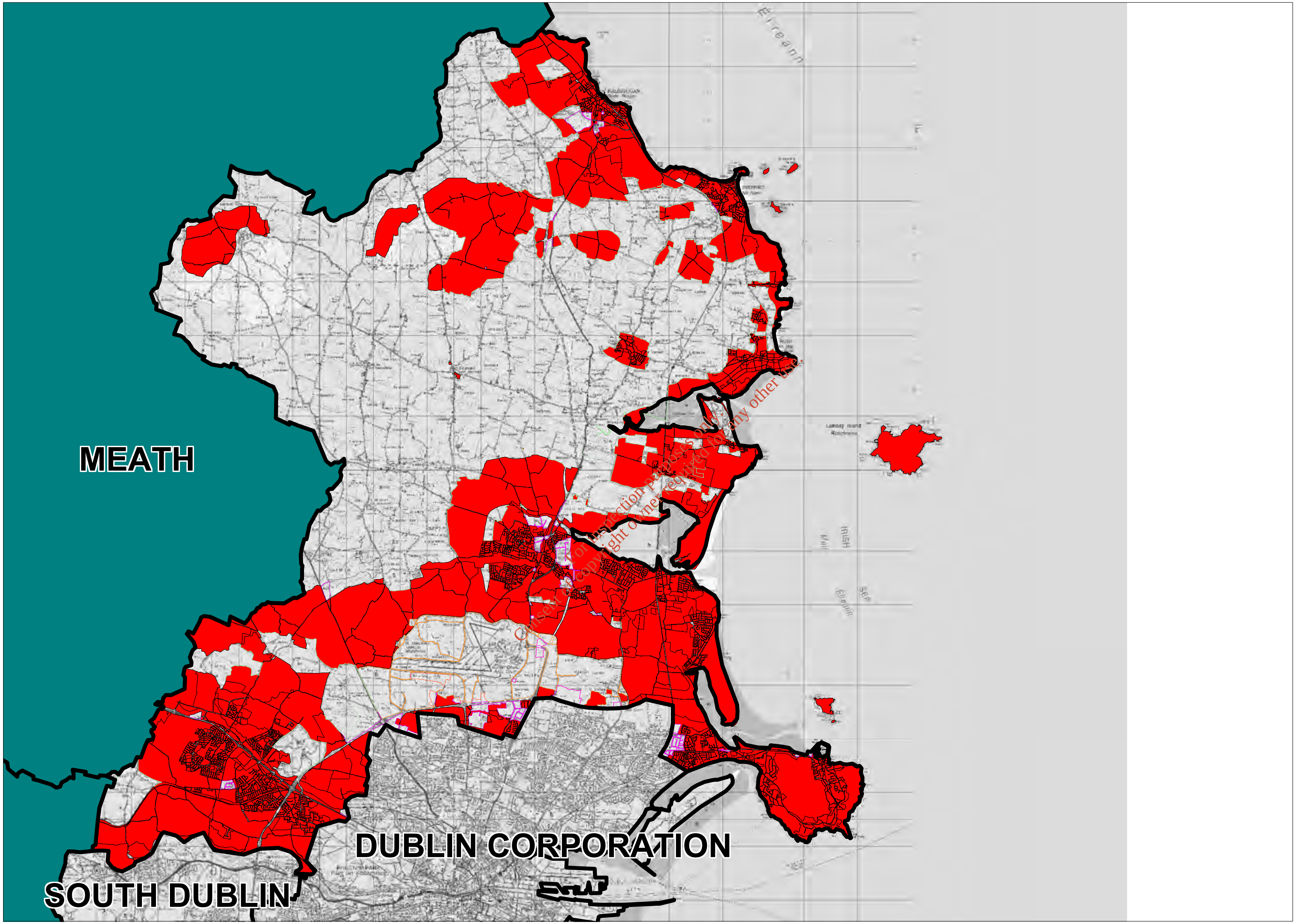

Figure 5.6 Fingal Thermal Treatment Exclusionary Areas

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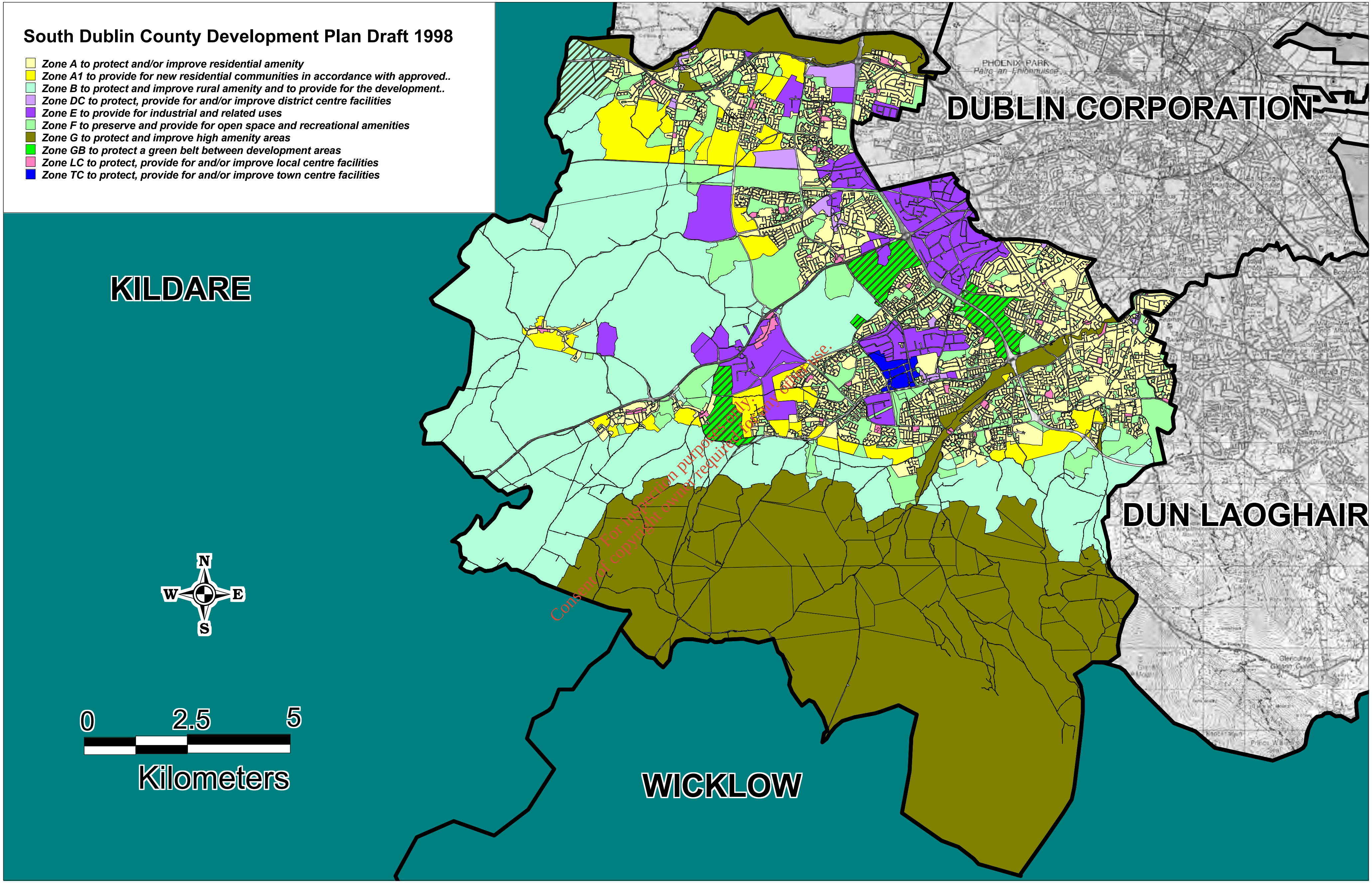

Figure 5.7 South Dublin Development Plan Zoning

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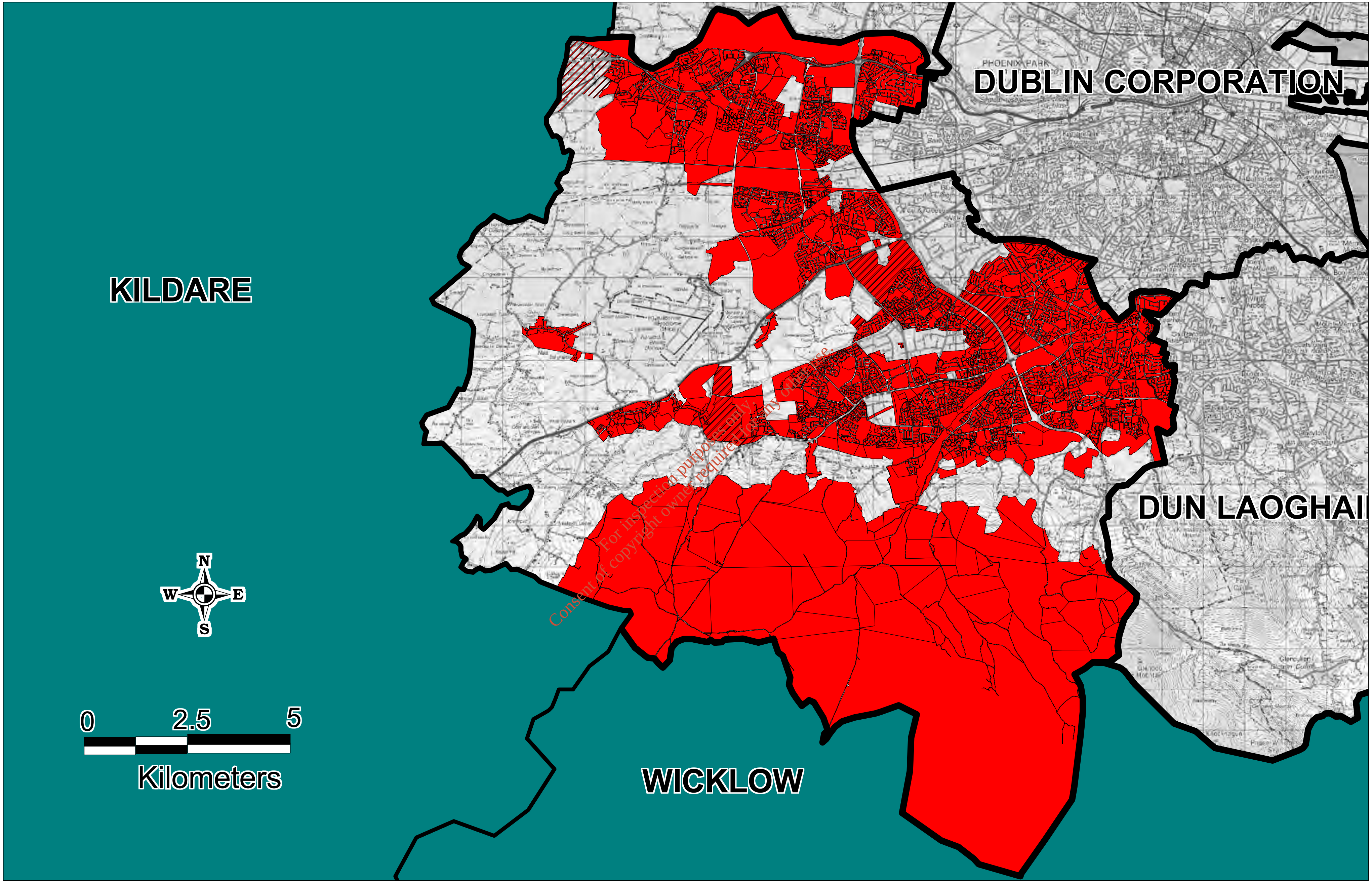

Figure 5.8 South Dublin Thermal Treatment Exclusionary Areas

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vast majority of the Dublin Mountains is therefore precluded from Thermal Treatment facility development.

Some of the main areas, which are excluded from Thermal Treatment facility development by zoning objectives A, A1, LC, DC, TC, F, G, GB and H(Figure 5.8) are as follows:

Ballyboden	Palmerstown
Clondalkin	Rathfarnham
Greenhills	Tallaght
Newcastle	Templeogue

Zone E, the zoning objective, which provides for industrial and related uses, lists 'Industry Special' as Permitted in Principle, examples of such areas are as follows:

- Ballyowen
- Clondalkin Area by the M50
- Cooldown Commons
- The Belgard/Cookstown/Monarch/Airton/Broomhill Industrial Parks north of Tallaght
- Walkinstown/Fox & Geese (east of the Red Cow M50 roundabout)

Zone B, the zoning objective, which provides for the protection and improvement of Rural Amenity and for the development of Agriculture, lists 'Industry Special' as Open for Consideration, examples of such areas are as follows:

- Ballybane
- Hazelhatch
- Newtown Lower/Upper
- Kiltipper

5.3.2 Proposed Natural Heritage Areas

The National Parks and Wildlife section of the Office of Public Works has prepared a list of proposed Natural Heritage Areas (pNHA's). A pNHA is an area deemed to be of special interest containing important wildlife habitat and often containing rare or threatened species. They may also be selected on the basis of their geology or geomorphology. pNHA's do not have any statutory protection yet but are protected under the Dublin City & each of the three County Development Plans. An amendment to the Wildlife Act (1976) has been proposed which will give legal backing to NHA's.

The Dublin Region also contains 2 Special Areas of Conservation (SAC's). These are protected under the Habitats Directive (92/43/EEC), which seek to protect wildlife and its habitats. SAC's are selected from NHA's on the basis of those which best meet the criteria of this directive. The species and habitats of these areas are protected making these areas sensitive to development of any kind.

Another group of sites under legislative protection are the Special Protection Areas (SPA's). These sites relate to the protection of birds and are covered under the European Bird Directive (79/409/EEC). Two categories of birds come under this:

1. Listed rare and vulnerable species

2. Regularly occurring migratory species

The EU Wild Birds Directive also obliges the conservation of wetlands of significance. The selection of SPA sites is based on scientific information and current EU standards. The SPA's are included in the pNHA's and may also overlap with the SAC's.

5.3.2.1 Dublin City

The pNHA's for Dublin City are illustrated on Figure 5.9. Under the Dublin City Development Plan, all pNHA's are regarded as exclusionary to the development of a Thermal Treatment facility. The pNHA's include the Royal and Grand Canals, Baldoyle Bay, Sandymount Strand, Dublin Harbour and Bay, and Feltrim Hills amongst others. The pNHA's include both SAC's and SPA's.

5.3.2.2 Dun Laoghaire-Rathdown County

The proposed natural heritage areas (pNHA's) are protected under the Dun Laoghaire-Rathdown County Development Plan (1998). A list of the NHA's and SAC's are included in the following table:

Site Name	Interest type and Importance Rating
Booterstown Marsh	Ecological; Local
South Dublin Bay*	Ecological; International
Dalkey coast and Killiney Hill (inc. Roches Hill & parts of Killiney Hill)	Ecological & Geological; International, National and Regional
Fitzsimon's Wood	Ecological; Local
Dingle Glen	Ecological; Local
Loughlinstown Wood	Ecological; Local
Shanganagh Coastline	Geological; National
Knocksink Wood	Ecological; International
Ballybetagh Bog	Ecological, Geological and Historical; International
The Scalp	Geomorphological; Regional
Ballyman Glen*	Ecological; International
Wicklow Mountain National Park (part of) *	Ecological & Geological; International

Source: Dun Laoghaire-Rathdown Development Plan (1998)
**These are also proposed Special Areas of Conservation (SAC's)*

Area No.7 'Shanganagh Coastline' and Area No. 10 'The Scalp' have not yet been designated.

All pNHA's as listed above are regarded as exclusionary to the development of Thermal Treatment facilities and have been identified on Figure 5.9.