Executive Summary

The four Dublin Local Authorities have agreed an integrated Waste Management Plan for the Dublin Region, which includes the provision of a Waste-to-Energy facility on the Poolbeg Peninsula. If the incinerator is built, Dublin City Council will establish a Community Gain Fund to confer some benefit to the communities most affected by the location of the incinerator.

To maximise the potential gain from the Fund, Dublin City Council has commissioned Trutz Haase, an independent Social & Economic Consultant, in association with Brady Shipman Martin, to undertake an audit of the social and community infrastructure in the Ringsend, Irishtown and Sandymount area. This report details the findings of their in-depth community consultation which took place from January to April 2006.

Background

The Waste Management Plan for the Dublin Region 2005-2010 has been developed jointly by Dublin City Council, South Dublin County Council, Fingal County Council and Dun Laoghaire-Rathdown County Council. The Plan follows latest government policy in that it develops a waste management strategy for the region as a whole. It also takes into account important European requirements towards reduced waste production, more recycling, and the development of environmentally more sustainable forms of final disposal. To reduce the amount of waste going into landfill, and in line with many of the other regional waste management plans that are currently being developed throughout Ireland, the Waste Management Plan for the Dublin Region also envisages the building of a Waste to Energy facility on the Poolbeg peninsula.

After Carranstown (County Meath) and Ringaskiddy (County Cork) the Dublin Waste to Energy Project will be the third case of its kind entering the statutory process in Ireland. The pending planning application for the incinerator has already given rise to considerable public comment through the media, both in support of its speedy construction, as well as against waste incineration in general, and on the Poolbeg peninsula in particular and the project has the potential to develop into a major environmental conflict. Every possible step thus has to be undertaken to reach a mutual accommodation between the interests and needs of the wider community and those of the communities most affected by the location of the proposed incinerator.

Current Government policy suggests that this is best done by applying the concept of Community Gain and, over the past few years, it has become standard practice for a condition to be attached to the grant of planning permission for major pieces of waste infrastructure, requiring the operators to contribute to a special fund which is used to support certain initiatives in the local area. It is in anticipation of a similar planning condition from An Bord Pleanála with regard to the Dublin Waste to Energy Project, that Dublin City Council asked the consultants to undertake a social and community audit of the three communities most affected and to assist them in identifying how gaps in the provision of community facilities and infrastructure might best be addressed through such fund.

The Scope of the Study

In the course of consultation with key representatives of the communities, it became quickly apparent that the scope of the study had to be broadened beyond its original remit. The majority of residents of the adjacent communities are strongly opposed to the siting of the incinerator on the Poolbeg peninsula, and the question arises as to whether a Community Gain Fund as stipulated by Dublin City Council has the capacity to address the key needs and aspirations of the local communities in such a way that it can provide an effective tool for consensus building.

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Similar questions have recently been voiced by the National Economic and Social Council (NESC): In light of the growing number of environmental conflicts that have developed in Ireland over the past decade, the NESC states in its 2006 Strategy that it plans to undertake a study on environmental policy. As international experience suggests that there are more effective approaches to conflict resolution than commonly adopted in Ireland, one theme of that study is likely to be the structures and procedures of conflict resolution and consensus building currently applied.

The Dublin Waste to Energy Project is an essential element of the agreed *Waste Management Plan for the Dublin Region*. Given the considerable conflict with the Ringsend, Irishtown and Sandymount communities that could arise from this, it is impossible for the consultants to undertake the present study without also giving regard to the process by which a potential conflict can be avoided and a mutual accommodation be sought between the needs of the wider community, as represented through Dublin City Council and the Waste Management Plan for the Dublin Region, and the interests of the local communities that are most affected by the location of the proposed incinerator.

Community Gain

Current Government policy states that *"the concept of community gain recognises the reality that if Ireland is to deal with its waste in a modern environmentally progressive way, new facilities have to be provided. It operates on the basis that the facilities will have to be located somewhere and that there should be a mechanism by which some benefit can accrue to the communities in the location chosen." (Waste Management – Taking Stock and Moving Forward).* It further attempts to specifically 'de-link' the concept of community gain from a perception of "buying-off" objecting communities.

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However, independent of whether the Irish Government acknowledges the need for an *appropriate* gain as an essential element of conflict resolution and mutual accommodation, international studies, as well as previous Government documents clearly state that the key aspect of 'community gain' is that it offers a proportionate benefit for alleviating the inequity and perceived losses incurred by a community when proposed major infrastructure is planned for its locality. Internationally, 'community gain' has been implemented in one of three forms: 'community gain', 'planning gain' or 'host community benefits'. Whichever its precise form, the studies show that key to the concept of Community Gain being successful in the building of consensus are *negotiated agreements* between the local communities affected and the developers who will be in charge of the development of the facility.

Building Consensus

The key to building consensus lies in some real gain being obtained by the communities most affected by the location of the incinerator. The immediate question thus becomes: *"what are the host communities' needs and aspirations?"* Only if this question can be answered in a comprehensive manner, can one determine the precise form of Community Gain that may achieve consensus building. In some cases, it may be appropriate and sufficient to ensure Community Gain by means of a Community Gain Fund which, in turn, is used to finance a number of projects which benefit the community. In other cases, it may be necessary to respond to the wider needs and aspirations of the affected communities with regard to the overall development of their area.

The search for a consensus and mutual accommodation thus has to start with true consultation and negotiation between the representatives of the interests of the wider community and the local communities which are being asked to accept the waste facility in their proximity. In the case of the Dublin Waste to Energy Project, the inclusion of incineration as part of the overall waste management strategy is an agreed policy both at national and regional level, a fact that can not simply be overruled by any one community. On the other hand, and partly as a result of its unique location, the Ringsend, Irishtown and Sandymount

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areas frequently have had to facilitate infrastructure developments of regional or even national importance with little consideration given to the cumulative effects which these developments have on the communities in question. The audit of the social and community infrastructure of the three area as presented in this study includes both the consideration of how best to maximise the benefit of a Community Gain Fund if instituted as part of a planning permission for the Dublin Waste to Energy Project, as well as the needs of the communities in the wider context of the future development of their area.

Gaps in Community Facilities and Infrastructure

Concentrating on the needs of the Ringsend, Irishtown and Sandymount area in terms of community facilities and infrastructure; i.e. those elements which can meaningfully be addressed through a Community Gain Fund, the study identifies five priorities which, if appropriately addressed, could maximise the benefit accruing to the communities from such fund:

The first priority emerging from the household survey are more sports facilities for young people. This contrasts with several other studies which generally describe the area as one relatively well provided for in terms of sport facilities, a view supported by the consultants' own audit of the area. The apparent contradiction can, however, be explained when taking into account who actually makes use of the existing facilities. Access to the existing sports facilities is not evenly spread across all geographical areas or social spectrum. Thus, besides the provision of additional sports facilities, particular emphasis needs to be given towards the employment of sports coaches and the development of outreach programmes which draw a wider range of young people towards the existing opportunities.

The second priority relates to the availability of playgrounds. There is a dearth of playgrounds in the whole study area. The lack of access to playgrounds is particularly felt in the Ringsend and Irishtown area, as well as amongst younger families and those who are financially less well-off.

The third priority identified relates to the availability of community services for elderly people. While the shortage in community services for elderly people is not particular to the study area, it is a strongly felt issue and the Community Gain Fund could provide an important dimension in the improvement of such services which would be perceived as a real benefit to the area.

The fourth priority is the improvement of community health services. While mirroring the lack of services for elderly people with regard to the age groups which identify both as a priority, the lack of community health services is further particularly felt in the Ringsend and Irishtown areas, as well as amongst less well-off families and those with larger number of children.

The fifth priority is the improvement of the environment, which is strongly felt across all three communities particularly with regard to improved landscaping and the appearance of the built environment. There are some differences in emphasis with regard to environmental protection, and the provision of environmental and/or heritage facilities, which are stronger felt in the Sandymount area.

The consultants believe that the identified priorities might best be served through the development of two flagship projects: a community centre for the Ringsend and Irishtown area with a strong focus on young people, including the provision of sport and recreation, and a community centre for the Sandymount area with an emphasis on providing offices and meeting rooms for the residents organisations, as well an interpretive and environmental dimension. Both centres would provide an anchor for (outreach) services for the elderly, as well as housing primary health services. Overall, the centres would aim at providing a new focus for civic and community activities, a focus which is currently lacking.

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Developing Community Representation

The degree of benefit accruing to the communities from a Community Gain Fund, and the projects supported by it, will crucially depend upon the degree of ownership that the communities perceive with regard to the flagship projects and the fund as a whole. To this end, the process by which these projects are being developed is likely to be as important as the centres themselves.

Currently there exists no structure in the Ringsend, Irishtown and Sandymount area which allows the communities to develop a shared vision for their area. Several attempts to engage in a process to this end over the past decade have come to a halt, with the result that community interests are fragmented and lack adequate representation.

The consultants believe that a Community Gain Fund, if instituted as part of the planning permission for the proposed incinerator, could have an important catalyst role to initiate a process by which different community interests will come together and develop a shared vision for the improvement of their area.

Addressing the Wider Aspirations of the Community

The appropriate management of the Community Gain Fund constitutes an important end in itself. The greatest benefit to the communities, however, could result from developing an Integrated Plan for their area and the building of effective institutions of community representation vis-à-vis Dublin City Council, Government departments and statutory agencies.

There is clear evidence from the consultation with community representatives undertaken in the course of the social and community audit that part of the opposition to the Dublin Waste to Energy Project is related to a range of other issues where the communities feel that their interests have not been sufficiently guarded and where there has been insufficient consultation. These issues include, amongst others, the overall land use of the Poolbeg peninsula, the gains for the communities from the redevelopment of the docklands, questions with regard to the protection of the coastal zone, the smells from the waste water treatment plant, and the effects of the introduction of the HGV Management Strategy, to name but a few.

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While there are mechanism in place by which residents can respond and make submissions to each of the individual plans, no consideration is given to the cumulative effect of the developments on the existing communities, nor is sufficiently space given to the communities to develop an Integrated Plan for their area, which they can identify with and which provides a basis for effective community representation on all of these issues.

Based on their consultation, it is the consultants' belief that the Community Gain Fund, if taken on its own, will not be perceived as sufficient benefit for the adversely affected communities and thus fail to achieve mutual accommodation with regard to the Waste to Energy Project. If consensus is to be built, it is most likely to be driven by the application of the concept of Community Gain and/or Planning Gain with regard to the wider development issues which the communities face.

In summary: the Community Gain Fund may provide a useful first step, but its success is likely to be influenced by the commitment of Dublin City Council towards supporting the development of an Integrated Plan for the Ringsend, Irishtown and Sandymount area, the building of stable structures of community representation, and a commitment to true consultation and negotiation through these structures on some of the wider development issues with which the three communities are currently confronted.

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Key Recommendations

In the light of the discussion provided throughout the report, the consultants make a limited number of key recommendations.

1. Achieving True Community Representation

Consultation and negotiation with the Ringsend, Irishtown and Sandymount communities has to start with taking account of what the real issues, needs and aspirations of these communities are and which of these may form part of a negotiated settlement between the Local Authority, private developer and the affected communities. To this end, Dublin City Council should assist the communities to develop an infrastructure which allows them to formulate, communicate, and ultimately negotiate their concerns.

2. Acknowledging a Comprehensive Definition of Community Gain

Current government policy does endorse the concept of 'community gain', but merely requires that some benefit shall accrue to communities in which proximity major pieces of waste infrastructure are being located. Dublin City Council's intention to set up a Community Gain Fund if planning permission is granted to the Dublin Waste to Energy Project is thus within the current minimum requirements.

However, the key aspect of 'community gain' is that it offers some form of compensation for alleviating the inequity and perceived losses incurred by a community when a proposed waste facility is planned for its locality. Internationally, 'community gain' has been implemented in one of three forms: 'community gain', 'planning gain' or 'host community benefits'. To provide a successful basis for consensus building and conflict resolution it is likely that community Gain needs to be sought outside the confines of a purely monetary Community Gain Fund.

3. Entering Into Real Consultation and Negotiation with the Local Communities

The statutory process is *not* the place of consultation and negotiation. Real consultation and negotiation between Dublin City Council, the private developers, and the three communities should have taken place from the time the proposal for an incinerator on the Poolbeg Peninsula has first been made.

While Dublin City Council has made considerable efforts in disseminating information about the Dublin Waste to Energy Project, residents do not perceive this to be objective and independent. Furthermore, information is no substitute for consultation and negotiation. A meaningful process of consultation and consensus building requires appropriate structures of community representation and a comprehensive approach to community gain. Such an approach is also likely to make the management and operation of any ensuing Community Gain Fund more acceptable to the community.

4. Clarifying the Scope of What Can be Negotiated

The scope of what can be negotiated has to take into account the overall needs of the communities most affected by the location of the incinerator. The gains sought by the communities do not have to necessarily be connected directly with the proposed incinerator, nor do they necessarily have to be defined in terms of the benefits accruing on foot of a Community Gain Fund.

Based on international literature and experience, mutual accommodation with regard to the siting of waste facilities has worked best where the authorities have been able to take key aspirations of the respective communities into account. Based on the consultation with community representatives in the course of this study, it is the consultants' belief that the wider issues that surround the development of the communities may be more important than the benefit that may accrue through a Community Gain Fund on its own.

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5. Supporting the Development of an Integrated Plan

There is a long history of the use of the Poolbeg Peninsula to provide for the wider needs of Dublin and the region as a whole, with little consideration given to the cumulative effects which this may have on the residents of adjacent communities. Best practice in Ireland and elsewhere shows that the overall development of an area can be framed by means of developing a plan for the area that treats the area in its totality, taking into account the full range of influences, in terms of land use, transport, economic and social issues and environmental impacts. While Dublin City Council has commenced this process with the publication of the Draft Poolbeg/Southbank Framework Plan, there is a need for the communities to develop an Integrated Plan for their area which takes as its starting point the visions and aspirations of the existing communities. Dublin City Council should undertake every step necessary to facilitate the communities to develop appropriate structures of community representation and provide them with the resources necessary to develop such a Plan.

6. Respecting the Interests of the Affected Communities

The communities of the Ringsend, Irishtown and Sandymount area are under renewed pressure as the area is being affected by a number of large-scale development proposals and city policies, each with a different focus and spatial remit, and none of which considers the combined effects on the residents of the Ringsend, Irishtown and Sandymount area. Furthermore, the Waste Management Plan for the Dublin Region names the Poolbeg Peninsula as the preferred location for a large-scale incinerator to serve the whole of the Dublin region, which is perceived as the largest single threat to the adjacent communities.

The Integrated Plan is likely to recommend potential solutions to the main issues of concern to the community. It is the responsibility of Dublin City Council to take these seriously, enter into consultation with regard to the issues identified and, ultimately enter into a process of negotiation with the communities about these. This is the true meaning of 'community gain', and this will be reflected in an adopted Integrated Plan accepted by the community.

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7. The Community Gain Fund

Based on the extensive audit of the existing community facilities and infrastructure, and the preferences expressed by residents in course of the MRBI household survey, the consultants identify five priorities which should be addressed by the Community Gain Fund: (i) more sports facilities for young people, (ii) more playgrounds, (iii) better community services for elderly people (iv) better community health services, and (v) improving the environment.

Based on an analysis of the social and economic composition of the Ringsend, Irishtown and Sandymount area, there is some merit to addressing social need which, as a whole is more strongly concentrated in Ringsend and Irishtown. On the other side, the Community Gain Fund has to provide a reasonably equal benefit to all communities that are affected by the location of the Dublin Waste to Energy Project. Thus, there also has to be a substantive gain to accrue for the residents in Sandymount.

Taking account of the suggested priorities, the social and economic priorities, a fair geographical distribution, and the lack of structures for effective community representation, the consultants believe that the Community Gain Fund should largely be used for the development of two flagship projects: firstly a large-scale re-building of the Ringsend and Irishtown Community Centre and, secondly, a Community Centre for the Sandymount area.

In each case, the centres would act as a centre of community supports along the five priorities identified. The fund would be able to cater both for the associated capital costs, as well as covering the ongoing costs associated with the initiatives. Of equal importance would be that the centres would act as a focus for developing better structures of community representation and towards a process by which the communities can enter effective consultation and negotiation with the respective authorities.

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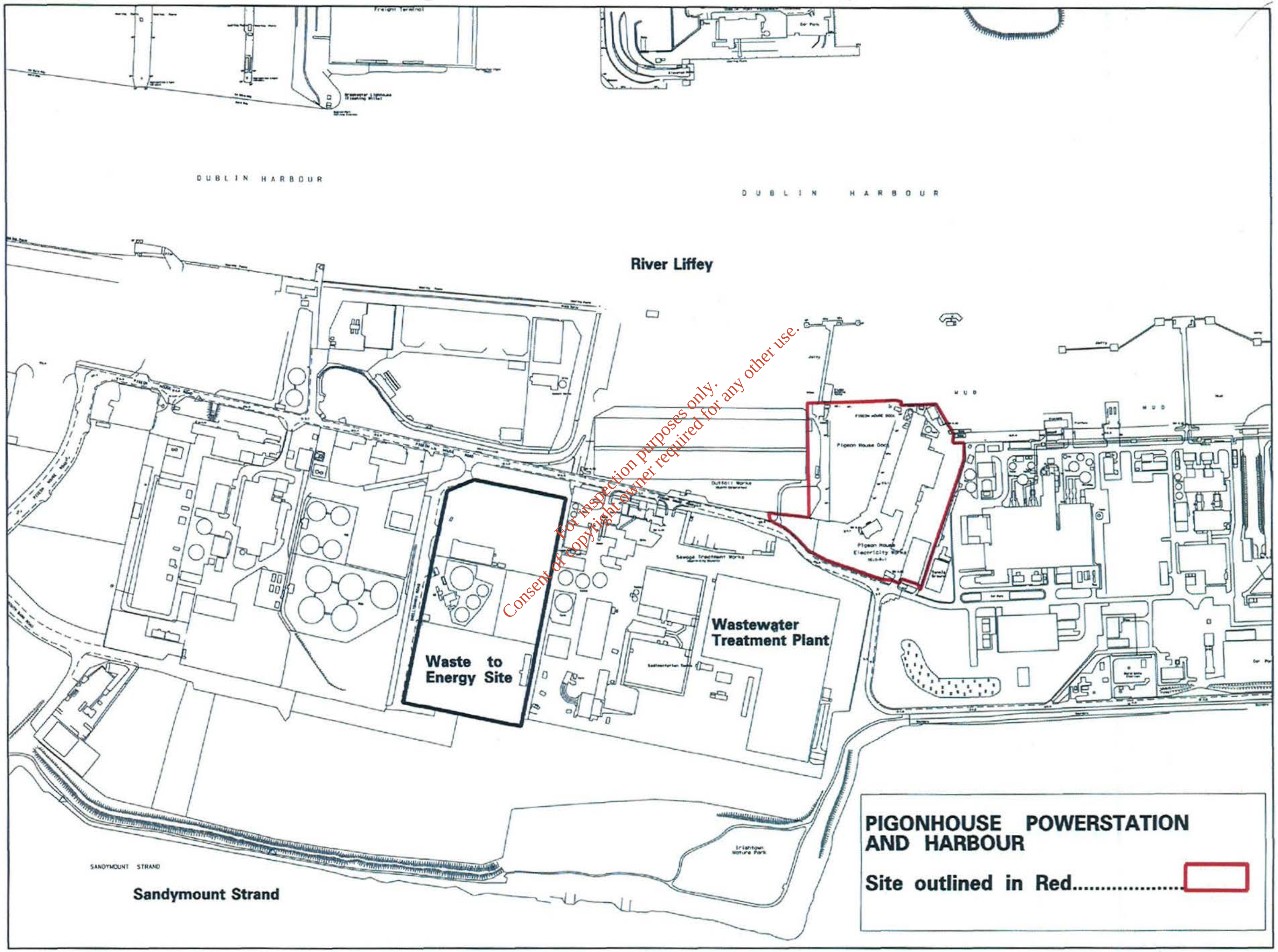

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Health Effects of Municipal Waste Incinerators

-A Literature Survey-

by

Dieter Schrenk, MD PhD

Professor of Toxicology

University of Kaiserslautern, Germany

June 2006

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1. Introduction

The general question if residents living in the proximity of waste storage/treatment sites show a higher rate of certain diseases or adverse health effects has been studied in a number of publications. A major drawback of most of these studies is that they provide medical/ epidemiological data only, i.e., they do not analyze or even provide evidence for the dose and identity of substances/chemicals which could eventually be responsible for the observed health problems.

A usual procedure in investigating possible health effects related to, e.g., hazardous waste sites is 1.) to list major substances stored at the site and classify the cohort living in the vicinity as 'potentially exposed'. The scientific weakness of such an approach is enormous since the presence of a chemical on a storage site may or may not be related to (an undefined level) of exposure. 2).The next step in the procedure is the collection of health data such as data from public databases, investigations with local physicians or questionnaires handed out to cohort members. 3) A frequent bias in this procedure is that people living in the vicinity of an unwanted site show a well-known tendency to blame health effects on this site. This problem may also apply to practising medical doctors. Another problem with such studies is to find an appropriate control group. In particular the impact of the socio-economic status on health is eminent. Furthermore, the socio-economic status in areas where the waste treatment site is located often differs significantly from that of the control group. 4) In many instances the frequency of certain disease or health defects is low and shows a high rate of fluctuation over time. In addition the prevalence of estimated 'potential exposure' being also low makes the risk estimates highly imprecise.

It is peculiar that many authors of 'waste and health' studies of that type are well aware of these severe drawbacks and list them extensively in their papers (e.g. Orr et al., 2002), but nevertheless do not hesitate to publish their 'findings'. The only substantial conclusion from such studies usually is, that 'more studies are needed'. The motivation for such statements remains obscure.

In the following, a number of studies published in peer-reviewed journals, as well as two reports published by the British Society of Ecological Medicine and by Greenpeace on the issue of exposure, health effects and municipal waste incinerators (MWIs) are summarized and discussed. Citations from the original publications are printed in *italics*.

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2. Exposure

The analysis of 'exposure' to toxic chemicals originating from modern MWIs has not been successful so far. The reason for this fact is that the additional exposure levels are so low that they cannot be detected as a significant change in environmental levels. Likewise, Fries and Paustenbach (1990) estimated that the potential human health risks due to TCDD (2,3,7,8-tetrachlorodibenzo-*p*-dioxin, the most toxic 'dioxin' congener) emissions from incinerators are insignificant compared to other background sources.

Some publications on this matter merely list the chemicals formed or present in the incinerator fly ash. An example is the paper by Rowat (1999) which mentions a number of 'hazardous' chemicals present or formed during the incineration process. These lists usually comprise the polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs), polycyclic aromatic hydrocarbons (PAHs), other organic chemicals, metals and heavy metals, and inorganic gases.

In more recent compilations of this type, particulate matter or PMx (providing information on the size distribution of the particles) have been added. In many instances these publications mix a number of known information on the general toxicity of these groups of compounds with unscientific speculation on their release.

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As an example for this type of arguments, the summary of a paper by Rowat (1999) is given below with a few comments:

1. Incinerator chemical reactions are extremely complex, and many of the resultant organic chemicals have not been identified and therefore have not been measured or tested for toxic effects.

This argument is correct but useless. The fact that the chemical reaction of incineration is highly complex is due for almost any type of incineration in particular for wood fires, automobile engines, candlelight, coal and oil burning etc. In none of these cases, all chemicals present or formed during the process of incineration have been identified or tested. If this would be a requirement for the use of fire, any type of burning, a basis of modern civilization, had to be prohibited. Furthermore, the highly advanced technology of flue gas cleaning and the strict regulations make the incineration of municipal waste one of the safest types of incineration. It can be expected that the local unfiltered burning of wood (fireplaces) or candles in homes is a much more relevant source of hazardous compounds, e.g., in homes.

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2. Regardless of how well an incinerator operates, metals will still be emitted, often in combination with chlorine (or other halogens such as fluorine or bromine). Insufficient data exists on the amounts and hazards of these metals.

It is a frequent mistake to mention the chemicals 'emitted' from certain sources ignoring the dose levels. The fact that a certain compound can be detected at extremely low levels is toxicologically meaningless and depends only on the methods and equipment used for analysis. The combination with traces of chlorine or other halogens also has no toxicological meaning. For the emissions of metals it is well known that their levels clearly are below the EU directive. The toxicology and hazards of major heavy metals are among the most thoroughly investigated in toxicology.

3. Some studies have demonstrated that incinerators often operate at less than peak efficiency, and polycyclic organic emissions can be increased 1000-fold during cold start-up.

The question is not if the incinerator operates at peak efficiency or below but how the emission levels of critical flue gas components are. There is convincing evidence that modern MWIs are in compliance with strict EU regulations on emission levels. Cold start-up is a very rare event which lasts shortly and only happens when the incinerator has been shut-down for cleaning or maintenance. If such emissions were relevant, an increased level in PAHs (not volatile) would be measurable in the vicinity of modern MWI (e.g. in the major wind direction) which is not the case.

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4. Some of the emissions are almost invariably dioxins and furans, which are formed in the incinerator stack. These are highly toxic and are apparently building up in the fat tissues of all humans, world-wide, with an estimated 7-year half-life in the human body.

Again the author makes the same mistake as throughout his manuscript namely to describe the chemical identity of the emissions only. From a toxicological point of view such a discussion is useless. The important issue is to know the levels/concentrations released from the MWI and the anticipated or estimated additional exposure due to the MWI's operation. In spite of the fact that PCDD/Fs can accumulate in the human body, those levels have been declining dramatically over the last decades, in particular in those countries with MWIs. This fact proves the lack of correlation between dioxin exposure and MWIs.

5. Incinerator fly ash and wash-water must at present be regarded as hazardous waste themselves, and no universally adequate solution has been found for their disposal.

It is not necessary to find a 'universally adequate' but an adequate solution for the handling of fly ash. It has been shown many times in the past that such a handling/disposal can be carried out in a safe way.

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6. Emitted gases such as NO_2 and SO_2 contribute heavily to acid rain and smog, and to the formation of ozone in smog and sunlight. NO_2, SO_2 and ozone have been proved to cause respiratory illness, and smog has been shown to cause increased death rate.

This statement is not relevant for modern MWIs. The author ignores the fact that MWIs are negligible as a source for these gases. It has been described in many instances that automobile exhaust, heating, and other sources are crucial for air pollution by these gases.

7. Toxic effects an build-up in human tissues of other incinerator-emitted organics such as benzene, toluene, PCBs, alkanes, alcohols, and phenols are well documented.

This statement is simply wrong. Benzene is rapidly metabolized in mammalians including humans, the same is true for most alkanes, alcohols and phenols. For some PCB congeners there is evidence for accumulation in the body. PCBs are not emitted from modern MWIs in relevant concentrations.

8. As of 1990 reports, more than half of existing incinerators had no pollution control equipment, and no real-time monitor existed for measuring destruction and removal efficiency.

It is surprising to see that the author in a 1999 paper refers to the technical state in 1990. Obviously, he ignores developments and changes in technology. The fact that a number of contaminants cannot be measured on-line is due, e.g., to the extremely low levels present in cleaned flue gas. Long term side-stream collection experiments have proven, however, that the emissions are well below the strict EU regulation levels for emissions.

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Sedman et al. (1994) evaluated the exposure to metal emissions from hazardous waste incinerators in California through non-inhalation pathways. They concluded that no facility contributed a significant portion of the reference dose for certain metals including arsenic, cadmium, mercury, lead, chromium, and beryllium. The deposition of theses metals from ambient air would result in substantially greater human exposure through non-inhalation pathways than the emissions from most of the facilities.

Deml et al. (1996) determined the concentrations of PCDD/Fs in human blood and in milk from non-occupationally exposed persons living in the vicinity of the MWI in Schwandorf, Germany. The MWI has been in operation since 1983, with a capacity of 350.000 tons of waste per year. As compared to background levels in the general population in Germany it gave no indication of an enhanced body burden of PCDD/Fs. According to the authors, this finding was in agreement with an earlier report showing normal background concentrations of

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PCDD/Fs in soil, fruit and vegetable samples from the same area. Thus, no health hazard related to PCDD/F emissions from the MWI is expected.

Boudet et al. (1999) used the maximum emissions measured at the stack of a modern MWI in Grenoble (France) for the pollutants benzene, trichloroethane, nickel, and cadmium. The authors used a Gaussian plume dispersion model to estimate the distribution of the pollutants in the atmosphere throughout the metropolitan area. Major conclusions in this study are 1.) that the relative contribution of modern MWIs to population exposure to significant health-related pollutants is small. The median additional cancer risks after life-long exposure were estimated for benzene as 2.6 x 10^{-10}, for nickel as 8.6 x 10^{-8}, and for cadmium as 1.5 x 10^{-8}. For cadmium this means that, based on theoretical considerations, 1.5 additional cases of cancer were estimated for 10^{8} (100 million) persons exposed to the MWI-derived cadmium emissions. Since the Grenoble area has 0.5 million inhabitants, 0.005 cancer cases over a life-long exposure period in the whole area would theoretically be attributable to this emission. It is evident from these considerations that epidemiological studies of any type will be unable to test this hypothesis, i.e., to verify if any additional risk is real or not. Furthermore it strongly indicates that eventual findings of a statistically significant increase in cancer risk 'around modern MWIs' are highly likely to be due to confounders or other sources.
In the same study, inhalation exposure due to MWI emissions of cadmium accounted for less than 1 % of the WHO Air Quality Guideline while the margin of exposure between the exposure estimates and the NOAEL (no observed adverse effect level) for trichloroethane was 10^{9}-fold.

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Ohta et al. (2000) analyzed PCDDs, PCDFs, and 'dioxinlike' PCB congeners in environmental samples around a MWI near Shintone Village (Japan) where the cancer death rate between 1985 and 1995 was clearly above the average cancer death rate in Japan. The incinerator built in 1971 was not equipped with any gas cleaning devices. Thus more or less untreated incineration products are released into the environment. Under these conditions soil samples collected in the major wind direction (leeward side) showed much higher TEQ levels than samples taken from the windward side. However, the authors claim that residents in the area leeward to the incinerator had 'higher health' compared to residents in other areas. No data on actual blood levels of contaminants such as 'dioxinlike' hydrocarbons have be provided so far for residents living in the vicinity of this incinerator.

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Domingo et al. (2000) analyzed soil and herbage samples in the vicinity of an old MWI in Montcada, Spain. The authors found changes in the soil contamination with total I-TEQ between 1996 and 1997. Trends of these changes were different in the main wind directions North-East, North-West, and South suggesting that sources different from the MWI at least had contributed to the soil levels. Air level estimates form the same area (Domingo et al., 2002) were carried out in 2000 when 'technical improvements' had been carried out at the MWI. The authors conclude that airborne exposure to PCDD/PCDFs was markedly reduced after the improvements. However, they also conclude that inhalation exposure to PCDD/PCDFs is almost 'imperceptible' compared with dietary background exposure to these contaminants both in areas closed to or at long distance to MWIs.

Meneses at al. (2004) tried to calculate the cancer risk resulting from PCDD/F emissions of a Spanish MWI. They calculated PCDD/F concentrations in environmental media by means of a simple-compartment-multimedia model. Changes in cancer risk were based on emission measurements before (111 ng I-TEQ/m^3) and after (0.086 ng I-TEQ/m^3) installation of a modern flue gas cleaning. The major conclusion was that the cancer risk form PCDD/F emissions from the MWI was extremely low, i.e., about 1000-fold below that calculated for PCDD/F emissions from other sources in the same area.

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3. Health Effects

3.1. Fourth Report of the British Society of Ecological Medicine on the 'Health Effects of Waste Incinerators'

In this report (2006), moderated by J. Thompson and H. Anthony, the health issues related to MWIs are discussed in detail. In the Introduction the authors already mention that *'some' attention has been paid to the concentrations of the major chemicals emitted.*. This statement strongly underestimates the amount of data on emissions from modern MWIs and the strict legislation on the emissions of major toxicants which is applied in the EU. Then the authors claim that the limitations of emissions do not take into consideration the point of view that *many chemicals build up over time in the human body*... If this was true, it should be possible to detect these chemicals at significantly higher amounts in the vicinity of modern MWIs. This is, however, not the case (see below).

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Then, the authors mention that *ash contains high concentrations of toxic substances such as dioxin....* The fact than toxic substances accumulate in the ash is due to the highly efficient gas cleaning process in MWIs. Since people are not exposed to fly ash but the treatment of fly ash and/or the final safe disposal of fly ash is part of any application to build and establish a modern MWI, this point is irrelevant. At present, techniques are available to either remove or destroy the toxic components or to dispose fly ash under safe conditions.

Epidemiological studies on the occurrence of certain diseases in the vicinity of MWIs are very difficult to carry out. Their interpretation requires great caution. Statements like ' *most show higher than expected levels of cancer...*' are misleading. For a scientific interpretation a statistical analysis is required. The fact that a certain figure of cancer incidence or mortality is slightly higher than expected is irrelevant and frequently due to bias or hazard. Usually, in these studies the levels of toxic compounds in air and/or in the body of people living in the area were not analysed.

A major point of caution is that MWIs usually are located in industrialized areas. There the incidence of certain diseases may be higher than in rural areas. The emissions from modern MWIs contribute to the overall burden of toxic compounds to a negligible amount. Further measures have to be taken to reduce emission from relevant sources of exposure such as traffic, heating, heavy industry, old power plants etc.

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In Chapter 2 on *Emissions from Incinerators and other Combustion Sources* the authors claim that *incinerators produce huge amounts of fine and ultrafine chemicals.* This statement is unacceptable from a scientific point of view. First it is unacceptable that the authors almost never provide any exact figures which could underline their statements. The term '*huge amounts*' is completely meaningless as long as no exact figures are given and are compared with background or with emissions from other sources. The fact that MWIs produce fine and ultrafine particles is almost meaningless. The important issue is how much particulate matter the MWIs release into the environment. The statement that *common baghouse filters act like a sieve and thus allow the transfer of 'huge amounts' of fine particles* is incorrect. In fact modern MWIs are equipped with washers which can hold back particles. Major sources of fine and ultrafine particles are traffic, heating, farming, heavy industry etc.

The statements on heavy metals, nitrogen oxides and organic pollutants are full of errors and misinterpretations. The authors claim that *the amount of metals emitted will vary hugely.* They do not provide a reference for this statement. The statement that *removal of nitric oxide by incinerators is only about 60% effective* is not supported by any reference. It is meaningless

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because the amount of nitrogen oxide emitted from the stack is the relevant figure and not the percentage of NO_x removed from the gas.

The list of qualitative findings on various organic chemicals at the end of the chapter is irrelevant because the dose makes the poison, i.e. the finding of a few molecules of a compound does not mean anything. The question of quantitative analysis of emissions and risk is completely ignored in this chapter.

In Chapter 3, 3.1 on *Health Effects of Pollutants* the authors provide a lengthy discussion of the adverse effects of fine particles. They do not, however, discuss the question what the contribution of modern MWIs to the overall exposure to fine particles is. It is feasible to assume that other sources are much more prominent than modern MWIs.

In subchapter 3.2 - 3.6. the issue of *Heavy Metals* and other toxic compounds is discussed. The toxicology of these compounds is presented based on certain references. A link between these statements and modern MWIs is not provided or discussed here.

In Chapter 4 on *Increased Morbidity and Mortality near Incinerators* the reader expects substantial information.

In Chapter 4.1 on *Cancer* many scientist will be disappointed. The first case mentioned does not have controls. A so-called 'cluster' is mentioned. In this cluster obviously dioxin levels in blood were never measured. Instead dioxin levels in soil are mentioned (which are not directly related to blood levels). The study obviously has never been published in a scientific peer-reviewed journal but is available on the internet only.

The next chapter contains more errors and misinterpretations. An adjusted cancer mortality rate of 1.08 is completely meaningless because of the standard error. That means that the likelihood to obtain an adjusted rate of exactly 1.00 compared to the control cohort is very low. Usually a rate different from 1.00 is due to biological variability. This has nothing to due with increased or decreased cancer risk.

The Knox et al. 1953 paper is on hazard but obviously not on modern incinerators.

The 1980 paper is biased by the fact that other sources of emissions were not considered.

The other studies were carried out in the vicinity of old-technology incinerators. Even there doubts are appropriate because of small case numbers and the lack of blood analysis for dioxins (in particular in the cases where a link to dioxin exposure is claimed).

With respect to birth defects five reports are mentioned. The Sint Niklaas study cannot be considered since it has not been published in a peer-reviewed journal.

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The ten Tusscher study (2000) is on 'open chemical combusting' not on modern MWIs.

The French study found defects and anomalies around incinerators. It is not mentioned that defects and anomalies usually occur in humans (and in animals). The epidemiological approach depends on the proper control group which is extremely difficult to define. It appears non-scientific to search for such anomalies around incinerators without convincing statistical evidence. Odds ratios for spina bifida of 1.17 and for heart defects of 1.12 are within background.

The next statement refers to hazardous waste sites. Again this statement is unrelated to modern MWIs.

In Chapter 5 on *Disease Incidence and Pollution* a number of partially wrong or incorrect statements and citations can be found. When, e.g, IARC (the International Agency for Research on Cancer) mentioned that 80% of cancers are due to environmental influences it does not mean environmental pollutants but factors not directly related to heritable genetic disposition. These 'environmental' factors include lifestyle factors such as lack of exercise, over-nutrition, smoking, alcoholic beverages, sexual behaviour etc. In fact leading institutions such as WHO concluded that environmental pollutants play a very minor role in overall cancer incidence probably in the range of a few percent. It is amazing how these facts so well established and recognized in cancer research are ignored in the report by the British Society of Ecological Medicine.

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It is unacceptable to correlate the number of cancer cases in the USA with the number of waste sites in the country.

The statement that cancer incidence is higher in industrialized areas explains the 'findings' of a relationship between MWIs and cancer.

The subchapter on so-called links between exposure to pollutants and cancer contains a number of statements which have no scientific basis and are even not feasible for non-experts. Likewise, the liver is mentioned as an organ with a high fat content, which is definitely wrong. Cancer incidences have been increasing in organs such as the prostate which does not have a high fat content either.

What follows is a crude list of historic examples which in some instances in fact showed a correlation between increased cancer risk and air pollution. Again, these statements are unrelated to modern MWIs.

In the next chapter the hazardous 'chemistry' is blamed for causing cancer. The authors ignore that natural products or substances derived from natural products such as the food

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contaminant fungi Aspergillus niger or heterocyclic aromatic amines formed during frying of fish and meat are among the most potent mutagens and carcinogens known. The statement '*incinerators emit carcinogens*' is not scientific. It is also true that ovens emit carcinogens when we bake a cake, toasters emit carcinogens when we toast bread, pans emit carcinogens when we fry fish or meat (not to talk about barbecues), cars emit carcinogens when we drive and so on...

In the next chapter major neurological diseases are linked to pollutants. Again it is completely unclear what this has to do with modern MWIs. It is unacceptable that some doubtful correlations between levels of pollutants and major neurological diseases which are not more than speculation are taken as a basis for serious statements.

Even violence and crime (and other problems of modern times) is linked to pollutants in this report.

In the Chapter on *the foetus, the breast-fed infant and children* the issue of dose again is ignored. The authors focus on the mere presence of 'chemicals' claiming that chemicals made by humans (i.e. the chemical industry) are dangerous whereas toxicologists learn at the University that the most potent 'chemicals' have been made by nature.

These chapters are a mixture of correct statements, statements ignoring major findings mixed together with conclusions from inadequate studies such as the Sint Niklas study. The issue of dose, i.e. the quantitative issue, which is of central relevance in toxicology, is completely ignored. Likewise, the question on how much of a certain compound is really released from a modern MWI and to what percentage it contributes to background exposure is never discussed.

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The issue of so-called *chemical sensitivity* discussed on pg. 29. is one of the most controversial issues in environmental medicine. It is unclear why it is discussed here. Its linkage to chemicals or contaminants is unlikely when considering the recent literature.

The so-called precautionary principle cannot be used and should not be applied to any environmental issue in the sense that precaution means 'stop the project'.

Many of the following chapters are completely unrelated to modern MWIs.

The issue of monitoring is discussed in an inappropriate way. The major toxicants emitted from MWIs are known. The chimera of '*highly toxic unknown substances*' is as old as it is

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wrong. Our own experiments prove, e.g., that the acute toxicity of MWI fly ash can mainly if not exclusively be attributed to heavy metals.
The dioxin emissions from MWIs are so low that they can hardly be measured on-line. For this reason the dioxins have to be collected over several days. Such monitoring has been carried out e.g. by Hagenmaier in modern MWIs demonstrating that the emission levels are well below 0.1 ng TEQ/m^3 emission gas.

The chapter on risk assessment shows that the authors do not trust scientific toxicology and epidemiology. Unfortunately, they do not tell the reader what they suggest to use instead to find out the truth except for their 'personal feelings or guess'. Their comments on risk assessment are biased. They accuse the method for their uncertainties. That the 'best guess' of the authors is hampered by enormous uncertainties and overwhelming inconsistencies is ignored.

The conclusions made by the authors are wrong for the following reasons.

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1) The epidemiological studies claiming a relationship between incinerators and health problems are all hampered by small case numbers and/or lack of chemical analysis and/or biased by other sources in the same area and/or inadequate controls. A number of studies mentioned by the authors did not find significant relationships (A relative risk in the range of 1.1 or similar is meaningless).

2) Particulate matter (PM) in fact is suspected to be related to a number of diseases. Modern MWIs are not a major source for PM. The relative contribution of major sources of PM to human exposure is even not discussed in the report.

3) The issue of concentration/dose is a central issue in toxicology. It is permanently ignored in this report. The mere presence of a chemical is meaningless, the dose makes the poison.

4) Radioactive can easily be monitored. Modern MWIs are no relevant source of radioactivity.

5) The issue of fly ash is part of the environmental impact analysis. Fly ash can be treated and/or disposed safely.

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6) The long term build up of toxicants is not real for most compounds. Some compounds in fact can accumulate in the human body. They can easily be measured. No accumulation of any chemical related to MWIs significantly higher than background was ever found in people in the vicinity of a modern plant. These plants have now been in operation for more than 15 years in many countries. There are no health problems or environmental impact documented which can be related to the MWIs.

7) Not a toxicological issue.

8) There is no toxic impact by modern MWIs. The prevention of any emission of harmful molecules (ignoring the dose issue) is not realistic It would require the end of any civilization (including the use of fire). It is wrong to believe that this status (before civilization) would be chemically 'safe', since nature produces/bears the most effective toxicants known.

In summary this report is a compilation of facts and statements which are either wrong or used in a misleading way or are not related to the issue of modern MWIs. It cannot be considered as a serious and reliable source of scientific information. In contrast it reflects a strongly biased point of view probably with a political motivation. It ignores facts and, which is more concerning, ignores science.

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3.2. Greenpeace Report on Incineration and Human Health

This report was published in 2001 by Greenpeace Research Laboratories, University of Exeter, UK. The authors are M. Allsopp, P. Costner and P. Johnston.

Related to *'Health impacts on populations living near to incinerators'* (Chapter 3) the authors claim *that a limited number of studies have been conducted to determine whether individuals residing near to incinerators have been exposed to pollutants. Studies are restricted to investigations of exposure to dioxins and heavy metals. Results of these studies are mixed. Some reported elevated exposure among nearby residents while others found no evidence of increased exposure.*

This introductory statement leaves the reader with the impression that the overall exposure situation for people living in the vicinity of a MWI is unclear, and therefore, needs further

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investigation. This notion is highly misleading which becomes evident when the individual studies cited by the authors are analysed in detail:
The study by Gonzalez et al. (2000) found an increase in dioxin blood levels, two years after the MWI (in Spain) went into operation. However, the increase was not different in the residents living near to the MWI and those living further away which led Gonzalez et al. to the conclusion that *the increase in dioxin blood levels was unlikely to be attributable to the incinerator.*

The study by Miyata et al. (1998) was conducted in the vicinity of a traditional Japanese waste incinerator without any gas cleaning.

The study by Startin et al. (1994) was also carried out in the vicinity of a MWI which was not equipped with modern flue gas cleaning and was closed in 1991. The dioxin blood levels in seven residents in Derbyshire, UK, were 'higher' than in a 'comparison group' which was the German population. It is self-evident that such a comparison is worthless.

The study by Holdke et al. (1998) was never published in a journal but was only available as an abstract. No judgement can be made on the scientific quality of this study.

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Deml et al. (1996) found no increase in dioxin blood levels in residents living in the vicinity of a modern MWI in Germany.

Van der Hazel and Frankfort (1996) did not see a difference in blood dioxin levels between residents living near to a modern Dutch MWI and a control group from the Dutch general population.

Kurttio et al. (1998) found higher levels of mercury in the hair of residents living near to a hazardous waste incinerator in Finland between 1984 and 1994. The incinerator was not equipped with modern flue gas cleaning.

In summary, this analysis shows that only two studies could demonstrate higher levels of dioxin or mercury in residents living close to an incinerator when compared to an apparently adequate control group. In both cases the incinerators where not quipped with any flue gas cleaning (Japan) or had insufficient flue gas cleaning (Finland). In all cases where modern

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MWIs were in operation no indication for a relevant or measurable exposure of people due to the MWI was found. This fact is unfortunately ignored by Allsopp, Costner and Johnston.

In the following chapter on *biomarkers* the authors refer to a study on urinary excretion of thioethers. It is completely unacceptable from a scientific point of view to relate urinary thioethers to MWIs or any other putative source without identifying the chemical structure of the thioethers thus providing at least some scientific evidence for a possible relationship. Urinary thioethers can be derived from hundreds of compounds even including endogenous compounds. These include food constituents, food contaminants, occupational chemicals, cosmetics, household products, environmental agents etc.

In chapter 3.2 entitled *Health Effects – Epidemiological Studies* the authors claim that *the majority of epidemiological studies on the health of populations residing near to incinerators have focused either on incidence of cancer or respiratory symptoms. Additionally, some research has investigated other potential effects including congenital abnormalities and changes in the sex ratio. Considering the widespread use of incinerators on a global scale, the number of studies that have investigated health effects in residents near to these facilities is sparse.*
In subchapter 3.2.1 studies on cancer are discussed.

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The study by Viel et al. (2000) analysed the incidence of soft tissue sarcoma and non-Hodgkin's lymphoma in the area of Besancon (France). It was found that the incidences of both diseases were increased in the vicinity of an MWI without modern flue gas cleaning. The dioxin emissions were reported to be in the range of 16.3 ng I-TEq/m^3 which led the authors to the suggestion that dioxins were the causative agents. The study does not contain any data on the levels of dioxins in air, soil or in the blood or adipose tissue derived from residents of the various areas or from cancer patients. If a dioxin exposure was suspected to cause these disease, this hypothesis could have been easily tested by such analysis.
The authors of the study claim that confounders were unlikely. However, the issues of population density, local genetic clustering, heterogeneity of the population (racial confounders) and diagnostic bias (proximity to University hospital) were not adequately addressed.

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Biggeri et al. (1996) analysed the spatial relationship between four sources of air contamination in Trieste, Italy, and lung cancer risk based on a case-control study. The risk of lung cancer was related to a location of residence close to the city centre and close to a MWI with insufficient gas-cleaning technology. It is mentioned by the authors, however, that the distances from the four sources were highly correlated. Furthermore, the emissions are not identified or analyzed which, from the authors' point of view, should be responsible for the effects of the incinerator on lung cancer risk. A number of probable confounding factors are discussed below.

The studies on laryngeal cancer appear to unreliable. In particular, the incidence of laryngeal cancer is highly modulated by widespread individual risk factors, i.e., consumption of alcoholic beverages containing more than 20% ethanol (calvados, whiskey, gin etc.) and smoking. Proximity to MWI has to be tested for the confounder 'urbanization'.

The studies by Elliott et al. (1996, 2000) carried out in the United Kingdom are discussed below. They are hampered by the probable confounders urbanization and socio-economic status. In all studies from this group no exposure data are provided.

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The studies by Knox (2000) and Knox and Gilman (1998) have the same and other drawbacks. They are discussed below in more detail.

In subchapter 3.2.2 studies on respiratory effects are discussed.
In the introduction the authors claim that *Incinerators, in particular cement kilns, emit considerable quantities of SO_2 and NO_2. Long term exposure to theses substances is known to have negative impacts on respiratory health*...This statement is quite typical for the whole report. It uses inadequate generalizations e.g. from cases of cement kiln emissions to the general group of 'incinerators'. Furthermore, meaningless statements such as about *'considerable quantities'* are made.

An early study by Zmirou et al. (1984) is cited. The authors of that study mention that it was not possible to conclude a cause-effect relationship between the incinerator and respiratory effects.

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It follows a list of publications which deal with respiratory diseases in the vicinity of a hazardous waste incinerator including reports about workers employed in the plant, studies on people living in the vicinity of a Taiwanese wire-reclamation incinerator without flue gas cleaning, a study on cement kilns in the United States and others about installations completely unrelated to modern MWIs. It remains unclear what the aim of such an unselected list of descriptions was.

The studies by Shy et al. (1995) and Lee and Shy (1999) on respiratory diseases in the vicinity of a modern MWI found no relationship between both and no impact of the MWI on the PM_{10} levels. These publications are discussed in detail for their limitations. One example is that the authors did not see a relationship between PM_{10} levels and respiratory function. Obviously, it appears hard to believe for the authors that a threshold for measurable PM_{10} effects on respiratory function exists.

In a subchapter on sex ratios (3.2.3) the authors claim hat Mocarelli et al. (2000) had reported changes in the sex ratio of births in Seveso after the TCDD incident in 1976. A study by Williams et al. (1992) found an excess of female births in an area 'identified as being most vulnerable to air pollution from incinerators'. The authors noted, however, that *it is not possible to attribute causality of increased female births to materials released by incinerators.*

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In subchapter 3.2.4 studies on congenital abnormalities are discussed.
The studies were carried out in the vicinity of waste incinerators without modern flue gas cleaning (1961-1969). *The study by ten Tusscher et al. (2000) found an increase in the incidence of orofacial clefts in babies born after the incinerator began.* The authors relate cleft palate formation to TCDD exposure. However, no increases in cleft palate incidence were found in Seveso. Furthermore, no data on dioxin exposure (external or internal) were provided by ten Tusscher et al.
The second study on the Neerland neighbourhood in Belgium did not found statistically significant influences on chromosomal damage in children or on congenital malformations in the area. The report claims that the probability of giving birth to a baby with congenital malformation was 1.26 times greater for Neerland women than for Flemish women in general. For those familiar with the annual and spatial fluctuations of the incidences of malformations, such a figure must appear meaningless, however.

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In subchapter 3.2.5 studies on multiple pregnancy are discussed.
The authors conclude that the findings on a relationship between multiple pregnancy and MWIs are inconsistent.

In subchapter 3.2.6 studies on hormonal effects are discussed.
A study carried out by Osius and Karmaus was published as an abstract in 1998.

3.3. Publications in peer-reviewed journals

Elliott et al. (1996) examined the cancer incidences of over 14 million people living near 72 MWIs in Great Britain between 1974 and 1987. The excess from 0 to 1 km distance ranged from 37% for liver cancer to 5 % for colorectal cancer. A major problem with this study is the 'urbanization factor', i.e., people living in industrialized, highly populated areas show higher incidences for various diseases including cancer. Reasons for this effect may be lifestyle (smoking, alcoholic beverages, lack of exercise, 'population stress') as well as air pollution from heating, traffic, dust etc. It appears not useful to publish 'correlations' to MWIs under these circumstances. The authors accuse TCDD and other 'dioxins' as probably causative for their findings without providing any data on the actual TCDD or dioxin levels in the populations or individuals investigated.

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Biggeri et al. (1996) analysed the spatial relationship between four sources of air contamination in Trieste, Italy, and lung cancer risk based on a case-control study. The risk of lung cancer was related to a location of residence close to the city centre and close to a MWI with insufficient gas-cleaning technology. It is mentioned by the authors, however, that the distances from the four sources are highly correlated. Furthermore, the emissions are not identified or analyzed which, from the authors' point of view, should be responsible for the effects of the incinerator on lung cancer risk. Furthermore, the likelihood of exposure to occupational carcinogens was obtained from 'expert evaluation'. Smoking habits were investigated by the use of a questionnaire which, in particular in the case of lung cancer, can not be considered as reliable.

Knox (2000) studied the incidence of child cancer/leukaemia in a migration study in Great Britain. He found a highly significant excess of migrations away from birthplaces close to

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MWIs. The relative risks calculated by Knox within 5.0.km of these sites were about 2:1. The author claims, however, that the specific effects of the MWIs could not be separated clearly from those of adjacent industrial sources on combustion effluents. The study does not take into account if the place of residence was located on the leeward or windward side of the MWI. It does also not consider other sources but was obviously designed to focus on MWIs. Data on the actual levels of air pollutants in the areas of migration are not provided.

In 2006, Knox and Gilman published another paper on a similar issue, i.e., the effects of migration towards or away from 'sources' of 'hazardous chemicals' in Great Britain on the incidence of death from childhood cancer. The authors found that the risk of childhood cancer death was related to proximity to several types of 'industrial sources' around the time of birth. The 'industrial sources' were identified by the use of 'map searches' or 'business directories', i.e. by best guess. In contrast to the paper by Knox (2000) MWIs are no longer listed among the types of 'toxic industrial sites'. It is also no longer claimed that migration towards a 'toxic industrial site' during childhood (before the age of 16) is the critical risk factor. Instead, the location of residency around the time of birth is now suggested as the critical parameter. For unknown reasons, the socio-economic background of the mothers was not evaluated. Furthermore, the incidence of cancer death but not that of cancer is considered. This may be particularly misleading since socio-economic factors may clearly influence the success of childhood cancer treatment. In addition, very critical confounders such as smoking habits of the parents are not investigated or discussed.

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Viel et al. (2000) examined the spatial distribution of soft-tissue sarcomas and non-Hodgkin's lymphomas around a French MWI with relatively high levels of dioxin emission (16.3 ng I-TEQ/m^3). They found identical clusters of increased standardized incidence ratios for both types of cancer 'around the MWI'. The authors discuss the possible confounding by urbanization since the highest incidence was found for the area of Besancon, the area with the highest population density among the areas investigated. The authors claim that the evidence for a relationship between urbanization and the incidence of non-Hodgkin's lymphoma is 'still controversial' and no similar findings were reported for the incidence of soft tissue sarcoma. Furthermore, no increases in incidences were found for other urbanized areas such as Montbeliard, Sochaux, and Audincourt. They do not mention, however, that the overall population of the area of Besancon is much higher than that of the next three densly populated areas, Montbeliard, Sochaux, and Audincourt. It is completely unclear, why they did not

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chose a control area of the same degree of urbanization without MWI. Furthermore, it remains unclear why no blood levels of PCDD/PCDFs were measured in spite of the authors' suggestion that these compounds were responsible for the observed findings. The detection of PCDD/F blood levels is a well established procedure to analyse the exposure to these compounds because of their long elimination half-life in humans. In summary, this study leaves more questions open than it answers.

Elliott et al. (2000) reported an excess risk of 37% for liver cancer within 1 km of MWIs in the United Kingdom. They state that '*one difficulty in interpreting these numbers is the issue of socio-economic confounding. ....registered cases of primary liver cancer in Great Britain are strongly related to deprivation - ... showing more than twofold variation in risk between the most affluent areas and the most deprived.* Besides this obvious confounding factor which has much higher power than the 'effect' found for the distance from MWIs, the authors make no attempt to speculate on the possible causal factor which should be responsible for the increased liver cancer risk. This is a major drawback of most epidemiological studies dealing with this issue. In case of such hypotheses (which the authors avoid) a measurement of the levels of the accused contaminant would have been appropriate and necessary.

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Hazucha et al. (2002) carried our a 3-year epidemiological study were they tested spirometric lung function once annually among residents in three communities in North Carolina surrounding a hazardous waste, biomedical, or municipal waste incinerator, and among residents in three comparison communities. The average monthly concentrations of particulate matter with diameters of 2.5 µm and less ($PM_{2.5}$), ranging from 14.6 – 31.5 µg/m^3 in ambient air, in all communities were similar during the 3 years of study supporting the notion that MWIs have no measurable influence on the $PM_{2.5}$ load of ambient air. There was no difference in percent predicted forced vital capacity, forced expiratory volume in 1 sec, or forced expiratory flow rate over the middle 50% of the forced vital capacity among members of the 'incinerator communities', compared with 'non-incinerator communities', and there were no significant differences in lung function within the three sets of communities. *There was no evidence form this study that an association exists between residence in the three waste incinerator areas, which met state and federal emissions regulations, and average spirometric pulmonary function of non-smoking community members.*

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In a study by Floret et al. (2003) the vicinity of the MWI in Besancon (France) was also investigated (see above). The authors compared the pattern of non-Hodgkin's lymphoma diagnosed between 1980 and 1995 with a Gaussian-type dispersion model for 'dioxin'. This model had been applied as part of an EIS for a new combustion chamber. They found that *the risk of developing non-Hodgkin's lymphoma was 2.3 times higher (95% confidence interval = 1.4 – 3.8) among individuals living in the area with the highest dioxin concentration than among those living in the area with the lowest dioxin concentration.* Here, the authors tend to ignore that the 'dioxin levels' were based on a model. For unknown reasons, they did not measure the actual dioxin levels in ambient air or in blood of the individuals. All studies which have measured the dioxin levels in ambient air in the vicinity of modern MWIs did not found any measurable influence of the MWI (e.g. Deml et al., 1996). It appears highly likely that confounding factors have influenced the outcome, in spite of the notion made by the authors that the emission levels of the Besancon incinerator were (average?) 16.3 ng I-TEQ/m^3, i.e., 163-fold higher than the EU regulation limit (part of the incinerator was shut down in 1998). Likewise, the racial background of the population was shown to influence the rate of non-Hodgkin's lymphomas being significantly higher among blacks than among whites in the United States (Wu et al., 2005).

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Tango et al. (2004) analyzed the association of adverse reproductive outcomes in Japan with the proximity of the residence area of the mothers to MWIs with high dioxin emissions. None of the reproductive outcomes tested (male/female sex ratio, low birth weight, very low birth weight, infant deaths due to congenital malformations, neonatal deaths, neonatal deaths due to congenital malformations, spontaneous fetal deaths, and spontaneous fetal deaths with congenital malformations) showed statistically significant excess within 2 km distance from the incinerator. A statistically significant peak-decline in risk with distance from the incinerators up to 10 km was found for infant deaths and infant deaths with all congenital malformations combined. For this study no data on exposure or body burden of 'dioxinlike' contaminants, on socio-economic status, smoking and alcohol history were available.

For risk assessment purposes (Glorennec et al., 2005) estimated the emissions for major contaminants in cleaned flue gas by using the median value of measured levels in gas samples (usually taken once a year) and a Gaussian plume dispersion model to calculate the ambient air concentrations attributable to the incinerator. A multimedia model was used to calculate concentrations in the food chain. The authors conclude that after compliance of the emissions

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following the upgrade of the incinerator in 2000, all hazard ratios and future individual lifetime excess risks appear minimal.

Cordier et al. (2006) studied the incidence of congenital malformations in communities surrounding 70 French MWIs that operated at least one year between 1988 and 1997. They found that the rate of congenital anomalies was not significantly higher in 'exposed' compared with 'unexposed' communities. Some subgroups of major anomalies, specifically facial clefts and renal dysplasia were more frequent in the 'exposed' communities. The risk of other types of anomalies increased with road traffic density. The authors conclude that although both incinerator emissions and road traffic may plausibly explain some of the excess risk observed, several alternative explanations, including exposure misclassifications, ascertainment bias, and residual confounding cannot be excluded. Some of the effects might, from the authors' point of view, be attributable to old-technology MWIs. They do not provide any data on external or internal exposure of the population or the mothers. The identity of the compounds possibly explaining the correlations seen is subject to speculation. Furthermore, the category 'other polluting sites' was restricted to 'smelting, metallurgy or industrial waste incinerator' giving the (wrong) impression that such facilities are the only sources (besides road traffic) of relevant environmental pollutants. Obviously, other sources such as conventional and nuclear power plants, chemical and petrochemical industry, emissions of organic solvents, use of agricultural chemicals etc. were not considered at all.

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4. Summary and Conclusions

Studies on a possible impact of municipal waste incinerators on health can be divided into studies on exposure to hazardous compounds and studies on health effects.

This report concentrated on three main report types:

- Fourth Report of the British Society of Ecological Medicine on the 'Health Effects of Waste Incinerators'
- Greenpeace Report on Incineration and Human Health
- Publications in peer-reviewed journals

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In peer-reviewed publications no increased levels of dioxins could be found in the vicinity of modern Municipal Waste Incinerators. However, there is good evidence that higher levels of internal and external dioxin exposure have existed and may still exist in the vicinity of Municipal Waste Incinerators with no flue gas treatment or insufficient flue gas treatment. Facilities without flue gas treatment are not found in Europe but do exist in countries such as Japan. Insufficient flue gas treatment did exist in Europe prior to 1990 in some facilities.

With respect to health effects a number of studies suggest a causal relationship between old Municipal Waste Incinerators and certain adverse health conditions/diseases such as cancer, respiratory diseases, congenital malformations and hormonal changes. Most of theses studies were hampered by the lack of adequate measurements on internal or external exposure and by the likelihood of strong confounders. Such confounders are mainly urbanisation, socio-economic deprivation and related factors.

The reports published by Greenpeace and by the British Society of Ecological Medicine on this issue are relatively non-selective compilations of all kinds of reports on waste treatment and health. They comprise of and discuss studies on health effects at the workplace (workers at the plant) and in the vicinity of Municipal Waste Incinerators without any flue gas cleaning, with inadequate flue gas cleaning, and with modern flue gas cleaning facilities. Furthermore, findings from sewage sludge incinerators, hazardous waste incinerators, municipal waste incinerators and other types of incinerators etc. are presented and finally combined in an unscientific way.

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In fact, there is not a single peer-reviewed study showing that modern Municipal Waste Incinerators release hazardous substances at a level causing any harm to the people in the vicinity. Monitoring studies have shown that emissions from modern facilities which are operating within the strict EU limit, have a negligible contribution to background levels. No study has shown any adverse health effects in the vicinity of a modern Municipal Waste Incinerator clearly related to the plant.

In summary modern Municipal Waste Incinerators can be regarded as safe facilities which have an imperceptible impact on the environmental and health situation in their neighbourhood.

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Appendix 13.4

Data on Existing Health in the Community

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Baseline health status assessment for Ringsend

- Dr. Anthony Staines, Department of Public Health Medicine and Epidemiology, UCD.

- Dr. Howard Johnson, Mr. Eugene Boyle, Dr. Bob McDonald and Dr. Deirdre Carey, Health information Unit, Eastern Regional Health Authority.

Executive summary

This is the report of a baseline health assessment of the Ringsend area, conducted as part of a wider baseline assessment before proposals for building a large municipal waste incinerator in the area are prepared.

Using routinely collected health data, gathered at the level of DEDs, we have tried to present a profile of the health of the people living in the affected area. We have compared their health, primarily, with the health of other people living in adjacent DEDs.

The DED containing most of the affected area, Pembroke East A, is significantly less affluent than most of the adjacent DEDs. The people living there also have much worse health. There is a striking excess of ill health and death related to respiratory causes in this DED. This is likely to be due to a combination of social, environmental and lifestyle factors.

When considering the impact of future developments on this population, their intrinsic vulnerability to adverse effects of development will need careful assessment.

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Background

The Department of Public Health Medicine and Epidemiology, in University College Dublin was approached by Ms. Jean Clarke, of M.C.O'Sullivan Ltd. (MCOS) in 2003. MCOS were acting as agents for Dublin Corporation. We were asked to prepare a proposal for a full Health Impact Assessment on a proposed municipal waste incinerator in Ringsend in South Dublin City.

This proposal was not acted on at the time, and we were asked instead to contribute to a baseline study as a precursor to a planning application for the incinerator. Specifically we were asked to use available routinely collected data to examine the current health status of people living near the proposed site, to place this in the context of the health of people living in surrounding areas, and to comment on this.

After discussion with colleagues in the Health Information Unit (HIU) of the Eastern Regional Health Authority we drew up a preliminary proposal which was accepted by Ms. Clarke on behalf of MCOS.

In outline, we suggested the use of some combination of available mortality data, routinely collected prescribing data, cancer incidence data, hospital admissions data, and data on congenital anomalies, analysed at the level of DED's, to compare the baseline health of the population living near the proposed site to that of their neighbours, and that of the wider population.

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Data sources

Five sources of routine data were evaluated for use in this project. These were routinely collected mortality data, derived from death certification; cancer incidence data , derived from active case ascertainment in hospitals by the cancer registry; routinely collected prescribing data collected by the GMS payments board, from prescriptions filled in pharmacies; hospital admissions data, recorded at hospital entry, and collated by the ESRI; records of the births of children affected by congenital anomalies, recorded by the Eurocat registry in Dublin.

Each of these sources of data is potentially useful, but each has substantial limitations. The main general problem is geocoding, which affects each one of these data sources in some way. For the kind of work proposed here it is essential to know where the people affected by a health event, a birth, death, hospital admission and so on actually lived at the time of the event. The process of linking a person to small area in which they live is called geocoding.

Most other EU countries have systems that permit the more or less simple linkage of a person to a specific place. The small area unit in Ireland is the District Electoral Division (DED). In England, which has some of the worst health information systems in the EU, it is possible to use postcodes to link someone's address to a small area. In Sweden there is full civil registration, so it is possible to link someone's personal number to a small area. In Ireland

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this has to be done by linking written address details to small areas. This is very expensive, hard to do in cities, and often impossible in rural areas.

The major problems with each data source will be discussed in turn.

Mortality data

Irish mortality data are collected at death registration. Registrars abstract death certificates, code the results, and send these centrally. The quality of death certification in Ireland is not known, but is probably very variable. By default, the area of residence written on the death certificates are only coded to county and city borough level. The HIU has carried out a series of special coding exercises, but despite a considerable effort, 5% of deaths cannot be linked to DED's. The data used here runs from 1994 to 1999. Data for 1999 to 2003 will be available later this year.

Cancer incidence data

Cancer incidence data are collected by the National Cancer Registry of Ireland (NCRI), which is based in Cork. They employ specially trained nurses, who search out cases of cancer in Irish hospitals. They also link death certificate diagnoses of cancer. The quality and completeness of the Cancer Registry data have to been shown to be very high.

The NCRI code addresses to DED level in house, using special software. In Dublin just over 5% of deaths could not be linked to DEDs. Cancer data is presently available for 1994 to 2000 inclusive. Data for 2001 will become available later this year.

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Prescribing data

The GMS payments board record detailed data on prescriptions given to medical card holders. Very considerable detail is recorded, including the dose, duration and the name of the drug prescribed. These are presented for analysis in groups, derived by considering the main therapeutic indications for the particular drug.

A major limitation of this system is that it only covers medical card holders. Therefore the value of this system in comparing health states between areas with different proportions of medical card holders is limited. Against that, medical card holders are presumably some of the most vulnerable individuals in society, so measuring their usage of prescription drugs should give a useful indication of the health of an area.

Our analysis reports on drugs coded as being used to treat asthma. This includes much drug treatment of older people with chronic bronchitis, as well as specific treatment for asthma. The data presented here are for 2002.

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HIPE data

Hospital discharges are recorded by the Hospital Inpatients Enquiry System (HIPE). Each state-funded acute hospital in Ireland participates in this system. Every hospital discharge is coded by specially trained staff based in the hospital. The main source of information is the discharge letter dictated by hospital medical staff.

HIPE records are coded to county level, to county borough level, to town, and, in Dublin only, to post code. Unfortunately Dublin has only 21 postcodes (Dublin 1,2,3 etc..). These are too coarse a geographical level to be useful for our purposes. While some hospital discharge records have been geocoded to DED level by the HIU in ERHA, the records are still incomplete for the hospital closest to our study area. For this reason, HIPE records are not usable for this exercise.

Eurocat data

Ireland is a member of the European system for recording the births of babies affected by congenital anomalies (Eurocat). Affected babies are identified, mostly, in maternity hospitals and registered. While the affected babies births are coded to DED level, there are no corresponding figures for unaffected babies.

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For this reason, it is not possible to calculate rates of births of affected babies. The rate is the number of affected babies born in a DED in a year, divided by the total number of babies born in that DED in that year. This, however, is what is required for the analyses presented here, and so this data source cannot be used.

Statistical methods

There are several difficult and technical problems that arise in analysing this type of health data from small areas. These are discussed in the appendix. After carefully considering the issues, we selected two statistical methods, indirect standardisation and Empirical Bayes (EB) smoothing for use in this project. Further details of both are contained in the Appendix.

Both methods produce estimates of the risk of the event being considered (death from a particular cause, a new diagnosis of cancer, or being prescribed a specific drug), compared with the risk in the whole ERHA area. Indirect standardisation produces, a Standardised Mortality Ratio (SMR), Standardised Incidence Ratio (SIR), or a Standardised Prescribing Ratio (SPR), for deaths, new diagnoses of cancer, and being prescribed a particular group of drugs respectively.

The EB methods produce the corresponding smoothed figures. These are more reliable estimates of the actual risk in a small area compared with the risk in the Dublin City region.

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Results

Following discussions with the HIU in ERHA it was decided to take 14 DEDs to make up the study area. The DEDs selected are those on the coast and just inland, lying north and south of the proposed site in Ringsend. The centre of interest is the Pembroke East A DED, which covers most of Ringsend, and where permission will be sought to erect a municipal waste incinerator. Table 1 lists basic features of the DEDs selected. They are also shown in Figure 1.

DED Code	DED Name	Population	Deprivation score(1)
42	Clontarf East B	6,458	1
43	Clontarf East C	3,029	1
44	Clontarf East D	2,772	1
48	Clontarf West C	3,372	2
49	Clontarf West D	2,140	2
108	North Dock B	3,628	4
110	Pembroke East A	4,304	4
111	Pembroke East B	3,595	1
112	Pembroke East C	3,900	1
114	Pembroke East E	3,337	1
115	Pembroke West A	3,241	2
116	Pembroke West B	3,140	1
117	Pembroke West C	4,188	1
143	South Dock	3,764	1

Table 1. Names, population sizes and deprivation scores for the DEDs making up the study area

[Map to be got please!]

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Figure 1. Map of Dublin, showing the study area.

Populations

There are fourteen DEDs in the study area (Figure 1). They had a total population in 1996 of just over 49,000 people, ranging from just over 2000 to just under 6350 people. They are divided sharply by deprivation score (1), with the Ringsend area and the North Dock area both being quite deprived, and all of the other areas being in the most affluent fifth of Dublin areas, or the second most affluent fifth.

Mortality data

Five major groups of causes of death were examined. These were all-cause mortality, deaths due to ischaemic heart disease, deaths due to all types of cancer, deaths due to all types of respirator disease, deaths due to cerebrovascular disease (strokes) and deaths due to injury and poisoning.

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Deaths were assigned to these groups using the ICD codes of the cause of death from the death certificates.

These groups were chosen because they fulfilled three criteria. They were available from existing data, they were important causes of death, and they were believed to be affected by poor external environments.

Results are presented in uniform format. Each cause of death is given as a singe table, listed in order of DED codes, with DED codes, DED names, the actual number of deaths observed, the SMR derived from indirect standardisation, the smoothed SMR smoothed using the Empirical Bayes method of Clayton and Kaldor, and 95% confidence limits for the SMR.

All deaths

DED Code	DED Name	Observed	SMR	Smoothed SMR	Lower CI	Upper CI
42	Clontarf East B	337	89	90	80	99
43	Clontarf East C	149	77	79	65	90
44	Clontarf East D	140	82	85	69	96
48	Clontarf West C	161	82	84	69	95
49	Clontarf West D	147	104	105	87	121
108	North Dock B	235	134	133	117	151
110	**Pembroke East A**	**245**	**143**	**141**	**125**	**161**
111	Pembroke East B	206	107	107	92	121
112	Pembroke East C	196	83	85	72	95
114	Pembroke East E	119	83	86	68	98
115	Pembroke West A	211	131	130	113	148
116	Pembroke West B	112	84	87	69	100
117	Pembroke West C	179	95	96	81	108
143	South Dock	176	134	132	114	154

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The highest death rates are found in Pembroke East A, with raised mortality also in Pembroke West A and North Dock B. This pattern, which is closely related to the level of deprivation, is highly unlikely to be due to chance. However there are fifteen DEDs in Dublin City with higher all-cause smoothed SMRs than Pembroke East A.

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Deaths from all cancers combined

DED Code	DED Name	Observed	SMR	Smoothed SMR	Lower CI	Upper CI
42	Clontarf East B	101	104	106	84	125
43	Clontarf East C	43	88	94	64	119
44	Clontarf East D	34	76	86	53	107
48	Clontarf West C	35	77	87	54	107
49	Clontarf West D	35	99	103	69	138
108	North Dock B	72	151	142	118	190
110	**Pembroke East A**	**65**	**136**	**130**	**105**	**174**
111	Pembroke East B	52	110	111	82	144
112	Pembroke East C	65	120	119	93	153
114	Pembroke East E	29	79	90	53	114
115	Pembroke West A	48	112	112	83	149
116	Pembroke West B	30	90	97	60	128
117	Pembroke West C	43	95	100	69	128
143	South Dock	40	120	118	86	164

This is similar to the previous table, showing higher death rates from cancer in North Dock and Pembroke East A. The latter is number 32 in order of decreasing cancer mortality. None of the other areas clearly shows a raised, or decreased cancer mortality.

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Deaths from respiratory disease

DED Code	DED Name	Observed	SMR	Smoothed SMR	Lower CI	Upper CI
42	Clontarf East B	43	79	84	57	107
43	Clontarf East C	23	82	89	52	123
44	Clontarf East D	16	67	78	38	108
48	Clontarf West C	24	80	87	51	119
49	Clontarf West D	16	77	87	44	125
108	North Dock B	34	144	137	100	201
110	**Pembroke East A**	**44**	**197**	**177**	**143**	**265**
111	Pembroke East B	30	106	108	72	151
112	Pembroke East C	33	91	95	63	128
114	Pembroke East E	12	60	75	31	104
115	Pembroke West A	24	108	110	69	161
116	Pembroke West B	19	99	104	60	155
117	Pembroke West C	32	115	115	79	162
143	South Dock	28	153	142	102	221

Pembroke East A has the fifth highest respiratory disease mortality in Dublin City. South Dock also has modestly increased mortality from this group of diseases.

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Deaths from Heart Disease

DED Code	DED Name	Observed	SMR	Smoothed SMR	Lower CI	Upper CI
42	Clontarf East B	81	92	94	73	114
43	Clontarf East C	37	82	88	58	113
44	Clontarf East D	35	88	93	61	122
48	Clontarf West C	46	103	105	75	137
49	Clontarf West D	32	97	101	66	137
108	North Dock B	55	134	130	101	175
110	**Pembroke East A**	**52**	**131**	**128**	**98**	**172**
111	Pembroke East B	47	106	107	78	141
112	Pembroke East C	45	84	89	61	112
114	Pembroke East E	27	83	90	54	120
115	Pembroke West A	55	147	140	111	191
116	Pembroke West B	25	82	90	53	120
117	Pembroke West C	47	110	111	81	146
143	South Dock	36	121	119	85	168

For heart disease, Pembroke West A, and North Dock have elevated mortality. Pembroke East A has non-significantly raised mortality, and is forty-second in order in Dublin City.

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Deaths from Stroke

DED Code	DED Name	Observed	SMR	Smoothed SMR	Lower CI	Upper CI
42	Clontarf East B	33	89	94	61	125
43	Clontarf East C	12	63	83	33	110
44	Clontarf East D	18	111	107	66	176
48	Clontarf West C	5	25	62	8	57
49	Clontarf West D	15	107	105	60	177
108	North Dock B	22	138	119	86	209
110	**Pembroke East A**	**22**	**146**	**122**	**91**	**221**
111	Pembroke East B	17	89	96	52	143
112	Pembroke East C	12	49	72	25	86
114	Pembroke East E	12	88	97	46	154
115	Pembroke West A	17	113	107	66	181
116	Pembroke West B	14	109	105	59	182
117	Pembroke West C	15	80	92	45	132
143	South Dock	19	153	123	93	240

There is less variation between DEDs for stroke death rates than for the other causes of death described here. In particular there is no good evidence of increased mortality in Pembroke East A.

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Deaths due to injury and poisoning

DED Code	DED Name	Observed	SMR	Smoothed SMR	Lower CI	Upper CI
42	Clontarf East B	6	54	73	20	118
43	Clontarf East C	3	55	84	11	161
44	Clontarf East D	5	102	110	33	240
48	Clontarf West C	7	117	117	47	239
49	Clontarf West D	7	175	143	71	365
108	North Dock B	5	86	100	28	201
110	**Pembroke East A**	**11**	**167**	**146**	**83**	**299**
111	Pembroke East B	5	78	95	25	183
112	Pembroke East C	10	135	128	65	248
114	Pembroke East E	5	96	106	31	223
115	Pembroke West A	4	70	92	19	180
116	Pembroke West B	1	23	73	1	127
117	Pembroke West C	2	27	64	3	100
143	South Dock	8	143	131	62	283

There is little real evidence of any substantial difference in death rates between the 14 DEDs. The pattern of SMRs, while not statistically significant, is similar to that noted previously.

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Cancer incidence data

Five groups of people newly diagnosed with cancers (incident cancers) were considered. These were diagnoses of breast cancer in women, prostate cancer in men, lung cancer, colorectal cancer and all cancers considered as one group. Cancers were coded by the National Cancer Registry, and geographical coding was done by the HIU.

These groups of cancer diagnoses were chosen because they were all relatively common, and hence, major public health problems. Little is known about the relationships between specific environmental factors and cancer incidence at this level. Lung cancer is mainly caused by smoking, but radon gas and air pollution are probably significant causes too. Breast and prostate cancer are both known to be affected by hormones.

Results are presented as for the mortality data.

All cancers

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DED CODE	DED NAME	OBSERVED	SIR	Smoothed SIR	LR_CI	UPR_CI
42	Clontarf East B	210	97	98	85	111
43	Clontarf East C	104	96	98	78	116
44	Clontarf East D	88	86	91	69	106
48	Clontarf West C	85	87	92	69	107
49	Clontarf West D	73	95	98	75	120
108	North Dock B	118	109	107	90	131
110	**Pembroke East A**	**124**	**110**	**108**	**91**	**131**
111	Pembroke East B	112	103	103	85	124
112	Pembroke East C	130	108	107	90	129
114	Pembroke East E	104	122	115	100	148
115	Pembroke West A	118	118	114	98	142
116	Pembroke West B	69	87	93	68	110
117	Pembroke West C	109	103	103	84	124
143	South Dock	95	124	116	100	151

There is little evidence for any differences in cancer incidence between the DEDs in the study area. There is only a very weak indication of an excess risk in Pembroke West A.

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Lung cancer

DED CODE	DED NAME	OBSERVED	SIR	Smoothed SIR	LR_CI	UPR_CI
42	Clontarf East B	27	83	90	54	120
43	Clontarf East C	9	54	75	25	103
44	Clontarf East D	11	69	86	35	124
48	Clontarf West C	13	91	102	48	155
49	Clontarf West D	12	101	110	52	176
108	North Dock B	32	193	172	132	272
110	**Pembroke East A**	**26**	**154**	**145**	**101**	**225**
111	Pembroke East B	11	69	86	34	123
112	Pembroke East C	13	75	89	40	128
114	Pembroke East E	14	112	116	61	188
115	Pembroke West A	18	120	121	71	190
116	Pembroke West B	12	103	111	53	179
117	Pembroke West C	11	71	88	36	128
143	South Dock	17	152	141	88	243

In contrast to the results for other types of cancer the incidence of lung caner is elevated in Pembroke East A. It is in the top fifth of DEDs in Dublin for this disease. Lung cancer is known to be strongly related to deprivation, probably as a consequence of smoking.

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Colorectal cancer

DED CODE	DED NAME	OBSERVED	SIR	Smoothed SIR	LR_CI	UPR_CI
42	Clontarf East B	36	116	107	81	161
43	Clontarf East C	15	96	97	53	158
44	Clontarf East D	15	101	99	57	167
48	Clontarf West C	11	79	92	40	142
49	Clontarf West D	17	153	113	89	245
108	North Dock B	10	65	87	31	120
110	**Pembroke East A**	**12**	**77**	**91**	**40**	**134**
111	Pembroke East B	18	118	105	70	186
112	Pembroke East C	17	100	99	58	160
114	Pembroke East E	13	110	101	59	188
115	Pembroke West A	15	106	101	60	175
116	Pembroke West B	7	63	88	25	130
117	Pembroke West C	19	129	108	78	202
143	South Dock	10	94	97	45	173

There is little evidence for any variation in colorectal cancer incidence between DEDs. Pembroke East A has a relatively low incidence but this is not significantly different from the Dublin average.

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Prostate cancer

DED CODE	DED NAME	OBSERVED	SIR	Smoothed SIR	LR_CI	UPR_CI
42	Clontarf East B	14	70	79	38	117
43	Clontarf East C	10	98	91	47	180
44	Clontarf East D	5	46	73	15	108
48	Clontarf West C	11	128	100	64	229
49	Clontarf West D	7	97	90	39	200
108	North Dock B	7	69	81	28	141
110	**Pembroke East A**	**15**	**146**	**107**	**82**	**240**
111	Pembroke East B	9	87	87	40	166
112	Pembroke East C	13	131	102	70	225
114	Pembroke East E	18	231	128	137	365
115	Pembroke West A	6	68	81	25	148
116	Pembroke West B	4	63	81	17	160
117	Pembroke West C	12	141	104	73	247
143	South Dock	11	164	107	82	294

Again there is little evidence of any substantial difference between areas. Both Pembroke East A and Pembroke East E have a high SIR for of prostate cancer, but on smoothing this falls markedly, implying that this apparent excess is unlikely to be of any significance.

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Breast cancer

DED CODE	DED NAME	OBSERVED	SIR	Smoothed SIR	LR_CI	UPR_CI
42	Clontarf East B	38	128	106	91	176
43	Clontarf East C	15	101	97	57	167
44	Clontarf East D	13	98	97	52	168
48	Clontarf West C	12	90	95	47	158
49	Clontarf West D	4	42	90	11	108
108	North Dock B	12	86	95	45	151
110	**Pembroke East A**	**9**	**57**	**89**	**26**	**107**
111	Pembroke East B	18	122	101	73	194
112	Pembroke East C	25	143	106	92	211
114	Pembroke East E	16	129	101	74	210
115	Pembroke West A	24	171	109	110	255
116	Pembroke West B	12	107	98	55	187
117	Pembroke West C	19	130	102	78	203
143	South Dock	10	99	97	47	182

There is little indication of any great variation between DEDs in this condition. Pembroke East A has a low incidence, but this rises substantially on smoothing, again suggesting that this is of no significance.

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Prescribing data

The prescribing data analysed here is of drugs coded as prescriptions for asthma. This includes many drugs used to treat chronic bronchitis and emphysema in older people, as well as asthma.

DED	DED name	Observed	SPR	LR_CI	UPR_CI
42	Clontarf East B	135	84	69	100
43	Clontarf East C	62	84	63	110
44	Clontarf East D	64	86	65	112
48	Clontarf West C	63	82	62	108
49	Clontarf West D	70	94	73	120
108	North Dock B	147	111	95	129
110	**Pembroke East A**	**171**	**132**	**116**	**151**
111	Pembroke East B	71	77	57	100
112	Pembroke East C	71	86	66	110
114	Pembroke East E	38	63	40	93
115	Pembroke West A	87	91	72	113
116	Pembroke West B	48	74	52	103
117	Pembroke West C	51	78	56	106
143	South Dock	83	106	85	130

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Interpretation of prescribing data, as discussed earlier, is difficult. While Pembroke East A has a high prevalence of recorded prescriptions for anti-asthmatic drugs, it also has a very high prevalence of medical card holders, far higher than the adjacent wards. As such, what is presented here is a comparison between a small proportion of the people resident in say, Clontarf East C, against the majority of the residents of Pembroke East A.

Nonetheless it seems likely that there is some increased prescribing for asthmas in this DED. This probably reflects a higher burden of respiratory disease, and is probably also a good marker of the extent of smoking in the study DEDs.

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Conclusions

In general the results are consistent, and not unexpected. People living in Pembroke East A have worse health than residents of most of the adjoining DEDs, apart from North Dock B and (for some conditions) Pembroke West A. This is especially true for respiratory disease and lung cancer.

The remaining DEDs in Pembroke make up Sandymount and parts of Ballsbridge, while the Clontarf DEDs are mostly the seafront, and the parts of Clontarf just inland from there. North Dock B is another very deprived inner city area.

Given the high level of deprivation in the area, the poor levels of health are not especially surprising, although the excess of respiratory diseases is very striking. Poverty is the dominant factor influencing differences in health status between small areas in Ireland, as in the other countries where such analyses have been done. However, it is very possible that other factors are at work here. These could include smoking, occupation exposure to respiratory toxins, and air pollution affecting residents.

Ireland is a very unequal country, a fact reflected in poor levels of health overall, and in the concentration of ill health in deprived areas which this study has identified. The measurement of poverty chosen here is the SAHRU deprivation score (1, 2). This was developed by Alan Kelly and his colleagues in Trinity College Dublin, and has been widely used in the Irish health services.

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The DED has experienced rapid social change over the last few years, partly due to gentrification of the existing housing stock, and partly due to extensive residential development in the DED. As a result the 2004 health of this population may be rather better than that presented here.

The implications of this for the proposed development are uncertain. There are many suggestions in the literature that poorer people may be more susceptible to environmental hazards than wealthier people. It is hard to come to any definitive conclusions about this, since poorer people are generally forced to live in more contaminated areas anyway. It is possible that on-going work in Britain on rural poverty, and in the United States on environmental equity might answer this question in the next few years.

This report, as such, merely documents the sad but not unexpected pattern of health inequalities in the study areas. What is not addressed in this report is differential exposure to environmental hazards (3). There is certainly an important issue of environmental equity to be addressed here, however this is work for another project.

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Appendix

Statistical issues

Comparison of health status between small areas poses several severe statistical problems, which current, and any likely future methods, can only partly overcome (2, 4).

MAUP

One source of these difficulties is the essentially arbitrary choice of boundaries. It has been known to geographers for many years that the choice of the boundaries into which an area is dissected has a major impact on the inferences that can be made from observations on that area (5). Put more bluntly, the choice of boundary can change the answers obtained from projects like this. The technical term for this in geography is the Modifiable Areal Unit Problem (MAUP).

There are no really satisfactory solutions to this problem. Integrity in analysis provides some defence, where the analyst chooses a set of boundaries, on either practical, or sound theoretical grounds, and sticks to them.

In our situation, there is really only one set of boundaries available, the DED's and we are using these.

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Smoothing – yes or no?

A second issue, more technically statistical, is the problem of small numbers. Briefly, the number of events in small areas is likely to follow a Poisson distribution. Especially for less common events, small differences in the number of events observed, can lead to very large differences in the estimate of the risk for small areas (4, 6, 7).

For example, the expected number of cases of leukaemia in a small area, such as a DED, might be 0.2. Thus if no case happens to occur, the estimated risk will be zero, while if only one case occurs, the estimated risk is 5 times the average risk over the whole region. Neither is likely to be very credible as an estimate of the real risk of disease in a small area.

A response to this is to avoid the use of simple estimates of risk, and to report instead estimates which reflect the degree of credibility of the estimated risk. There are several ways to do this, and the method chosen here, empirical Bayes' smoothing, has the merits of simplicity. Fully Bayesian modelling is an alternative, but it remains difficult to report the results of such models to general audiences.

In summary, the risk identified for each small area, is weighted, so that risks derived from small areas, are given less weighting, and smoothed towards the overall average risk for the whole study area, while risks derived from larger

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areas are smoothed less. The degree of smoothing is related to the size of the population in each area.

Spatial autocorrelation

The final technical issue is known as spatial autocorrelation. The problem here is simple. There is a strong tendency for areas that are close together to be similar. Most of the statistical methods that we use assume that areas are (statistically) independent of each other. This means that each additional area studied adds as much information as any other area. However, this is seldom true. For example if you are already studying Ballygall A, B and D, adding Ballygall C tells you less about health in Dublin, than adding, say Drumfinn.

There are two approaches to this issue. The first is to say that this is a non-problem. Spatial autocorrelation measures the real effect of social factors that are common between areas, and that correcting for it, in effect, removes real differences and real similarities between areas.

The second is to try and model it. This modelling involves making an assumption about the degree and extent of the autocorrelation. These assumptions are not easy to test. The modelling is also difficult, and very hard to explain to non-specialists.

The truth probably lies between these two positions. For this report, particularly as we are only considering a restricted area of the city, we have decided not to address the issue.

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Statistical methods

After consideration of these issues two methods were chosen to analyse the data for this project. These were Indirect standardisation, which compares the rate of ill health between area, after adjusting for differences in the age and sex of the people between areas. The second is Empirical Bayes smoothing of SMR's as described in the paper of Clayton and Kaldor.

Indirect standardisation.

This is a statistical method in common use in epidemiological studies. It is intended to solve the problem of comparing health outcomes between areas with different demographics. This is a major problem because the rates of most human diseases increase steeply with age. Also, for most diseases, women have lower rates than men of the same age. Thus a map of death rates for Dublin, would mainly identify the areas where older people live.

This is not useful for most purposes, so a procedure is adopted, where the actual number of deaths (or new cases of cancer, or hospital admissions ...) occurring in an area is counted. This is referred to as the Observed number of deaths (O). This is then compared to the expected number (E), the number of deaths (etc ...) which would have occurred in that area had the death rates (etc ...) for the whole city applied in that area. This is a simple calculation. The

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ratio of Observed to Expected (O/E) is then referred to as a standardised ratio, typically a Standardised Mortality Ratio (SMR) for deaths, a Standardised Incidence Ratio (SIR) for new cases of cancer, and so on. It is customary to multiply the ratio by 100 for presentation.

Empirical Bayes Smoothing

The method implemented here is the algorithm presented by Clayton and Kaldor in a classic 1987 paper (6). The rationale for this procedure is simple. SMRs from small area data typically cover a very wide range of values. Figure 2, which is a plot of the prostate cancer incidence data for Dublin City at DED level, is a typical example.

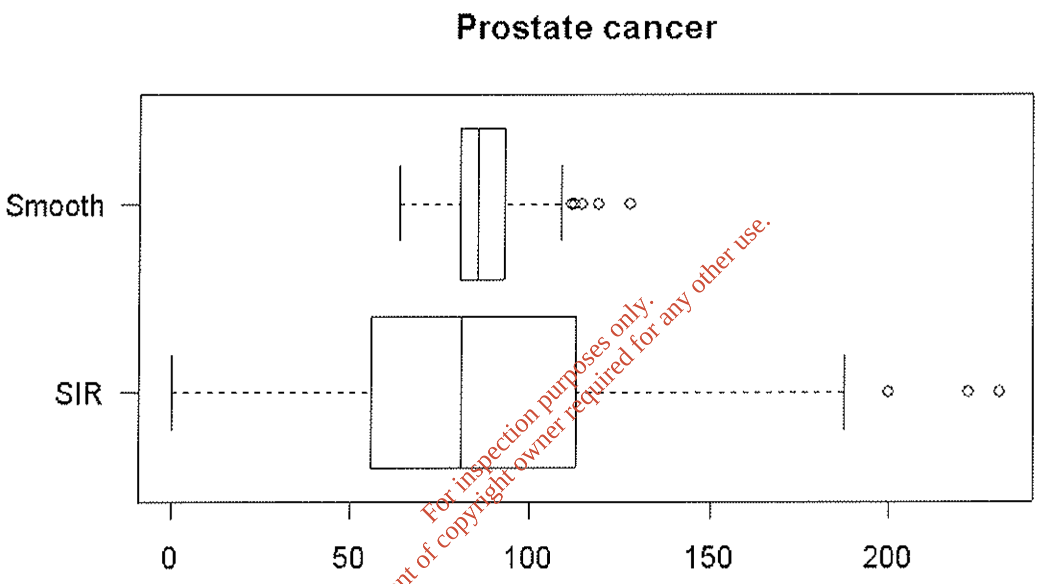

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Figure 2. Comparison of unsmoothed, and empirical Bayes smoothed SIRs for Prostate cancer.

The very wide range of SIRs in the unsmoothed boxplot is simply not credible. It is most unlikely, that the real range of incidence of prostate cancer in Dublin runs from zero to more than twice the Dublin City average. The smoothed values are more believable.

The Clayton-Kaldor method provides a very simple implementation of a sophisticated statistical model for the true SIRs in this situation.

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Chapter	Appendix	Title
14	Appendix 14.1	Terrestrial Ecology

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ELSAM DUBLIN WASTE TO ENERGY PLANT:

ECOLOGICAL ASSESSMENT

FINAL REPORT
APRIL 2006

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Prepared for

ARUP CONSULTING ENGINEERS

by

BIOSPHERE ENVIRONMENTAL SERVICES
29 La Touche Park, Greystones, Co. Wicklow
Tel: 01-2875249 E-mail: maddenb@eircom.net

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14.0 TERRESTRIAL ECOLOGY

14.1 INTRODUCTION

The site for the proposed waste to energy plant is on the southern side of Pigeon House Road and immediately west of the new sewage treatment works. To the west of the site there is an ESB electricity station and complex. Recently cleared ground lies to the south. The Irishtown Nature Park is located to the east-southeast of the site. Cooling water pipes will cross the Pigeon House Road and run north in a narrow corridor to the river. Suggest change this para to standard site description text that can be used for the introduction for each chapter.
Add – The terrestrial ecology assessment was completed by Biosphere Environmental Services.

All of this area of Dublin Port is reclaimed land and much of it was used as a municipal landfill in the past. The reclaimed land of the former landfill is a rich hunting ground for casual and alien plant species and in the Flora of County Dublin (Doogue et al. 1999), it is noted that some 200 different kinds of plants were recorded in this area during field surveys.

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The present study provides a baseline assessment of the flora and fauna species within and around the site for the waste to energy plant. A specific assessment was made of the Irishtown Nature Reserve owing to its close proximity to the site. While important areas of conservation value exist in the immediate vicinity, these are estuarine and/or ornithological in character and are described and evaluated elsewhere. Impacts on terrestrial ecology by the proposed development are assessed and mitigation measures recommended as considered necessary. The assessment is carried out in compliance with the European Communities (Environmental Impact Assessment) Regulations, 1989-2000, and follows the Environmental Protection Agency's Guidelines on the information to be contained in Environmental Impact Statements (EPA, 2002).

14.2 METHODOLOGY

As part of the study methodology , two visits were made to the site – one in late-May, 2003 and one in mid-August 2003. These were timed so as to provide the maximum amount of information on plants and breeding birds. In August 2004, a specific survey of the vegetation and flora of the Irishtown Nature Park was carried out. A further visit was made to the site in early April 2006 to assess any significant changes since the 2003 work.

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The survey methodology consisted of systematically walking the site area and recording habitats, plant species and vegetation types present. Habitat classification is according to Fossitt (2000). Notes were made on bird species present within and around the site. Presence of mammals is indicated principally by their signs, such as dwellings, feeding signs or droppings - though direct observations are also occasionally made.

During the survey, particular attention was given to the possible presence of habitats and/or species which are legally protected under Irish or European legislation (especially the Flora Protection Order 1999; Wildlife Act 1976; Wildlife Amendment Act 2000; EU Habitats Directive; EU Birds Directive).

The standard literature was checked for references to the site and locality. The main source of information for the area is the Flora of County Dublin. A 1998 report on Irishtown Nature Park and Sandymount Strand by J. O'Neill was also consulted.

14.3 DESCRIPTION OF THE BASELINE ENVIRONMENT

14.3.1 Habitats, vegetation and flora within site

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The main part of the site [need to agree terminology with Elsam] -comprises two principal habitats: Buildings and artificial surfaces (BL3) and Recolonising bare ground (ED3). In addition, there is a small patch of Amenity grassland (GA2) at the entrance to the Hibernian Mollasses complex. The habitats are described below with reference to the accompanying map (Fig. 1). Both English and scientific names are given for plant species following Scannell and Synnott (1987).

Buildings and artificial surfaces (BL3)
The majority of the site is classified as built ground. Included are the Hammond Lane industrial complex and the Hibernian Mollasses complex. The survey was concentrated in the southern part of the site where some plants would be expected on the open tarmacadam surfaces. Much of this area, which is a former car-park, still has a smooth surface though some breaks and cracks are appearing which provide a niche for plant species. The southernmost strip, approximately 15 m in width, comprises a rough gravel surface and here plants have been able to colonise, with greatest growth alongside the fence line. These are typical ruderal species (i.e. weed-like) and include the following:

Groundsel *Senecio vulgaris*
Colt's-foot *Tussilago farfara*
Yarrow *Achillea m illefolium*
Robin-run-the-hedge *Galium aparine*
Scentless mayweed *Tripleurospermum inodorum*
Nettles *Urtica dioica*
Red clover T*rifolium repens*
Wild teasel *Dipsacus fullonum*
Fennel *Foeniculum vulgare*

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Butterfly-bush *Buddleja davidii*
Common mallow *Malva sylvestris*
Red Valerian *Centranthus ruber*

The presence of rue-leaved saxifrage *Saxifraga tridactylites* on gravel within the disused carpark is of some interest as this plant has a somewhat localised distribution in Co. Dublin though has been recorded –on/vicinity of? Ringsend Dump in the past.

Some gorse *Ulex europaeus* and sycamore *Acer pseudoplatanus* (some in excess of 5 m high) is established along the fenceline, along with brambles *Rubus fruticosus* and wild rose (*Rosa* spp.).

Recolonising bare ground (ED3)
A small, mostly enclosed area of unmanaged ground that is partly vegetated occurs in the mid eastern sector of the site. This habitat also occurs at the northern boundary of the site (strip of c.20 m in width along the Pigeon House Road), along the track at the eastern boundary of the site adjacent to the sewage treatment works (strip of c.5 m in width) and at the southern boundary of the site (area up to 30 m in width which continues southwards). It also occurs scattered along the Shellybanks Road. A wide range of ruderal species occur, with rank grasses well-established in some parts. The following were recorded:

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Wild teasel *Dipsacus fullonum*
Butterfly-bush *Buddleja davidii*
Colt's-foot *Tussilago farfara*
Fennel *Foeniculum vulgare*
Bastard cabbage *Rapistrum rugosum*
Mugwort *Artemsia vulgaris*
Japanese knotweed *Fallopia japonica*
Thistles *Cirsium* spp.
Groundsel *Senecio vulgaris*
Scentless mayweed *Tripleurospermum inodorum*
Common mallow *Malva sylvestris*
Red dead-nettle *Lamium purpureum*
Purple toadflax *Linaria purpurea*
Yarrow *Achillea millefolium*
Nettles *Urtica dioica*
Red clover *Trifolium repens*
Meadow vetchling *Lathyrus pratensis*
Common vetch *Vicia cracca*
Black medick *Medicago lupulina*
Robin-run-the-hedge *Galium aparine*
Dove's-foot cranesbill *Geranium molle*
Dock *Rumex obtusifolius,*
Spear-leaved Orache *Atriplex prostrata*
Cock's-foot *Dactylis glomerata*

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Scutch *Elymus repens*
Yorkshire fog *Holcus lanatus*
Common bent *Agrostis stolonifera*

In areas which have not been recently disturbed, brambles and young sycamore are becoming established.

Recolonising bare ground also occurs along the route of the cooling water pipes to the north of the Pigeon House Road.

Amenity grassland (improved) (GA2)
A small patch of amenity grassland occurs at the entrance to the Hibernian Mollasses complex. This is a typical mown sward of grasses such as rye grass *Lolium perenne* and meadow grasses *Poa spp.*, along with such species as creeping buttercup *Ranunculus repens*, speedwell *Veronica serpyllifolia*, and narrow-leaved plantain *Plantago lanceolata*.

14.3.2 Habitats, vegetation and flora around site

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The site is surrounded by developed land to the north, east and west. These areas include buildings, hard surfaces and some ground with a weedy vegetation (Recolonising bare ground). Some bare ground and spoil heaps (ED2) also occurs to the south of the site, along with further Recolonising bare ground. The Shellybanks Road skirts the western boundary of the site and associated with this is a line of planted sycamore trees and a strip of shrubbery (WS3).

The sycamore trees can be classified as a low **Treeline WL2**. There is approximately 26 trees, all sycamore, which were planted along the eastern side of the Shellybanks Road. These are in the region of 7-8 m in height. A strip of shrubbery (**Ornamental/non-native shrub WS3**) has been planted along the western side of the road. This is dense and predominantly of Escallonia (*Escallonia* spp.), with brambles and such species as butterfly bush. Some trees also occur, with cypress (*Cypressus* spp.), white poplar (*Populus alba*) and sycamore.

14.3.3 Fauna

14.3.3.1 Mammals, amphibians and reptiles
Brown rat *Rattus norvegicus* was the only mammal species recorded within the site. House mouse *Mus domesticus* would also be expected, and probably the ubiquitous pygmy shrew *Sorex minutus*. The low number of species reflects the low diversity of habitats present.

Signs of fox *Vulpes vulpes* were found near the boundary fence of the Irishtown Nature Park and this species, which has a permanent presence in the port area, could pass through

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the site at times. Long-tailed field mouse *Apodemus sylvaticus* may also occur, and possibly rabbits *Oryctolagus cuniculus*. The site does not have suitable roost sites for bats.

The habitats on site or in the immediate vicinity are not suitable for amphibians such as the common frog *Rana temporaria* or for the common lizard *Lacerta vivepara*.

14.3.3.2 Birds

Few bird species occur within the site owing to the low diversity of habitats present. Only two species, wren *Troglodytes troglodytes* and dunnock *Prunella modularis*, were considered to nest within the site, and these were confined to the strip of vegetation along the southern and south-west boundary lines. Starlings *Sturnus vulgaris* and pied wagtail *Motacilla alba* were noted in the vicinity of the buildings on site and could breed in suitable holes or gaps within the buildings.

A small number of other species were recorded in the shrubbery along the Shellybanks Road, with robin *Erithacus rubecula*, blackbird *Turdus merula*, great tit *Parus major*, blue tit *Parus caerulea,* greenfinch *Carduelis chloris* and chaffinch *Fringilla coelebs* all nesting. A single reed bunting *Emberiza schoeniclus* was recorded in August in the rough vegetation to the south of the site and could nest locally. At least one pair of skylarks was present in the recently cleared ground south of the site. Other birds which nest in the general vicinity include woodpigeon *Columba palumbus*), jackdaws *Corvus monedula*, hooded crow *Corvus corone cornix* and magpie *Pica pica*.

A flock of c.30 linnets *Carduelis cannabina* was present on the rough ground to the south of the south in August, along with a small number of goldfinches *Carduelis carduelis*.

Recently planted grassland within the adjacent sewage works, and also to the south of it, supports brent geese *Branta bernicla horta* during winter. Gulls, mostly black-headed *Larus ridibundus*, are common in the vicinity of the sewage works during winter.

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14.3.4 Irishtown Nature Park

The Irishtown Nature Park physically consists of an elevated central plateau of land which slopes down to the sea on its southern side and is bounded on its northern edge by amenity grassland adjacent to the sewage works. Its eastern boundary contains a small area of sand dune in front of the main road whilst its western edge culminates in a path linking the Park with the road at Sandymount. A full description of the habitats and vegetation is given in Appendix 14.1.

The vegetation and plant species complement reflect the past use of the site together with its current management as a park and amenity area. Most of the southern side is under the influence of the sea and especially salt spray and this has allowed coastal vegetation to develop in places. As might be expected from the past use of the area and from the planting that has been carried out, there is little in the way of natural or semi-natural habitats to be found within the Park. The only piece, which has not been directly

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influenced in its development by humans, lies on the eastern side in the corner between the Park proper and the main road. Here a small area of sand dune occurs.

Over most of the Park a habitat of coarse grassland is found which mostly corresponds to the category **Amenity Grassland GA2**. Species such as perennial rye grass *Lolium perenne*, red fescue *Festuca rubra*, creeping bent *Agrostis stolonifera* and creeping thistle *Cirsium arvense* are present. Blackberry *Rubus fruticosus* is invading this in parts. Also invading this grassland are stretches of scrub consisting mostly of native species such as blackthorn *Prunus spinosa*, elder *Sambucus nigra* and ash *Fraxinus excelsior*. However, two exotic species, sycamore *Acer pseudoplatanus* and Japanese knotweed *Reynoutria japonica,* are acting invasively here. This habitat can be broadly accommodated within the category of **Scrub WS1**.

Non-native, planted shrubs have formed a scrub of sorts, and includes escallonia *Escallonia macrantha,* butterfly bush *Buddleja davidii*, field maple *Acer campestre* and 2 species of Cotoneaster. Trees are present in the form of evergreen oak *Quercus ilex,* sessile oak *Quercus petraea* and Italian alder *Alnus cordata*. This habitat is that of **Ornamental, non-native shrubs WS3**.

The stony, rock and boulder-dominated areas adjacent to the sea, reflect the infilled nature of the area and the species cover is sparse and very scattered. Weedy species such as teasel, *Dipsacus fullonum,* mugwort *Artemisia vulgaris*, red valerian *Centranthus ruber* and common mallow *Malva sylvestris* are found here. This habitat can be included within **Buildings and artificial surfaces BL3** and nearer the sea, the influence of salt spray has allowed the growth of a number of coastal species notably sea beet *Beta maritima* and sea mayweed *Matricaria maritima*.

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The habitat **Re-colonizing bare ground ED3** is common throughout and the principal species here is coltsfoot *Tussilago farfara* and hoary mustard *Hirschfeldia incana*.

In summary, the Park, whilst not of significant conservation importance, is rich in plant species as they have come from a number of sources.

14.3.5 Assessment of scientific importance of survey area

The site for the waste to energy plant represents ground that has been entirely modified by man for industrial purposes. All habitats present within and immediately around the site are classified in the broad categories of built land and disturbed ground – such habitats are not of conservation value. There are no flora or fauna species of significant conservation value in this area. However, the disturbed areas within and around the site support a wide range of plant species, many alien in origin, including such localised plants as bastard cabbage *Rapistrum rugosum* and wild teasel *Dipsacus fullonum*.

The presence of skylarks on waste ground to the south of the south is of some note as skylark is listed as a species of moderate conservation concern owing to a moderate decline in the breeding population in Ireland in the last 25 years (Newton et al. 1999). The

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occurrence in winter of brent geese on the grasslands associated with the sewage treatment works is of note as these are part of the Dublin Bay internationally important population.

The Irishtown Nature Park, to the south-east of the site, has local ecological interest. However, the issue of invasive species requires attention, especially Japanese knotweed and hedge bindweed *Calystegia sepium*, as the dominance of these will lower the diversity of plant species in the Park. Also, the issue of allowing native scrub of elder, blackthorn and hawthorn to spread into the grassland areas should be addressed.

The site is located within Dublin Bay, much of the estuarine/marine component being of high conservation importance for habitat and ornithological interests (see elsewhere for review of various designations). From the terrestrial perspective, the closest designated sites are as follows:

- Booterstown Marsh proposed Natural Heritage Area (code: 01205), situated almost 3 km south of the site and of interest for its salt marsh and the presence of the legally protected species Borrer's Saltmarsh-grass *Puccinellia fasciculata*.

- Grand Canal proposed Natural Heritage Area (code: 02104), situated approximately 2 km east of the site, and of interest for aquatic habitats.

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14.4 IMPACTS ON SITE AND IMMEDIATE SURROUNDINGS

The proposed development will involve clearance of all the existing habitats within the site. As the existing habitats are not of conservation importance, and as there are no associated rare or even scarce species of flora and fauna, the impact by site clearance is not considered of significance. Further, some of the existing species will continue to occur in the newly created habitats within the site. Overall, the replacement of the existing habitats with further, highly modified or artificial habitats is rated as a Neutral impact.

The construction activities could have a disturbance effect on the brent geese which feed during winter on the grassland to the south-east of the site. However, the geese within Dublin Bay are well used to high levels of disturbance and background noise and are unlikely to be much affected by construction activities. Even if disturbed, which would be temporarily, they have many other sites in the Dublin Bay area to retreat to.

The construction activities would not be expected to have any adverse impacts on the flora and fauna of the Irishtown Nature Park.

Once operational, the plant would not be expected to have any impacts on the terrestrial ecological interests of the immediate area.

14.5 IMPACTS ON DESIGNATED SITES

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The proposed development will not have any impacts, direct or indirect, on the ecological interests of the Booterstown Marsh or Grand Canal proposed Natural Heritage Areas, as these sites are separated from the development area by distances of 3 km and 2 km respectively.

Potential impacts on the estuarine and marine designated sites are dealt with elsewhere. Reference has already been made to the possible impact on the brent geese in the area, which are part of the qualifying interests of the North Bull Island and Sandymount Strand/Tolka Basin Special Protection Areas. None of the other wetland bird species of Dublin Bay frequent the area of the proposed development.

14.6 MITIGATION MEASURES

Owing to the low ecological interests at this site, and considering that there are no significant adverse impacts, specific mitigation measures are not required.

The landscaping plan for the site should include some native trees and shrubs as these would be useful for local wildlife. Taking into account the exposed nature of the site, suitable species are limited but could include ash, native alder, willows and rowan. (Cross ref with landscape and visual section.)

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14.7 RESIDUAL IMPACTS

The redevelopment of this site would not have any residual ecological impacts as the existing ecological interests within the site and in immediate surrounding areas are negligible.

14.8 REFERENCES

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Chapter	Appendix	Title
15	Appendix 15.1	Maps
	Appendix 15.2	Littoral and Sublittoral Flora and Fauna
	Appendix 15.3	Previous Studies
	Appendix 15.4	Biotype Descriptions
	Appendix 15.5	Photographs
	Appendix 15.6	Granulometry, LOI, Heavy Metals
	Appendix 15.7	Dúchas Site Synopsis

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APPENDIX 1. MAPS

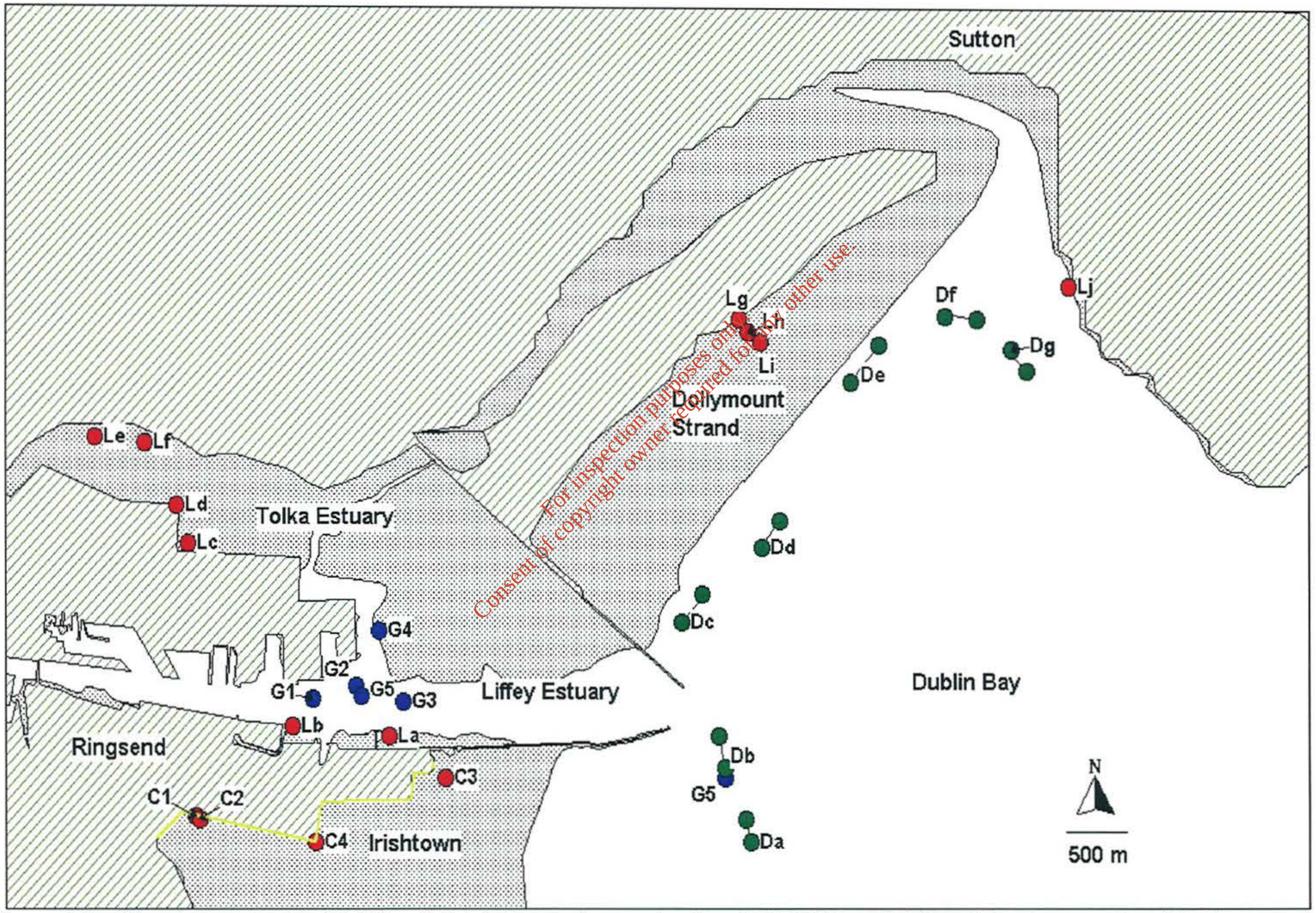

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Figure 1.1 Locations of the littoral sites (La-Lj, C1-C4 red dots), the grab sample sites (G1-G6 blue dots) and the dredge sites (Da-Dg green dots) of the present survey. The extent of the Irishtown biotope survey area is shown as a yellow line.

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1.

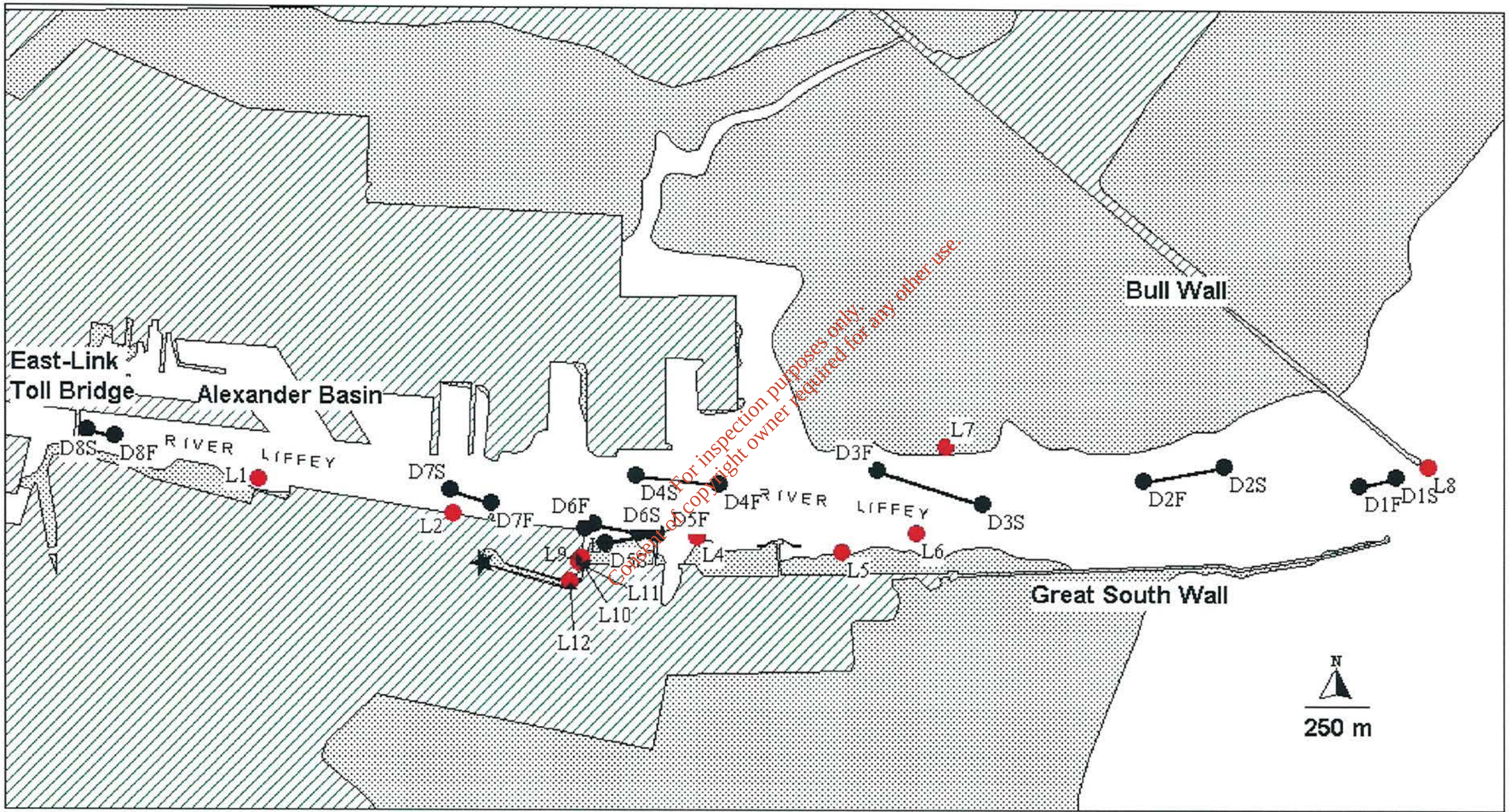

Figure 1.2 Locations of the sampling sites of the 1998 Liffey estuary survey for the combined cycle power station EIS. Littoral sites (L1-12 red dots), sublittoral dredges (D1-D8 black dots where S is start and F is finish point of dredge)

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Figure 1.3 Biotopes of the western section of the Irishtown study area. Littoral core samples C1, C2, C4 are shown as red dots. Colours represent lower biotope codes. Biotopes are described in Appendix 4.

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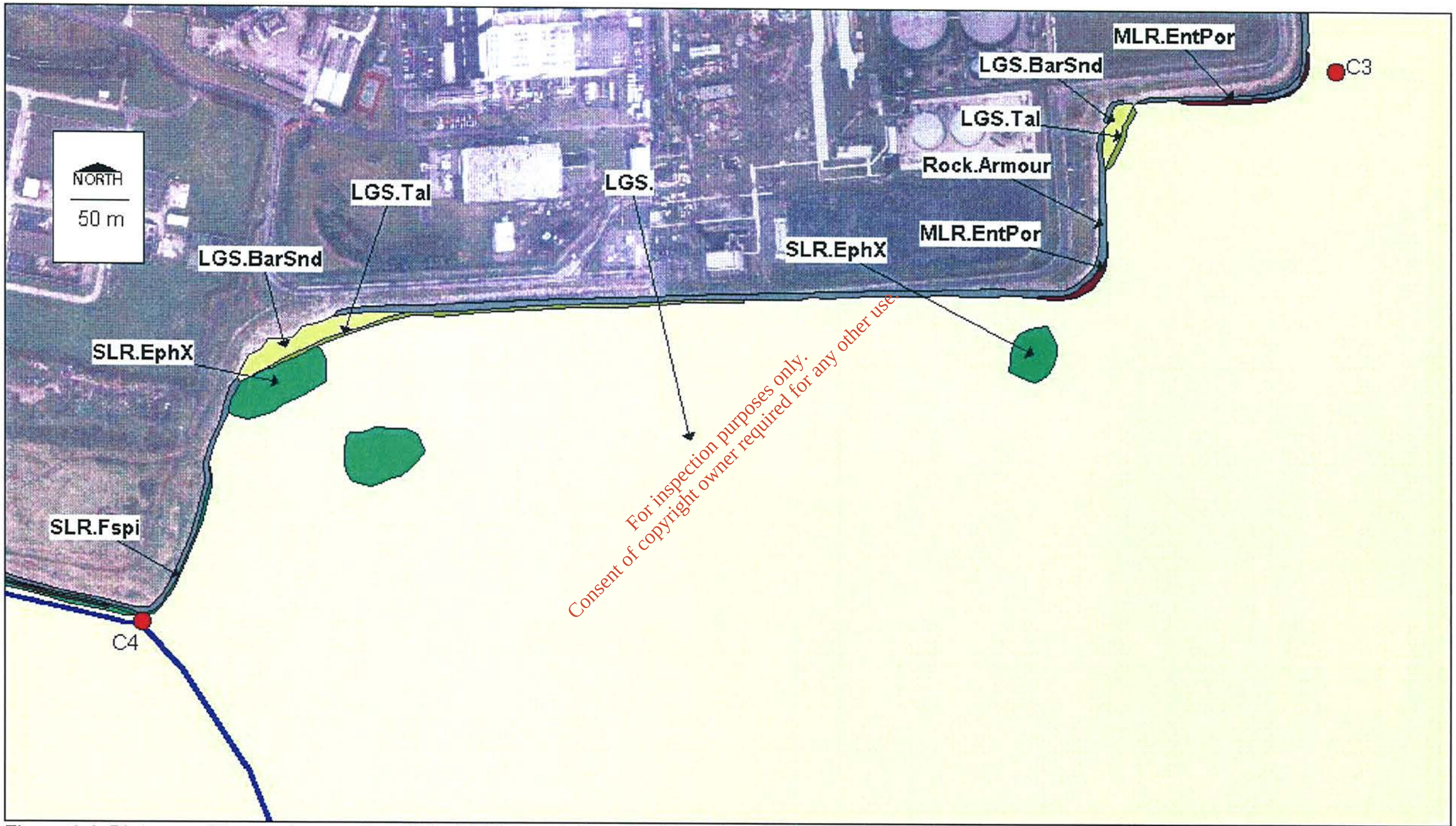

Figure 1.4 Biotopes of the eastern section of the Irishtown study area. Littoral core samples C3, C4 are shown as red dots. Colours represent lower biotope codes. Biotopes are described in Appendix 4.

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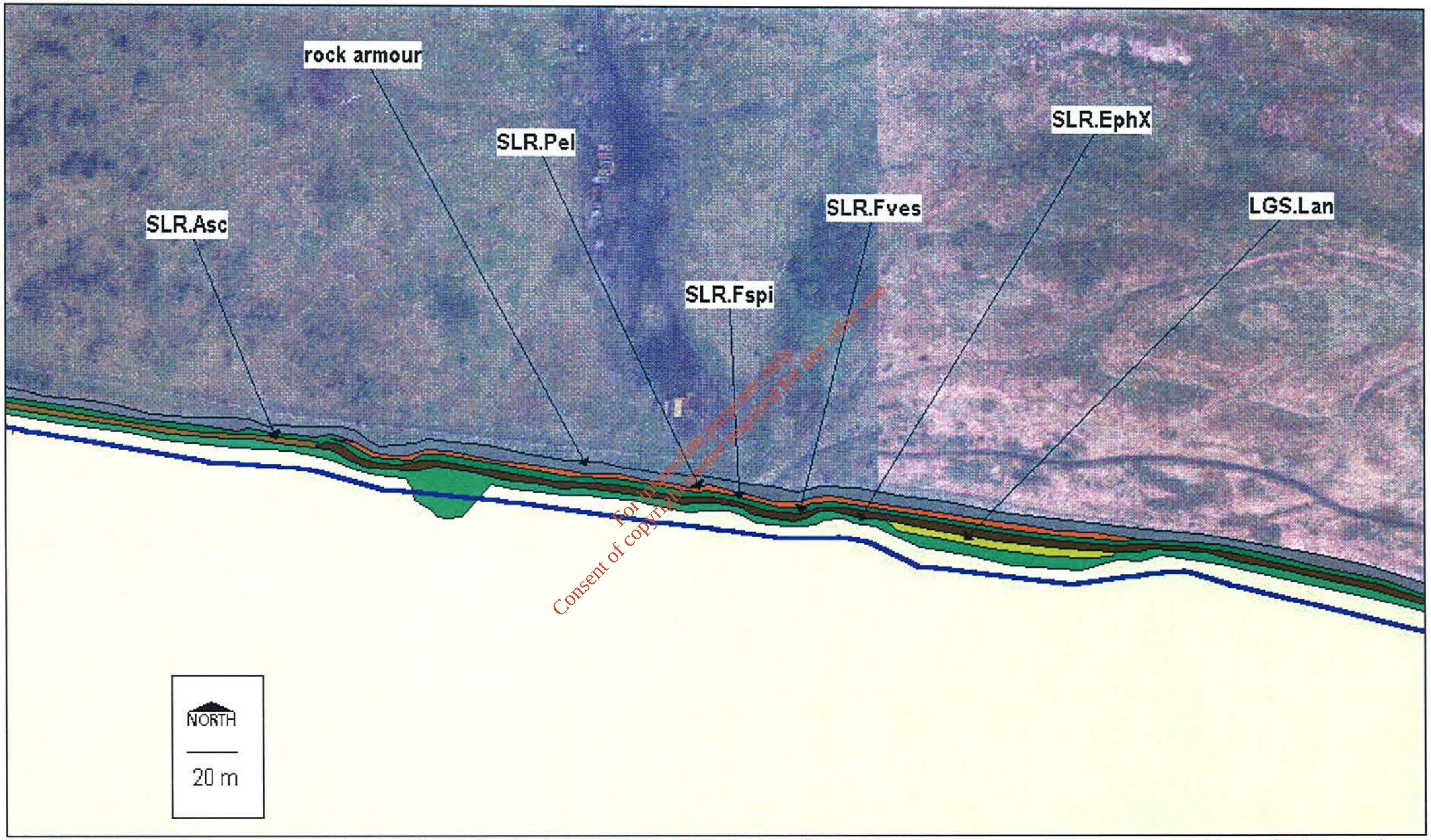

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Figure 1.5 A close up of a section of biotopes illustrating typical biotopes present along the Irishtown study area. Colours represent lower biotope codes. Biotopes are described in Appendix 4.

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APPENDIX 2. LITTORAL AND SUBLITTORAL FLORA AND FAUNA

Table 2.1. Site locations and details of littoral sites, August 2003.

Site no.	Latitude	Longitude	Location and substrata
C1	53.3365 N	6.2085 W	Muddy sand, northwest extreme of Irishtown.
C2	53.3363 N	6.2080 W	Fine compact sand, northwest extreme of Irishtown.
C3	53.3390 N	6.1783 W	Fine compact sand with *Arenicola marina* casts, north Irishtown.
C4	53.3348 N	6.1940 W	Fine muddy sand, north of Irishtown.
La	53.3417 N	6.1852 W	Structure in Liffey estuary, downstream of Ringsend power station.
Lb	53.3423 N	6.1968 W	Structure in Liffey estuary, downstream of south container yard.
Lc	53.3542 N	6.2094 W	Tolka estuary, south side, black anoxic mud.
Ld	53.3567 N	6.2108 W	Tolka estuary, south side, black anoxic mud.
Le	53.3625 N	6.2193 W	Tolka estuary, north side, black anoxic mud.
Lf	53.3607 N	6.2147 W	Tolka estuary, north side, black anoxic mud.
Lg	53.3687 N	6.1428 W	Dollymount strand, upper shore, fine sand.
Lh	53.3678 N	6.1417 W	Dollymount strand, mid shore, fine sand.
Li	53.3672 N	6.1402 W	Dollymount strand, lower shore, fine sand.
Lj	53.3727 N	6.0985 W	Sutton / south Howth Head, coarse sediment and bedrock.

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Table 2.2. Site locations and details of sublittoral grab and dredge sites, August 2003. (BSL – Below Sea Level).

Site no.	Depth (metres BSL)	Latitude (start)	Longitude (finish)	Latitude (start)	Longitude (finish)	Location and substrata
G1	9	53.3440 N	6.1943 W			Liffey estuary, black anoxic mud
G2	5	53.3448 N	6.1892 W			Liffey estuary / Tolka estuary, Black anoxic mud
G3	9	53.3441 N	6.1184 W			Liffey estuary / Tolka estuary, Black anoxic mud
G4	9	53.3438 N	6.1835 W			Liffey estuary, black anoxic mud
G5	2	53.3485 N	6.1863 W			Tolka estuary, anoxic mud and broken shell
G6	5	53.3390 N	6.1445 W			Just west of Liffey mouth, fine compact sand
Da	6	53.3348 N	6.1413 W	53.3363 N	6.1420 W	South west of Liffey mouth, fine compact sand
Db	6	53.3397 N	6.1445 W	53.3417 N	6.1452 W	Just west of Liffey mouth, fine compact sand
Dc	4	53.3490 N	6.1497 W	53.3508 N	6.1472 W	North of north Bull Wall, fine compact sand
Dd	4	53.3538 N	6.1400 W	53.3557 N	6.1378 W	Seaward of south Bull Island, fine compact sand
De	2	53.3647 N	6.1292 W	53.3670 N	6.1258 W	Seaward of Bull Island, fine compact sand
Df	3	53.3688 N	6.1178 W	53.3687 N	6.1140 W	Seaward of north end Bull Island and Sutton, fine compact sand
Dg	5	53.3668 N	6.1097 W	53.3653 N	6.1080 W	Seaward side of Sutton, south of Howth Head, fine compact sand with some mud

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Table 2.3. Abundance of flora and fauna recorded during the present littoral survey. P=Present; O=Occasional; F=Frequent; C=Common; A=Abundant, after Hiscock (1996). Biotope no. is the reference number for Biotope codes (Appendix 4 Table 4.1).

Species/higher taxa	C1	C2	C3	C4	La	Lb	Lc	Ld	Le	Lf	Lg	Lh	Li	Lj
Cnidarians (hydroids and sea anemones)														
Metridium senile	-	-	-	-	A	-	-	-	-	-	-	-	-	-
Polychaetes (worms)														
Polychaeta indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nereididae indet	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hediste diversicolor	6	-	-	6	-	-	-	-	1	16	-	-	-	-
Neanthes virens	-	-	-	-	-	-	1	1	-	-	-	-	-	-
Nephtys sp.	-	-	1	-	-	-	-	-	-	-	-	3	2	-
Scolelepis squamata	2	2	-	2	-	-	-	-	-	-	-	1	-	-
Magelona mirabilis	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Capitella capitata	-	4	-	8	-	-	-	-	-	-	-	-	-	-
Terebellidae indet.	-	-	-	-	-	-	-	-	-	-	-	1?	-	-
Crustaceans (crabs, barnacles and amphipods)														
Semibalanus balanoides	-	-	-	-	F	A	-	-	-	-	-	-	-	-
Amphipoda indet.	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Bathyporeia sp.	-	1	-	-	-	-	-	-	-	-	-	-	1	-
Corophium sp.	-	-	-	2	-	-	-	-	-	-	-	-	-	-
Cancer pagurus	-	-	-	-	P	-	-	-	-	-	-	-	-	-
Carcinus maenas	1	-	1	-	-	-	-	-	-	-	-	-	-	1
Molluscs (snails and bivalves)														
Hydrobia sp.	-	C	C	-	-	-	-	-	-	-	-	-	-	-
Patella vulgata	-	-	-	-	-	P	-	-	-	-	-	-	-	-
Mytilus edulis	-	-	-	-	SA	-	-	-	-	-	-	-	-	-
Cerastoderma edule	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Angulus tenuis	-	-	15	-	-	-	-	-	-	-	-	1	9	-
Macoma balthica	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Donax vittatus	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Scrobicularia plana	-	-	-	-	-	-	-	-	-	4	-	-	-	-
Bryozoans (seamats)														
Bryozoan crust indet.	-	-	-	-	-	P	-	-	-	-	-	-	-	-
Echinoderms (urchins, seastars and seacucumbers)														
Amphiura chiajei	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Tunicata (sea squirts)														
Tunicata indet.	-	-	-	-	-	P	-	-	-	-	-	-	-	-
Rhodophycota (red algae)														
Rhodophycota indet.	-	-	-	-	P	A	-	-	-	-	-	-	-	-
Porphyra sp.	-	-	-	-	P	P	-	-	-	-	-	-	-	-
Chromophycota (brown algae)														
Fucus ceranoides	-	-	-	-	P	P	-	-	-	-	-	-	-	-
Fucus serratus	-	-	-	-	P	P	-	-	-	-	-	-	-	-
Fucus spiralis	-	-	-	-	P	C	-	-	-	-	-	-	-	-

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Species/higher taxa	C1	C2	C3	C4	La	Lb	Lc	Ld	Le	Lf	Lg	Lh	Li	Lj
Chlorophycota (green algae)														
Enteromorpha sp.	-	-	-	-	P	P	-	-	-	-	-	-	-	-
Ulva sp.	-	-	-	-	P	P	-	-	-	-	-	-	-	-
Total no. species / higher taxa	5	4	4	5	11	11	1	1	1	2	0	4	6	1
No. individuals	13	7+	17+	19	-	-	1	1	1	20	0	6	15	1
Biotope number	13	10	7	16	-	-	14	14	14	17	9	10	11	-

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Table 2.4. Abundance of flora and fauna recorded during the present littoral biotope survey of Irishtown. P=Present; O=Occasional, F=Frequent; C=Common; A=Abundant, after Hiscock (1996). Biotope no. is the reference number for Biotope codes (Appendix 4 Table 4.1).

Species / Higher taxa	LGS.BarSnd	LGS.AP	LGS	LGS.Lan	LGS.Tal	LGS.HedMac	LMS.Pcer	MLR.EntPor	SLR.Asc	SLR.EphX	SLR.Fspi	SLR.Fves	SLR.Pel
Cnidaria (hydroids and sea anemones)													
Actinia equina	-	-	-	-	-	-	-	-	O	-	-	-	-
Polychaetes (worms)													
Hediste diversicolor	-	-	-	-	-	P	P	-	-	-	-	-	-
Nephtys sp.	-	-	P	-	-	-	-	-	-	-	-	-	-
Scolelepis squamata	-	P	-	-	-	P	P	-	-	-	-	-	-
Capitella capitata	-	P	-	-	-	P	P	-	-	-	-	-	-
Lanice conchilega	-	-	-	C	-	-	-	-	-	-	-	-	-
Arenicola marina	-	P	P	-	-	P	-	-	-	-	-	-	-
Crustaceans (crabs, barnacles and amphipods)													
Semibalanus balanoides	-	-	-	-	-	-	-	C	O	-	F	-	-
Amphipoda indet.	-	-	-	-	-	-	P	-	O	-	-	O	-
Talitridae indet.	-	-	-	-	P	-	-	-	-	-	-	-	-
Bathyporeia sp.	-	P	-	-	-	-	-	-	-	-	-	-	-
Corophium sp.	-	-	-	-	-	-	P	-	-	-	-	-	-
Carcinus maenas	-	-	P	-	-	P	P	-	-	-	-	P	-
Molluscs (snails and bivalves)													
Littorina littorea	-	-	-	-	-	-	-	-	-	-	-	O	-
Littorina saxatilis	-	-	-	-	-	-	-	-	-	-	F	-	-
Hydrobia sp.	-	-	-	-	-	-	-	-	-	-	P	-	-
Mytilus edulis	-	-	-	-	-	-	-	-	O	-	-	C	-
Cerastoderma edule	-	-	-	-	-	-	P	-	-	-	-	-	-
Angulus tenuis	-	-	P	-	-	-	-	-	-	-	-	-	-
Macoma balthica	-	-	-	-	-	P	P	-	-	-	-	-	-
Rhodophycota (red algae)													
Porphyra sp.	-	-	-	-	-	-	-	F	-	-	-	-	-
Polysiphonia lanosa	-	-	-	-	-	-	-	-	O	-	-	-	-
Chromophycota (brown algae)													
Ascophyllum nodosum	-	-	-	-	-	-	-	-	C	-	-	F	-
Fucus spiralis	-	-	-	-	-	-	-	P	F	-	C	-	O
Fucus vesiculosus	-	-	-	F	-	-	-	P	O	-	-	A	-
Pelvetia canaliculata	-	-	-	-	-	-	-	-	-	-	-	-	F
Chlorophycota (green algae)													
Enteromorpha sp.	-	-	-	F	-	-	-	C	F	A	C	A	O
Ulva sp.	-	-	-	F	-	-	-	-	-	-	-	A	-
No. species / higher taxa	0	4	4	4	1	6	8	5	9	1	5	8	3
Biotope no.	9	10	7	12	8	16	13	6	3	5	1	2	4

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Table 2.5. Abundance of flora and fauna recorded during the present sublittoral survey. P=Present; O=Occasional, F=Frequent; C=Common; A=Abundant, after Hiscock (1996). Biotope no. is the reference number for Biotope codes (Appendix 4 Table 4.1).

Species / higher taxa	Da	Db	Dc	Dd	De	Df	Dg	G1	G2	G3	G4	G5	G6
Cnidarians (hydroids and sea anemones)													
Hydractinia echinata	-	P	-	-	-	-	-	-	-	-	-	-	-
Actiniaria indet.	-	-	-	-	-	-	-	-	-	-	-	P	-
Polychaetes (worms)													
Polychaeta indet.	-	-	-	P	-	-	P	1	-	-	-	-	1
Polynoidae indet.	-	-	-	P	-	-	-	-	-	-	-	-	-
Sigalionidae indet.	-	-	-	-	-	-	-	-	-	-	-	-	1
Nephtys sp.	-	-	-	-	-	-	P	-	-	-	-	-	-
Capitella capitata	-	-	-	-	-	-	-	3	-	-	-	-	-
Pomatoceros triqueter	-	-	-	-	-	-	-	-	-	-	-	P	-
Crustaceans (crabs, barnacles and amphipods)													
Balanus crenatus	-	-	-	-	-	-	-	-	-	-	-	P	-
Amphipoda indet.	-	P	P	P	P	P	P	-	1	-	-	-	6
Decapoda indet.	P	-	-	-	-	-	-	-	-	-	-	-	-
Crangon crangon	F	F	C	A	A	-	C	-	-	-	-	-	-
Pagurus bernhardus	F	P	-	-	-	-	-	-	-	-	-	-	-
Pisidia longicornis	-	P	-	-	-	-	-	-	-	-	-	-	-
Macropodia rostrata	-	-	P	P	-	-	-	-	-	-	-	-	-
Liocarcinus sp.	-	P	-	-	P	-	-	-	-	-	-	-	-
Liocarcinus holsatus	P	-	P	P	-	-	-	-	-	-	-	-	-
Carcinus maenas	-	-	-	P	-	P	-	1	-	-	-	-	-
Molluscs (snails and bivalves)													
Nucula sulcata	P	-	-	-	-	-	-	-	-	-	-	-	-
Mytilus edulis	-	-	-	-	-	-	-	-	-	-	-	P	-
Parvicardium ovale	-	-	-	-	-	-	-	-	-	-	1	-	-
Fabulina fabula	-	-	-	-	-	-	P	-	-	-	-	-	-
Donax vittatus	P	-	-	-	-	-	-	-	-	-	-	-	-
Chamelea gallina	P	-	-	-	-	-	P	-	-	-	-	-	-
Corbula gibba	-	-	-	-	-	-	-	-	-	-	-	-	1
Bryozoans(sea mats)													
Bryozoa indet	-	-	-	-	-	-	-	-	-	-	-	P	-
Echinoderms (urchins, seastars and sea cucumbers)													
Asterias rubens	O	-	-	-	-	-	-	-	-	-	-	-	-
Amphiura chiajei	-	-	-	-	-	-	-	-	1	-	-	-	-
Ophiura ophiura	F	P	-	-	-	-	-	-	-	-	-	-	-
Pisces (fish)													
Syngnathus typhle	-	-	-	-	P	-	P	- -	-	-	-	-	-
Limanda limanda	-	-	-	P	P	-	-	-	-	-	-	-	-
Pleuronectes platessa	P	C	C	P	P	-	P	-	-	-	-	-	-
Solea sp.	-	-	-	-	P	-	-	-	-	-	-	-	-
Chlorophycota (green algae)													
Ulva sp.	-	-	-	-	-	P	-	-	-	-	-	-	-

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Species / higher taxa	Da	Db	Dc	Dd	De	Df	Dg	G1	G2	G3	G4	G5	G6
No. Species / higher taxa	10	8	5	9	7	3	8	3	2	0	1	5	4
No. individuals	-	-	-	-	-	-	-	5	2	0	1	-	9
Biotope no.*	18	18	18	18	18	18	19	20	20	20	20	21	18

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APPENDIX 3. PREVIOUS STUDIES

Table 3.1 Abundance of littoral flora and fauna recorded in the Liffey estuary during the 1998 survey for the combined cycle gas power plant EIS. P=Present; O=Occasional, F=Frequent; C=Common; A=Abundant, after Hiscock (1996).

Species	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12
Chironomidae	-	-	-	2	-	-	P	-	-	-	-	-
Porifera (sponges)												
Halichondria panicea	-	A	A	F	-	-	-	F	-	-	-	-
Hymeniacidon perleve	-	A	C	F	-	-	F	F	-	-	-	-
Cnidarians (hydroids and sea anemones)												
Obelia dichotoma	-	-	-	P	-	-	P	-	-	P	-	-
Obelia geniculata	-	-	P	P	-	-	-	-	-	-	-	-
Metridium senile	-	-	-	-	O	-	C	-	-	-	-	-
Nematodes												
Nematoda indet.	-	-	-	P	-	-	-	-	-	-	-	-
Polychaetes (worms)												
Polychaeta indet.[1]	-	-	P	-	-	-	-	-	-	-	-	-
Pholoe sp.	-	-	-	P	-	-	-	-	-	-	-	-
Phyllodoce sp.	-	-	P	-	-	-	-	-	-	-	-	-
Syllidae sp.[2]	-	-	P	-	-	-	-	-	-	-	-	-
Syllis gracilis	-	-	P	-	-	-	-	-	-	-	-	-
Neanthes virens	-	-	-	-	-	-	-	-	P	-	-	-
Spionidae indet.	-	-	-	P	-	-	-	-	-	-	-	-
Cirratulus cirratulus	-	-	-	-	-	-	-	-	A	-	-	-
Capitella sp.	-	-	P	A	-	-	P	-	-	-	-	-
Arenicola marina	-	-	-	-	-	-	-	-	O	-	-	-
Fabricia sabella	-	-	-	P	-	-	-	-	-	-	-	-
Pomatoceros triqueter	-	-	-	-	-	-	-	-	O	P	-	P
Spirorbis sp.	-	-	-	-	-	-	-	-	-	P	-	-
Crustaceans (crabs, barnacles and amphipods)												
Elminius modestus	-	C	C	A	A	C	-	C	-	O	-	-
Semibalanus balanoides	O	O	C	C	A	O	A	C	-	C	-	P
Balanus crenatus	-	-	-	-	P	-	-	-	-	-	-	-
Rissoides desmaresti[3]	-	-	-	1	-	-	-	-	-	-	-	-
Corophium acherusicum	-	-	3	-	-	-	-	-	-	-	-	-
Carcinus maenas	-	-	1	1	-	-	-	-	O	-	-	P
Molluscs (snails and bivalves)												
Acanthochitona fascicularis	-	-	-	-	-	-	-	-	1	-	-	-
Patella sp.	-	-	-	O	-	-	O	O	-	-	-	P
Littorina littorea	-	-	-	-	-	-	-	-	O	-	-	P
Littorina obtusata	-	-	-	-	-	-	-	-	-	-	-	P
Melarhaphe neritoides	-	-	-	-	-	-	A	-	-	-	-	-
Mytilus sp.[2]	-	-	2	15	-	-	1	-	-	-	-	-
Mytilus edulis	-	-	O	O	S	-	S	-	O	-	P	P
Cerastoderma edule	-	-	-	-	-	-	-	-	O	-	P	-
Bryozoans (sea mats)												
Bryozoan crusts indet.	-	-	P	-	-	-	-	-	-	-	-	-
Bowerbankia sp.	-	-	-	-	-	-	-	-	-	P	-	-
Tunicata (sea squirts)												

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[1] Juveniles
[2] Washed in
[3] Larvae

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Species	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12
Ciona intestinalis	-	-	-	O	-	-	-	-	-	-	-	-
Pisces (fish)												
Gobius paganellus	-	-	-	-	-	R	-	-	-	-	C	-
Rhodophycota (red algae)												
Porphyra umbilicalis	O	O	O	O	O	-	O	-	O	-	-	-
Chondrus crispus	-	O	O	-	-	-	F	-	O	C	-	P
Ceramium sp.	O	O	-	-	-	-	-	-	-	-	-	-
Chromophycota (brown algae)												
Ectocarpus indet.	-	O	-	-	-	-	-	-	-	-	-	-
Laminaria digitata	-	-	-	-	-	-	-	O	-	-	-	-
Laminaria saccharina	-	-	-	-	-	-	-	F	-	-	-	-
Ascophyllum nodosum	-	-	-	-	-	-	-	-	-	O	-	-
Fucus serratus	C	-	O	O	-	-	-	-	O	A	-	P
Fucus spiralis	C	C	-	-	-	-	-	-	-	-	-	-
Fucus vesiculosus	C	O	F	O	O	-	-	-	-	-	-	P
Chlorophycota (green algae)												
Enteromorpha sp.	-	O	C	O	-	O	F	-	O	A	-	P
Ulva lactuca	C	C	C	C	C	-	F	-	O	A	-	P
Cladophora rupestris	O	O	-	O	-	-	F	-	O	-	-	P
No. of species recorded	**8**	**13**	**21**	**24**	**8**	**4**	**15**	**7**	**15**	**11**	**3**	**13**

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Table 3.2. Abundance of sublittoral flora and fauna recorded during during the 1998 survey for the combined cycle gas power plant EIS. P=Present; O=Occasional, F=Frequent; C=Common; A=Abundant, after Hiscock (1996).

Species	D1	D2	D3	D4	D5	D6	D7	D8
Chironomidae indet.								
Cyrtolaelapidae indet.[1]	-	-	-	-	-	-	-	2
Erythracidae indet.	-	-	-	-	-	-	-	1
Cnidarians (hydroids and sea anemones)								
Hydrallmania falcata	P	-	-	-	-	-	-	-
Sertularia argentea[2]	P	-	-	-	-	-	-	-
Obelia dichotoma	-	-	-	-	-	P	-	-
Obelia longissima	P?	-	-	-	-	-	-	-
Metridium senile				1				
Polychaetes (worms)								
Harmothoe sp.	-	-	1	-	-	-	-	-
Eteone sp.	1	-	-	-	-	-	-	-
Anaitides maculata	8	-	-	-	-	-	-	-
Trypanosyllis coeliaca	4	-	-	-	-	-	-	-
Sphaerosyllis sp.	3	-	-	-	-	-	-	-
Nephtys sp.	-	-	-	-	-	-	1	-
Nephtys caeca?	-	-	20	-	-	-	-	-
Nephtys longosetosa	-	-	-	6	-	1	-	-
Spionidae indet.	-	-	2	-	-	-	-	-
Chaetopterus variopedatus	1	-	-	-	-	-	-	-
Ampharete grubii	-	-	1	-	-	-	-	-
Lanice conchilega	P	P	1	-	-	-	-	-
Fabricia sabella	-	-	-	-	-	-	-	-
Pomatoceros triqueter	P	-	-	-	-	-	2	-
Crustaceans (crabs, barnacles and amphipods)								
Elminius modestus	P	-	-	-	-	-	-	4
Balanus crenatus	P	-	-	-	-	-	-	-
Apherusa jurinei	1	-	-	-	-	-	-	-
Aora gracilis	1	-	-	-	-	-	-	-
Corophium sp.[3]	1	-	-	-	-	-	-	-
Crangon crangon	3	24	9	-	-	2	-	-
Pagurus bernhardus	-	10	-	1	-	-	-	-
Macropodia? Linaresi	1	-	-	-	-	-	-	-
Carcinus maenas	8	5	8	1	-	1	-	-
Molluscs (snails and bivalves)								
Juvenile bivalves	2	-	1	-	-	-	-	-
Buccinum undatum	1	1	-	-	-	-	-	-
Mytilus sp.[3]	P	-	-	-	-	-	-	-
Cerastoderma edule	-	-	-	-	-	-	3	-
Pharus legumen	-	-	1	-	-	-	-	-
Chamelea gallina[4]	-	-	-	1	-	-	-	-
Bryozoans (sea mats)								
Bryozoan crusts indet.	-	-	-	-	-	-	P	-
Alcyonidium parasiticum	P	-	-	-	-	-	-	-
Bugula plumosa	P	-	-	-	-	-	-	-
Echinoderms (starfish)								
Ophiura albida	1	-	-	-	-	-	-	-
Ophiura ophiura	4	-	-	-	-	-	-	-
Pisces (fish)								
Pleuronectes platessa	-	1	-	-	-	-	-	-

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[1] Washed in
[2] Drift
[3] Washed in
[4] Empty shell

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Species	D1	D2	D3	D4	D5	D6	D7	D8
Solea solea	-	1	-	-	-	-	-	-
No. of species recorded	**25**	**7**	**9**	**5**	**0**	**4**	**4**	**3**

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APPENDIX 4. BIOTOPE DESCRIPTIONS

Table 4.1 Biotope numbers and codes

Biotope number	Biotope code
1	SLR.Fspi
2	SLR.Fves
3	SLR.Asc
4	SLR.Pel
5	SLR.EphX
6	MLR.EntPor
7	LGS
8	LGS.Tal
9	LGS.BarSnd
10	LGS.AP
11	LGS.AP.Pon
12	LGS.Lan
13	LMS.PCer
14	LMU
15	LMU.Mu
16	LMU.HedMac
17	LMU.HedScr
18	IGS.FaS
19	IMS.FaMS
20	IMU.EstMu
21	IMX

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No. 1 SLR.Fspi *Fucus spiralis* on moderately exposed to very sheltered upper eulittoral rock
Moderately exposed to very sheltered upper eulittoral bedrock and boulders are typically characterised by a band of the spiral wrack *Fucus spiralis* overlying the black lichens *Verrucaria maura* and *V. mucosa*. Limpets *Patella vulgata*, winkles *Littorina* spp. and barnacles *Semibalanus balanoides* are usually present under the fucoid fronds and on open rock. During the summer months ephemeral green algae such as *Enteromorpha* spp. and *Ulva lactuca* may also be present. This zone usually lies below a *Pelvetia canaliculata* zone (Pel or PelB); occasional clumps of *Pelvetia* may be present (usually less than common) amongst the *F. spiralis*. In areas of extreme shelter, such as in Scottish sealochs, the *Pelvetia* and *F. spiralis* zones often merge together forming a very narrow band. Fspi occurs above the *Ascophyllum nodosum* (Asc) and/or *Fucus vesiculosus* (Fves) zones and these two fucoids may also occur, although *Fucus spiralis* always dominates. Vertical surfaces in this zone, especially on moderately exposed shores, often lack the fucoids and are characterised by a barnacle-*Patella* community (BPat.Sem).

No. 2 SLR.Fves *Fucus vesiculosus* on sheltered mid eulittoral rock
Moderately exposed to sheltered mid eulittoral rock characterised by a dense canopy of large *Fucus vesiculosus* plants (typically abundant to superabundant). Beneath the algal canopy the rock surface has a sparse covering of barnacles (typically rare-frequent) and limpets, with mussels confined to pits and crevices. *Littorina littorea* and *Nucella lapillus* are also found beneath the algae, whilst *Littorina obtusata* and *Littorina mariae* graze on the fucoid fronds. The fronds may be epiphytised by the filamentous brown alga *Elachista fucicola* and the small calcareous tubeworm *Spirorbis spirorbis*. In areas of localised shelter, *Ascophyllum nodosum* may also occur, though never at high abundance (typically rare to occasional) - (compare with Asc). Damp cracks and crevices often contain patches of the red seaweeds *Osmundea* (*Laurencia*) *pinnatifida*, *Mastocarpus stellatus* and encrusting coralline algae. This biotope usually occurs between the *Fucus spiralis* (Fspi) and the *Fucus serratus* (Fser) zones; both of these fucoids may be present in this biotope, though never at high abundance (typically less than frequent). In some sheltered areas *Fucus vesiculosus* forms a narrow zone above the *A. nodosum* zone (Asc). Where freshwater runoff occurs on more gradually sloping shores *F. vesiculosus* may be replaced by *Fucus ceranoides* (Fcer).

No. 3 SLR.Asc *Ascophyllum nodosum* on very sheltered mid eulittoral rock

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Sheltered to very sheltered mid eulittoral rock with the knotted wrack *Ascophyllum nodosum*. Several variants of this biotope are described. These are: full salinity (Asc.Asc), tide-swept (Asc.T) and variable salinity (Asc.VS).

No. 4 SLR.Pel *Pelvetia canaliculata* on sheltered littoral fringe rock
Lower littoral fringe bedrock or stable boulders on sheltered shores are characterised by a dense cover of the fucoid *Pelvetia canaliculata*. The fucoid overgrows a crust of black lichens *Verrucaria maura* and *Verrucaria mucosa*, or *Hildenbrandia rubra* on very sheltered shores. This biotope lacks the density of barnacles found amongst the *Pelvetia* on more exposed shores (PelB). The littorinids *Littorina littorea* and *L. saxatilis* occur. The red alga *Catenella caespitosa* is characteristic of this biotope, as is the lichen *Lichina confinis*. Though not typical, this biotope may occur on moderately exposed shores where local topography provides shelter.

No. 5 SLR.EphX Ephemeral green and red seaweeds on variable salinity or disturbed eulittoral mixed substrata
Eulittoral mixed substrata (pebbles and cobbles overlying sand or mud) that is subject to variations in salinity and / or siltation are often characterised during the summer months by dense blankets of ephemeral green and red algae. The main species present are *Enteromorpha* spp., *Ulva lactuca* and *Porphyra* spp. Although fucoid algae occur in these areas they are typically rare. Small numbers of other species such as barnacles *Semibalanus balanoides* and *Elminius modestus* and keel worms *Pomatoceros* spp. are confined to any larger cobbles and pebbles. This biotope may be a summer variation of BLlit, in which ephemeral algal growth has exceeded the capacity of the grazing molluscs. In common with the other biotopes found on mixed substrata, patches of sediment are typically characterised by infaunal species including bivalves (*Cerastoderma edule* and *Macoma balthica*) and polychaetes (*Arenicola marina* and *Lanice conchilega*). Occasional clumps of *Mytilus edulis* may also occur, although at considerably lower density than in MytX.

No. 6 MLR.EntPor *Porphyra purpurea* or *Enteromorpha* spp. on sand-scoured mid or lower eulittoral rock
Moderately exposed mid-shore bedrock and boulders occurring adjacent to areas of sand which significantly affects the rock. As a consequence of sand-abrasion, fucoids are scarce and the community is typically dominated by ephemeral algae, particularly *Porphyra purpurea* and *Enteromorpha* spp. Under the blanket of ephemeral algae, barnacles and limpets occur in the less scoured areas. Few other species are present. In areas where sand abrasion is less severe, the sand-binding red alga *Rhodothamniella floridula* occurs with other sand-tolerant algae and fucoid algae (especially *Fucus serratus*) (Rho).

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No. 7 LGS Littoral gravels and sands
Clean gravel and/or sand in the littoral zone (the area between high and low tides) with a particle diameter range from 16 mm to 0.063 mm; shingle shores comprising mobile cobbles, pebbles and coarse gravel are also included. The shore and substratum type can range from steep mobile shores that are typically of coarse material (gravel and coarse sand), through less steep shores of coarse, medium or fine sand to level sandflats of fine sand that remain water-saturated throughout the tidal cycle. Mud (particle diameter less than 0.063 mm) does not exceed 10%, and is usually totally absent.

No. 8 LGS.Tal Talitrid amphipods in decomposing seaweed on the strand-line
A community of talitrid amphipods may occur on any shore where decomposing seaweed accumulates on the extreme upper shore strand-line. The community occurs on a wide variety of sediment shores composed of shingle and mixed substrata through to fine sands, but may also occur on mixed and rocky shores in some circumstances. The decaying seaweed provides cover and humidity for *Talitrus saltator* and other components of the community. The amphipods *Orchestia* spp. are also often present, as well as enchytraeid oligochaetes. Polychaetes, molluscs and other crustaceans may be brought in on the tide, but are not necessarily associated with the infaunal community. Further analysis of the data may determine that *Orchestia* spp. are associated with a denser strand and that there are differences in the community dependant upon the substratum-type. *Talitrus saltator* may occur further down the shore, almost invariably accompanied by burrowing amphipods such as *Bathyporeia* spp. (LGS.AEur).

No. 9 LGS.BarSnd Barren coarse sand shores
Freely-draining coarse sandy beaches, particularly on the upper shore, which lack a macrofaunal community due to their continual mobility. Trial excavations are unlikely to reveal any macrofauna in

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these typically steep beaches on exposed coasts. Burrowing amphipods *Bathyporeia* spp. or *Pontocrates* spp. and the isopod *Eurydice pulchra* may be found in extremely low abundances, but if present in any quantity should be classed as LGS.AEur. Other species that may be found in low abundance may be left behind by the ebbing tide.

No. 10 LGS.AP Burrowing amphipods and polychaetes in clean sand shores
Mid and lower shore clean sandy shores on wave-exposed or moderately wave-exposed coasts support a community of burrowing amphipods and polychaetes, sometimes with bivalves such as *Angulus tenuis*. The medium to fine-grained sand remains damp throughout the tidal cycle. The community consists of burrowing amphipods (*Pontocrates altamarinus*, *P. arenarius*, *Bathyporeia elegans*, *B. guilliamsoniana*, *B. pelagica*, *B. pilosa* and *B. sarsi*), the isopod *Eurydice pulchra*, the cumacean *Cumopsis goodsiri* and polychaetes (including *Nephtys cirrosa*, *Scolelepis squamata*, *Paraonis fulgens* and *Arenicola marina*). The presence of polychaetes is seen as coloured burrows running down from the surface of the sediment. The sediment is often rippled and typically lacks an anoxic black sub-surface layer. This community differs from the community of burrowing amphipods (LGS.AEur) in its greater variety of polychaete species and the presence of bivalves. The two sub-types are LGS.AP.P and LGS.AP.Pon depending upon the proportion of amphipods and polychaetes and the specific species present in the sand. More stable sediment, such as is found in sandy inlets or extensive coastal sandflats are LMS.PCer or LMS.MacAre.

No. 11 LGS.AP.Pon Burrowing amphipods *Pontocrates* spp. and *Bathyporeia* spp. in lower shore clean sand
Lower shore clean sand on wave-exposed or moderately wave-exposed coasts support a community of burrowing amphipods and polychaetes. Amphipods make up the greater part of the community and are typically dominated by *Pontocrates altamarinus*, *P. arenarius*, *Bathyporeia elegans*, *B. pelagica*, *B. pilosa* the isopod *Eurydice pulchra* and the cumacean *Cumopsis goodsiri*. Polychaetes are dominated by *Nephtys cirrosa*, *Paraonis fulgens* and *Scolelepis squamata*. *Angulus tenuis* is also frequently found in this biotope. Although the characterising species are not found very frequently, they are faithful to this biotope. The medium and fine sand remains damp throughout the tidal cycle and contains little organic matter. The presence of polychaetes may be seen as coloured burrows running down from the surface of the sediment. The sediment is often rippled and typically lacks an anoxic black sub-surface layer. LGS.AP.Pon is distinguished from LGS.AP.P as being less stable sediment with a community dominated by amphipods, particularly *Pontocrates altamarinus*, *Bathyporeia elegans* and *Cumopsis goodsiri* or the bivalve *Angulus tenuis*. This community differs from the community of burrowing amphipods (LGS.AEur) in its greater variety of polychaete and amphipod species. More stable sediment, found in sandy inlets or extensive coastal sandflats are considered to be LMS.PCer or LMS.MacAre, depending upon the community present.

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No. 12 LGS.Lan Dense *Lanice conchilega* in tide-swept lower shore sand
Medium to fine sand, which is usually clean but may contain some fines and supports dense populations of *Lanice conchilega*, usually on the lower shore but also sometimes on water-logged mid shores. The biotope occurs under tide-swept conditions in sheltered straits, sounds and fully marine sealochs or on shores moderately exposed to wave action. The biotope is distinguished from others in sandy beaches by the presence of *Lanice conchilega* at levels of common and above or as the main polychaete component. Other polychaetes present are tolerant of sand scour or mobility of the surface levels of the sediment and include glycerid polychaetes, *Anaitides mucosa*, *Nephtys cirrosa*, *Nephtys hombergii* and *Pygospio elegans*. Few crustaceans are found regularly and the bivalve component is restricted to cockles *Cerastoderma edule* and more rarely *Macoma balthica*. Pebbles and cobbles may also be mixed in with lower shore tide-swept sand with dense *Lanice conchilega* between the cobbles, but the infaunal component is rarely sampled. The infaunal community under these circumstances, provided that the cobbles are not packed very close together, will be similar to that in areas of purer sand. Dense *L. conchilega* also occurs in shallow sublittoral sediments (IGS.Lcon).

No. 13 LMS.PCer Polychaetes and *Cerastoderma edule* in fine sand or muddy sand shores
Fine sand on extensive moderately wave-exposed and sheltered shores, where the sediment is sufficiently stable to accommodate populations of *Cerastoderma edule* (at least occasional) and other bivalves. The community is found mainly on the mid and lower shore where the sediment is water-saturated most of the time. Slightly muddy conditions at some sites are reflected in a reduced amphipod population and a wider range of polychaetes compared to Amphipod-polychaete biotopes (LGS.AP). The community consists of polychaetes *Nephtys hombergii*, *Scoloplos armiger*, *Pygospio elegans*, *Spio filicornis* and *Capitella capitata*, oligochaetes, the amphipod *Bathyporeia sarsi*, and the bivalves *Cerastoderma edule* and *Macoma balthica*. This biotope carries commercially viable stocks

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of cockles *Cerastoderma edule*. It is therefore possible to find areas of this habitat where the infauna may have been changed through recent cockle dredging. Higher on the shore, adjacent to this biotope, LMS.BatCor is found with fewer polychaete and bivalve species due to the drier sediment found on the upper shore. LMS.PCer has broad transition areas with LMS.MacAre, LMU.HedMac.Pyg and LMU.HedMac.Are. LMS.MacAre and LMU.HedMac.Are are indicated by the presence of *Arenicola marina*, the latter also having *Hediste* (*Nereis*) *diversicolor*, oligochaetes and other species that indicate a more sheltered, muddy sand biotope. LMU.HedMac.Pyg has a greater proportion of the polychaetes *Hediste diversicolor*, *Pygospio elegans* and *Eteone longa*, oligochaetes and the amphipod *Corophium volutator*. The species richness of LMS.PCer, particularly for polychaetes and bivalves, is greater than the more wave-exposed biotopes LGS.AP.

No. 14 LMU Littoral muds

Shores of fine particulate sediment with a particle size less than 0.063 mm in diameter that typically forms extensive mudflats. Dry compacted mud can form steep and even vertical structures, particularly at the top of the shore adjacent to saltmarshes. Also included in this higher division are sandy muds which have between 20% and 70% sand, the remainder being made up of mud with a particle size less than 0.063 mm. Small amounts of gravel or pebbles may be found within mud, having little effect upon the structure of the associated communities. Littoral muds support communities characterised by polychaetes, certain bivalves and oligochaetes. The ragworm *Hediste* (*Nereis*) *diversicolor*, the Baltic tellin *Macoma balthica* and the furrow shell *Scrobicularia plana* are conspicuous members of muddy shore communities.

No. 15 LMU.Mu Soft mud shores

Shores of soft mud, typically with over 80% silt/clay fraction, giving very or extremely soft sediment shores. These are typically restricted to the upper reaches of estuaries and subject to variable, reduced or low salinity conditions. Although not very species-rich, with increasingly lower salinity conditions the mud supports even more impoverished communities, characterised by oligochaete worms.

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No. 16 LMU.HedMac *Hediste diversicolor* and *Macoma balthica* in sandy mud shores

Littoral sandy mud and mud in sheltered, often estuarine, conditions with a community of polychaetes together with the bivalve *Macoma balthica*. The most abundant large polychaete is typically *Hediste* (*Nereis*) *diversicolor*, which can be readily seen when digging over the sediment. Other smaller polychaetes include *Eteone longa*, *Nephtys hombergii*, *Aphelochaeta marioni*, *Pygospio elegans*, *Arenicola marina* and *Manayunkia aestuarina*. Oligochaete worms (e.g. *Tubificoides benedii*, *T. pseudogaster* and enchytraeids) are common or abundant and the amphipod *Corophium volutator* may be abundant. The mud snail *Hydrobia ulvae* is often common, with individuals or their fine tracks visible on the mud surface. The bivalve *Macoma balthica* may be accompanied by *Cerastoderma edule*, *Abra tenuis* and *Mya arenaria*. The surface of the mud may be covered with green algae such as *Enteromorpha* spp. or *Ulva lactuca*. There is usually a black anoxic layer close to the sediment surface. LMU.HedStr is a similar biotope that is associated with muddier sediment in reduced salinity conditions with *Streblospio shrubsolii*, *Manayunkia aestuarina* or *Tharyx killariensis* and with fewer bivalves. Three variations of this biotope are recognised: HedMac.Are, HedMac.Pyg and HedMac.Mare.

No. 17 LMU.HedScr *Hediste diversicolor* and *Scrobicularia plana* in reduced salinity mud shores

Mid and upper shore sandy mud and mud that is subject to variable and reduced salinity is typically colonised by the polychaete *Hediste* (*Nereis*) *diversicolor* and the bivalve *Scrobicularia plana*. The polychaetes *Eteone longa*, *Pygospio elegans* and *Streblospio shrubsolii*, oligochaetes, particularly *Tubificoides benedii* and the isopod *Cyathura carinata* are all characteristic of the infaunal assemblage. Other bivalves, such as the Baltic tellin *Macoma balthica* and cockle *Cerastoderma edule*, are also frequently recorded. The mud snail *Hydrobia ulvae* is usually common. The green alga *Ulva lactuca* may colonise the surface of the mud in the summer months or it may be covered by a mat of filamentous algae such as *Enteromorpha* spp. Typically, the sediment is wet in appearance and has an anoxic layer below 1 cm depth. The surface of the mud has the distinctive 'crow's foot' pattern formed by *Scrobicularia plana*. The biotope LMU.HedStr is very similar, but with some differences in the polychaetes and bivalves recorded. In LMU.HedStr, the frequency and abundance of *Eteone longa* is lower, whilst the frequency of the polychaetes *Nephtys hombergii*, *Streblospio shrubsolii*, *Aphelochaeta marioni* and *Melinna palmata* is greater. The bivalve richness in LMU.HedScr is typically higher with a greater frequency of *Cerastoderma edule*, *Macoma balthica*, *Scrobicularia plana* and *Abra tenuis*. LMU.HedScr may be intermediate between LMU.HedStr and LMU.HedMac or

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LMU.HedMac.Mare. It is muddier and is subject to a lower salinity level than LMU.HedMac. The diversity of species recorded is much greater than in LMU.HedOl.

No. 18 IGS.FaS Shallow sand faunal communities
Clean sands which occur in shallow water, either on the open coast or in tide-swept channels of marine inlets. The habitat typically lacks a significant seaweed component and is characterised by robust fauna, particularly venerid bivalves, amphipods and robust polychaetes.

No. 19 IMS.FaMS Shallow muddy sand faunal communities
Muddy sand habitats in the infralittoral zone, extending from the extreme lower shore down to more stable circalittoral zone at about 15-20 m. The habitat supports a variety of animal-dominated communities, particularly of polychaetes, bivalves and the urchin *Echinocardium cordatum*.

No. 20 IMU.EstMu Estuarine sublittoral muds
Shallow sublittoral muds, extending from the extreme lower shore to about 15 m depth in estuarine conditions. Such habitats typically support communities of oligochaetes, polychaetes, and bivalves such as *Aphelochaeta marioni*. In lowered salinity conditions the sediments may include a proportion of coarser material, where the silt content is sufficient to yield a similar community to that found in purer muds.

No. 21 IMX Estuarine sublittoral mixed sediments
Shallow sublittoral mixed sediments in estuarine conditions, often with surface shells or stones enabling the development of epifaunal communities, e.g. *Crepidula fornicata* (IMX.CreAph) and mussel *Mytilus edulis* beds (IMX.MytV), as well as infaunal communities. The habitat is therefore often quite species rich, compared with purer sediments.

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APPENDIX 5. PHOTOGRAPHS

Plate 5.1 Northwest Irishtown.

Plate 5.2 *Ascophyllum nodosum* with *Fucus spiralis* on the rock armour.

Plate 5.3 Various hard substrate biotopes on the rock armour of Irishtown.

Plate 5.4 Sandy biotope around Irishtown.

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Plate 5.5 Muddy sand biotope around Irishtown.

Plate 5.6 Sandy biotope with lug worm casts around Irishtown.

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Plate 5.7 Shore crab with mussels in Irishtown.


Plate 5.8 *Fucus spiralis* with mussels around Irishtown.


Plate 5.9 The area of site Lc in the Tolka estuary.


Plate 5.10 The area of site Ld in the Tolka estuary.


Plate 5.11 The sediment biotopes of Dollymount Strand, Bull Island.


Plate 5.12 The core sample from site Lc prior to sieving.

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Plate 5.13 Site La showing various biotope zones.

Plate 5.14 The area of site La.

Plate 5.15 The structure of site Lb.

Plate 5.16 The contents of dredge Dd showing shrimp, shore crab, plaice, dab and matted algae.

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Plate 5.17 The biological dredge with the contents of site Dg.

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APPENDIX 6. GRANULOMETRY, LOI, HEAVY METALS

Table 6.1 Data from granulometric analysis of sediment samples showing the percentage of the total sample which passed through each sieve size.

Sieve size µm	C4 Irishtown	Le Tolka estuary	G2 Liffey/Tolka estuary	G3 Liffey/Tolka estuary	Df Off Bull Island
5600	100	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	99.89
4000	100				99.79
2800	100				99.65
2000	99.94				99.55
1180	99.85				99.32
850	99.75				99.13
600	99.63				98.96
425	99.42				98.78
300	98.52				97.29
212	95.85				95.40
150	56.57				65.66
63	3.48				0.74

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Table 6.2. Granulometric scales used in classifying sediments after Wentworth (1922) and Folk (1954).

phi	mm	µm	Wentworth	Folk
-8	256	256000	Boulders	Gravel
-7	128	128000	Cobbles	Gravel
-6	64	64000	Cobbles	Gravel
-5	32	32000	Pebbles	Gravel
-4	16	16000	Pebbles	Gravel
-3	8	8000	Pebbles/granules	Gravel
-2	4	4000	Granules	Gravel
-1	2	2000	Granules	Gravel
0	1	1000	Very coarse sand	Sand
1	0.5	500	Coarse sand	Sand
2	0.25	250	Medium sand	Sand
3	0.125	125	Fine sand	Sand
4	0.0625	63	Very fine sand	Sand
5	0.0312	31	Silt	Mud
6	0.0156	16	Silt	Mud
7	0.0078	8	Silt	Mud
8	0.0039	4	Silt	Mud
>8	<0.0039	<4	Clay	Mud

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Table 6.3 Data from Heavy Metal analysis of sediments expressed as mg/Kg of metal to sediment.

Metal	C4 Irishtown	Le Tolka estuary	G2 Liffey/Tolka estuary	G3 Liffey/Tolka estuary	Df Off Bull Island
Mercury	<0.3	<0.3	<0.3	<0.3	<0.3
Lead	12.9	78.4	30.9	22.4	3.2
Cadmium	0.6	2.0	1.3	0.9	0.3
Chromium	10.5	23.7	25.7	23.4	7.7
Copper	6.8	64.9	28.8	18.0	1.2
Zinc	37.6	272.8	117.3	74.8	11.5
Nickel	12.47	19.42	22.59	16.41	5.55
Manganese	149.2	299.7	303.3	270.8	141.1

Table 6.4 Data from the Loss On Ignition analysis of sediments.

Loss on ignition (LOI) at 440 °C	C4 Irishtown	Le Tolka estuary	G2 Liffey/Tolka estuary	G3 Liffey/Tolka estuary	Df Off Bull Island
As % weight	93.56	96.42	96.32	95.62	89.64

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2. APPENDIX 7. DÚCHAS SITE SYNOPSIS

SITE NAME : NORTH DUBLIN BAY

SITE CODE : 000206

This site covers the inner part of north Dublin Bay, the seaward boundary extending from the Bull Wall lighthouse across to the Martello Tower at Howth Head.

The North Bull Island is the focal point of this site. The island is a sandy spit which formed after the building of the South Wall and Bull Wall in the 18th and 19th centuries. It now extends for about 5 km in length and is up to 1 km wide in places. A well-developed and dynamic dune system stretches along the seaward side of the island. Various types of dunes occur, from fixed dune grassland to pioneer communities on foredunes. Marram Grass (*Ammophila arenaria*) is dominant on the outer dune ridges, with Lyme Grass (*Leymus arenarius*) and Sea Couchgrass (*Elymus farctus*) on the foredunes. Behind the first dune ridge, plant diversity increases with the appearance of such species as Wild Pansy (*Viola tricolor*), Kidney Vetch (*Anthyllis vulneraria*), Bird's-foot Trefoil (*Lotus corniculatus*), Rest Harrow (*Ononis repens*), Yellow Rattle (*Rhinanthus minor*) and Pyramidal Orchid (*Anacamptis pyramidalis*). In these grassy areas and slacks, the scarce Bee Orchid (*Ophrys apifera*) occurs.

About 1 km from the tip of the island, a large dune slack with a rich flora occurs, usually referred to as the 'Alder Marsh' because of the presence of Alder trees (*Alnus spp*). The water table is very near the surface and is only slightly brackish. Saltmarsh Rush (*Juncus maritimus*) is the dominant species, with Meadow Sweet (*Filipendula ulmaria*) and Devil's-bit (*Succisa pratensis*) being frequent. The orchid flora is notable and includes Marsh Helleborine (*Epipactis palustris*), Common Twayblade (*Listera ovata*), Autumn Lady's-tresses (*Spiranthes spiralis*) and Marsh orchids (*Dactylorhiza* spp.)

Saltmarsh extends along the length of the landward side of the island. The edge of the marsh is marked by an eroding edge which varies from 20 cm to 60 cm high. The marsh can be zoned into different levels according to the vegetation types present. On the lower marsh, Glasswort (*Salicornia europaea*), Saltmarsh Grass (*Puccinellia maritima*), Annual Sea-blite (*Suaeda maritima*) and Greater Sea-spurrey (*Spergularia media*) are the main species. Higher up in the middle marsh Sea Plantain (*Plantago maritima*), Sea Aster (*Aster tripolium*), Sea Arrowgrass (*Triglochin maritima*) and Sea Pink (*Armeria maritima*) appear. Above the mark of the normal high tide, species such as Scurvy Grass (*Cochlearia officinalis*) and Sea Milkwort (*Glaux maritima*) are found, while on the extreme upper marsh, Sea Rushes (*Juncus maritimus* and *J. gerardii*) are dominant. Towards the tip of the island, the saltmarsh grades naturally into fixed dune vegetation.

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The island shelters two intertidal lagoons which are divided by a solid causeway. The sediments of the lagoons are mainly sands with a small and varying mixture of silt and clay. The north lagoon has an area known as the "Salicornia flat", which is dominated by *Salicornia dolichostachya*, a pioneer Glasswort species, and covers about 25 ha. Tassel Weed (*Ruppia maritima*) occurs in this area, along with some Eelgrass (*Zostera angustifolia*). Eelgrass (*Z. noltii*) also occurs in Sutton Creek. Cordgrass (*Spartina anglica*) occurs in places but its growth is controlled by management. Green algal mats (*Enteromorpha* spp., Ulva lactuca) cover large areas of the flats during summer. These sediments have a rich macrofauna, with high densities of Lugworms (*Arenicola marina*) in parts of the north lagoon. Mussels (*Mytilus edulis*) occur in places, along with bivalves such as *Cerastoderma edule*, *Macoma balthica* and *Scrobicularia plana*. The small gastropod *Hydrobia ulvae* occurs in high densities in places, while the crustaceans *Corophium volutator* and *Carcinus maenas* are common. The sediments on the seaward side of North Bull Island are mostly sands. The site extends below the low spring tide mark to include an area of the sublittoral zone.

Three Rare plant species legally protected under the Flora Protection Order 1987 have been recorded on the North Bull Island. These are Lesser Centaury (*Centaurium pulchellum*), Hemp Nettle (*Galeopsis angustifolia*) and Meadow Saxifrage (*Saxifraga granulata*). Two further species listed as threatened in the Red Data Book, Wild Sage (*Salvia verbenaca*) and Spring Vetch (*Vicia lathyroides*),

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have also been recorded. A rare liverwort, *Petalophyllum ralfsii*, was first recorded from the North Bull Island in 1874 and has recently been confirmed as being still present there. This species is of high conservation value as it is listed on Annex II of the E.U. Habitats Directive. The North Bull is the only known extant site for the species in Ireland away from the western seaboard.

North Dublin Bay is of international importance for waterfowl. During the 1994/95 to 1996/97 period the following species occurred in internationally important numbers (figures are average maxima): Brent Geese 2,333; Knot 4,423; Bar-tailed Godwit 1,586. A further 14 species occurred in nationally important concentrations - Shelduck 1505; Wigeon 1,166; Teal 1,512; Pintail 334; Shoveler 239; Oystercatcher 2,190; Ringed Plover 346; Grey Plover 816; Sanderling 357; Dunlin 6,238; Black-tailed Godwit 156; Curlew 1,193; Turnstone 197 and Redshank 1,175. Some of these species frequent South Dublin Bay and the River Tolka Estuary for feeding and/or roosting purposes (mostly Brent Goose, Oystercatcher, Ringed Plover, Sanderling, Dunlin).

The tip of the North Bull Island is a traditional nesting site for Little Tern. A high total of 88 pairs nested in 1987. However, nesting attempts have not been successful since the early 1990s. Ringed Plover, Shelduck, Mallard, Skylark, Meadow Pipit and Stonechat also nest. A well-known population of Irish Hare is resident on the island

The invertebrates of the North Bull Island have been studied and the island has been shown to contain at least seven species of regional or national importance in Ireland (Orders Diptera, Hymenoptera, Hemiptera).

The main land uses of this site are amenity activities and nature conservation. The North Bull Island is the main recreational beach in Co Dublin and is used throughout the year. Much of the land surface of the island is taken up by two golf courses. Two separate Statutory Nature Reserves cover much of the island east of the Bull Wall and the surrrounding intertidal flats. The site is used regularly for educational purposes. North Bull Island has been designated a Special Protection Area under the E.U. Birds Directive and it is also a statutory Wildfowl Sanctuary, a Ramsar Convention site, a Biogenetic Reserve, a Biosphere Reserve and a Special Area Amenity Order site.

This site is an excellent example of a coastal site with all the main habitats represented. The holds good examples of ten habitats that are listed on Annex I of the E.U. Habitats Directive; one of these is listed with priority status. Several of the wintering bird species have populations of international importance, while some of the invertebrates are of national importance. The site contains a numbers of rare and scarce plants including some which are legally protected. Its proximity to the capital city makes North Dublin Bay an excellent site for educational studies and research.

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SITE NAME: SOUTH DUBLIN BAY

SITE CODE: 000210

This site lies south of the River Liffey and extends from the South Wall to the west pier at Dun Laoghaire. It is an intertidal site with extensive areas of sand and mudflats, a habitat listed on Annex I of the E.U. Habitats Directive. The sediments are predominantly sands but grade to sandy muds near the shore at Merrion gates. The main channel which drains the area is Cockle Lake.

There is a bed of Eelgrass (*Zostera noltii*) below Merrion Gates which is the largest stand on the east coast. Green algae (*Enteromorpha* spp. and *Ulva lactuca*) are distributed throughout the area at a low density. Fucoid algae occur on the rocky shore in the Maretimo to Dún Laoghaire area. Species include *Fucus spiralis, F. vesiculosus, F. serratus, Ascophyllum nodosum* and *Pelvetia canaliculata*.

Lugworm (*Arenicola marina*) and Cockles (*Cerastoderma edule*) and other annelids and bivalves are frequent throughout the site. The small gastropod *Hydrobia ulvae* occurs on the muddy sands off Merrion Gates.

South Dublin Bay is an important site for waterfowl. Although birds regularly commute between the south bay and the north bay, recent studies have shown that certain populations which occur in the south bay spend most of their time there. The principal species are Oystercatcher (1215), Ringed Plover (120), Sanderling (344) and Dunlin (2628), Redshank (356) (average winter peaks 1996/97 and 1997/98). Up to 100 Turnstones are usual in the south bay during winter. Brent Geese regularly occur in numbers of international importance (average peak 299). Bar-tailed Godwit (565), a species listed on Annex I of the EU Birds Directive, also occur.

Large numbers of gulls roost in South Dublin Bay, e.g. 4,500 Black-headed Gulls in February 1990; 500 Common Gulls in February 1991. It is also an important tern roost in the autumn, regularly holding 2000-3000 terns including Roseate Terns, a species listed on Annex I of the E.U. Birds Directive. South Dublin Bay is largely protected as a Special Protection Area.

At low tide the inner parts of the south bay are used for amenity purposes. Bait-digging is a regular activity on the sandy flats. At high tide some areas have wind-surfing and jet-skiing.

This site is a fine example of a coastal system with extensive sand and mudflats, a habitat listed on Annex I of the E.U. Habitats Directive. South Dublin Bay is also an internationally important bird site.

25.2.2000

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