Appendix 4

Literature Review - Bird Collision Risk

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1. Introduction

The following report uses published peer reviewed literature to examine the potential impact of the building and stack at the Ringaskiddy Resource Recovery Centre. This review will help to inform the conclusions of the Appropriate Assessment (AA) Screening and Natura Impact Statement (NIS) which specifically addresses the impact of the proposed development on the Cork Harbour SPA. This literature review was prepared by Sorcha Sheehy PhD and Carl Dixon MSc.

A number of published reports have voiced concern over the potential of buildings to negatively impact on bird populations through collision mortality. Such impacts are of particular concern for sensitive species such as those which use the nearby Cork Harbour SPA. The highest buildings at the site of the proposed development will be the main process building (roof level is between 23.7-50.7m AOD, ground level 5mOD) and the stack (level of top stack is 70m, ground level 5mOD). Therefore, for the purposes of this report, the author assumes a total maximum building height of <75m AOD.

2. Impacts of bird collision

Birds have been colliding with manmade structures ever since humans started building them, with the earliest documented instances of collision mortality in the late 1800's (Coues 1876, Merriam 1885). There have been cases where large numbers of bird mortalities at stacks have been recorded. Daily searches of two stacks in Ontario, Canada over a 4-year period yielded 8,531 dead birds, the majority of which were passerine species (Weir 1976). However, the biological significance of collision mortality to any species is unknown. There are a number of factors, such as total population size, natural mortality levels, and other human related influences, for which insufficient data exist to be able to put the collision mortality factor in proper perspective. Although a wealth of literature exists on the subject of bird-strike with structures, much of it derives from one-off studies of individual installations, carried out or commissioned by developers or other interested and concerned parties.

Hence, the majority of studies have been undertaken in circumstances where a problem has been recognised or anticipated, and, consequently, reported bird fatalities may reflect the distribution of observation effort more than the actual occurrence of bird collisions. The focus of such studies and reports has changed over the years, with attention from power lines to wind turbines, following changes in public interests and/or concerns. As a result, few data sets of bird-strike are based on long-term, standardised, and systematic assessments, and those that are available are often derived from a single structure or a small number of installations rather than a wider-scale study. Therefore, attempts to assess the overall levels of collision mortality caused by structures, at a local, regional, or national level, are generally based on small and biased samples which are unreliable or, at best, yield estimates with extremely wide ranges.

Bird-building collisions are most frequent in urban areas containing many residential and commercial structures; however, the species most frequently killed, as well as those appearing most vulnerable to population-level impacts of building collision fatalities, are migratory birds that collide during spring and autumn migration while in transit between breeding and nonbreeding grounds (e.g., hummingbirds, warblers, thrushes, and native sparrows) Loss *et al*. 2014; Arnold 2011.)

Putting such bird-strike mortality in context is crucial to understanding its impact on bird populations. Despite widespread public attention and more than five decades of research, measures of anthropogenic sources of mortality for birds remain speculative. Estimates of total collision mortality from communication towers in North America range from 0.94 to 50 million birds annually (Banks 1979; Drewitt & Langston 2006), while estimates of collision mortality with windows range from 3.5 million up to 5 billion birds annually (Banks 1979; Klem 1990; Hager et al. 2008). Loss *et al.* (2014) estimatedthat between 365 and 988 million birds (median = 599 million) are killed annually by building collisions in the U.S., with roughly 56% of mortality at low-rises, 44% at residences, and <1% at high-rises.

Arnold and Zink (2011) developed a model using comparative data, including species-specific measures of mortality, relative abundance, and long-term population trends. They found that vulnerability to collision with buildings and towers varied over more than four orders of magnitude among species. Species that migrated long distances or at night, were much more likely to be killed by collisions than year-round residents or diurnal migrants. However, they found no correlation between relative collision mortality and long-term population trends for these same species. Therefore, they concluded that although millions of North American birds are killed annually by collisions with manmade structures, this source of mortality has no discernible effect on populations. A review of this publication by Klem *et al*. (2012), found there was no correlation between relative collision mortality and long-term population trends for these same species. Thus, although millions of North American birds are killed annually by collisions with manmade structures, this source of mortality has no discernible effect on populations. Although Klem *et al.* (2012) supported the conclusions of Arnold and Zinc (2011), concerns have been raised about these conclusions Scaub *et al.* (2011), Longcore *et al.* 2013.

It should be noted that relatively few studies have been carried out on stack collisions, and this may reflect the lower level of risk, or perceived risk, posed by such structures. While this literature review attempts where possible to focus on stacks, the relatively paucity of studies on this building type, means that the author has also examined other structures including communication towers, tall buildings and to a lesser extent wind turbines, in order to get a complete picture of the bird-strike risk posed by the proposed Ringaskiddy Resource Recovery Centre.

3. Factors affecting risk of collision

3.1 *Building height*

Reviewing the available literature, a number of trends have emerged, particularly linking building height to collision risk. Studies from North America suggest a positive correlation between bird collisions and the size or height of a building (Cabrera-Cruz *et al*., 2019; Loss *et al.*, 2014, Longcore et al. 2012). However, a more recent study, which focused on all building types in China reported that lower buildings experience a greater occurrence of collisions than taller ones (Binbin *et al.* 2025). Loss et al (2014) estimated that 56% of mortality at low-rises (4-11 storeys tall), 44% at residences (1-3 storeys tall), and 1% at high-rises (>11 storeys tall). However, the presence of windows of these buildings is likely to be a significant and confounding factor in their rates of collision.

Although there are few published studies of the effect of tower height, there is some evidence to suggest that towers lower than 60 m to 150 m pose a lower risk to migrating birds (Kerlinger 2000a, 2000b; Newton 2007). Observations from one study suggested that a change in tower height from 308 m to 90 m greatly reduced the number of fatalities (Crawford and Engstrom 2001). Building structure, size and dimensions clearly influence the risk of bird-strike, especially in conditions of poor visibility (Winkelman 1992a; Ogden 1996; Hotker *et al.* 2006). For example, there is evidence that taller communication towers present a greater risk to nocturnal migrants than shorter masts (Crawford and Engstrom 2001). Layout, orientation, and spacing are also important factors influencing collision risk, most notably for wind turbines and power lines (Winkelman 1992a, 1992b; Bevanger 1994). This should be considered when looking at cumulative impacts of the proposed Ringaskiddy Resource Recovery Centre alongside existing wind turbines in the Cork Harbour area (discussed in **Section 4**).

3.2 *Lighting*

Apart from size, often the most important structural factor related to collision probability is the use of lighting. Many tall structures require warning lights for aircraft and/or shipping. Additional sources of light include floodlighting and the interior lighting of office blocks, which are often illuminated through the night. There are many observations, both incidental and systematic, of birds being attracted to and disoriented by lights, especially on (but not restricted to) overcast nights with drizzle or fog (Laskey 1954; Cochran and Graber 1958; Weir 1976; Verheijen 1985; Gauthreaux and Belser 2006). Birds attracted to light are not only at risk of death or injury due to collision, but also at risk of exhaustion, starvation, or predation (Ogden 1996; Huppop *et al.* 2006). Even if migrants successfully escape lit structures, the consequent increase in energy expenditure may reduce their chances of successfully completing their migration.

Various explanations have been put forward for the apparent attraction of birds, especially nocturnally migrating passerines, to artificial lights (Avery *et al.* 1976; Verheijen 1985; Beason 1999), though none has been conclusively established. One study suggests that this may be due to the "trapping effect" of light rather than actual attraction (Avery *et al.* 1976). This theory suggests that on entering an illuminated area, especially on a cloudy night, passing migrants are reluctant to leave; when approaching the edge of the illuminated area they are hesitant to fly into the darkness beyond and, instead, fly back toward the light. There are no detailed studies of the different risks posed by different lighting systems, though several studies show that changes in the type of lighting used, particularly the replacement of continuous red or white lights with intermittent lighting, has, in some circumstances, reduced the trapping effect and thus mortality of nocturnal migrants (Ogden 1996; Kerlinger 2000a; Gauthreaux and Belser 2006). Evidence for the effects of red versus white lights is contradictory. Avery *et al.* 1976 concluded that lights of different colours (red and white), flash rates (including non-flashing), heights, intensities and configurations all seem to elicit similar phototactic responses in nocturnal migrants. Kerlinger (2000a) in a comprehensive review of the existing literature concluded that, in spite of general consensus to the contrary, few or no published papers or recent databases were able to substantiate that white strobe lights resulted in fewer collisions than other colour or types of light. It is likely that any light source visible to humans is also visible to birds and may therefore represent a potential hazard (Verheijen 1985).

Gauthreaux (2000) studied the flight behaviour of migrating songbirds in spring and fall at communication towers; one with white-strobe and one with red flashing lights, and a control area with no tower to determine whether behavioural differences were evident. A greater proportion of birds showing curved, circling, or hovering at red lighted towers than white lighted towers or the control area. More convoluted flight was also found with white lights than in the control area. The findings suggest white-strobe lights are resulted in fewer collisions than red lights on towers. However, it should be noted that a hurricane blew the towers down before the results could be replicated.

A few reports indicate that white strobe lights, whose ultraviolet content is unknown, are less attractive to birds than steady or flashing red lights (Gauthreaux and Belser 1999). Several species, tested under laboratory conditions, are disoriented by red and yellow lights due to some form of disruption of their magnetic compasses (Beason 1999; Kerlinger 2000a), although there is as yet no evidence that this is related to collision risk. It is probable that light intensity and flash duration are more significant than colour: The longer the period between flashes of light, the less likely birds are to be attracted or disoriented (Manville 2000; Huppop *et al.* 2006), perhaps because birds can escape the trapping effect during the short time when the beam is extinguished. Evidence for the effect of floodlighting is also contradictory. Whereas losses due to collisions at lighthouses in Britain were reduced following illumination with floodlights, the installation of floodlighting at a lighthouse in Ontario, Canada, appeared to increase mortality (Baldwin 1965). Floodlighting is also implicated in high mortality levels at other structures (Weir 1976; Ogden 1996). One plausible explanation for this variable effect relates to the direction and width of beam created, with a broad beam directed downward less likely to cause a trapping effect (Verheijen 1985).

Gehring *et al*. (2009) focused on the features of communication towers which are particularly hazardous to birds. By comparing the mortality rates at towers of varying heights and lighting a number of risk factors were identified. During the study period they found a mean of 3.7 birds under 116–146 m AGL towers equipped with only red or white flashing obstruction lights, whereas towers with nonflashing/ steady-burning lights in addition to the flashing lights were responsible for 13.0 fatalities. Further analysis revealed that towers lit at night with only flashing lights were involved in significantly fewer avian fatalities than towers lit with systems that included the Federal Aviation Administration (FAA) ''status quo'' lighting system (i.e., a combination of red, flashing lights and red, non-flashing lights). There were no significant differences in fatality rates among towers lit with red strobes, white strobes, and red, incandescent, flashing lights.

Rebke et al. (2019), exposed birds in the Northern Sea to combinations of light colour (red, yellow, green, blue, white), intensity (half, full) and blinking mode (intermittent, continuous) while measuring their number close to the light source with thermal imaging cameras. We found that no light variant was constantly avoided by nocturnally migrating passerines crossing the sea. The number of birds did neither differ between observation periods with blinking light of different colours nor compared to darkness. While intensity did not influence the number attracted, birds were drawn more towards continuous than towards blinking illumination, when stars were not visible. Red continuous light was the only exception that did not differ from the blinking counterpart. Continuous green, blue and white light attracted significantly more birds than continuous red light in overcast situations.

Syposz, et al (2019) compared number of flying shearwaters under dark conditions and in response to an artificially introduced light, and observed fewer birds in flight during 'light-on' periods, suggesting that adult shearwaters were repelled by the light. This effect was stronger with higher light intensity, increasing duration of 'light-on' periods and with green and blue compared to red light. Thus, we recommend lower light intensity, red colour, and shorter duration of 'light-on' periods as mitigation measures to reduce the effects of light at breeding colonies and in their vicinity.

3.3 *Location of structure*

The location of a structure can dramatically affect the likelihood of collision mortality. Clearly, structures present a greater risk of collision if placed on or near areas regularly used by large numbers of feeding, breeding, or roosting birds, or on migratory flyways or local flight paths, such as those between foraging and nesting or roosting areas (Scott 1972; Faanes 1987; Henderson *et al.* 1996; Exo *et al.* 2003; Everaert and Stienen 2007). Although many migrants tend to fly along a broad front, topographical features, such as mountain passes, may funnel high numbers into obstacles. Similarly, structures placed along landscape features followed by migrating birds, such as river valleys, or in coastal areas where large numbers congregate before and after crossing the sea, are likely to present a greater risk of collision (Alerstam 1990; Richardson 2000).

A radar study was commissioned by the Cork Lower Harbour Energy Group, in order to identify nocturnal bird movement and interconnectivity within the Cork Harbour SPA (Simms *et al.* 2011). A number of significant nocturnal flight corridors were identified, particularly connecting Lough Beg to the Owenboy River Estuary at incoming and outgoing tide periods. This is located to the south of the proposed Ringaskiddy Resource Recovery Centre. No widespread distinct patterns were observed between Monkstown Creek and Lough Beg, although minor patterns were observed from birds flying northwards from Lough Beg over the Martello tower area, to the west of the proposed Ringaskiddy Resource Recovery Centre. No distinct flight patterns were observed over the proposed development site.

3.4 *Differing Species Susceptibility*

Not all bird species are equally susceptible to collision, and some species suffer disproportionately high levels of collision mortality. The location of structures in areas where such species congregate often results in high numbers of fatalities (Howell and DiDonato 1991; Orloff and Flannery 1992; Bevanger 1995; Ogden 1996; Barrios and Rodriguez 2004; Smallwood and Thelander 2004; Everaert and Stienen 2007; Hunt and Hunt 2006; Klem 2006; Newton 2007). Susceptibility to collision depends on morphology and physical flight characteristics and perhaps differences in vision, as well as flight behaviour, degree of flocking, and, in some cases, particular activities, such as provisioning young (Alerstam 1990; Bevanger 1994; Henderson *et al.* 1996; Ogden 1996; Alonso & Alonso 1999b;

Richardson 2000; Everaert and Stienen 2007). In particular, flight characteristics have been shown to be one of the most important factors determining the likelihood of collision with power lines (Bevanger 1994; Savereno *et al.* 1996; Janss 2000).

In addition to anatomical differences, flight behaviour, such as the use of updrafts and thermals, habitual flight activity at dusk, dawn, or night, aerial display flights, aerial pursuit hunting or territorial disputes, and flying in flocks, also contribute to collision risk (Scott *et al.* 1972; Faanes 1987; Alerstam 1990; Alonso and Alonso 1999a; Richardson 2000; Larsen and Clausen 2002). Gregarious species that form flocks during the autumn and winter appear prone to collision. This is due to the greater concentration of bird movements and perhaps also to the relatively lower levels of attention and anticipation shown by birds when following the lead bird in a flock (Alonso and Alonso 1999a; Pettersson 2005). Bernadino *et al* (2018) examined the ratio of body mass (in g) to wingspan (in cm) is a proxy of wing loading. Species with high values for this ratio have low manoeuvrability in flight, and therefore, they are more susceptible to collision with power lines (Bevanger, 1998; Janss, 2000). Our method highlighted that the most susceptible species were large, long-lived and slow-reproducing birds, often habitat specialists with hazardous behavioural traits (especially flight height and flocking flight), with high spatial exposure to collision risk with power lines and unfavourable conservation status.

Flight height is clearly an important factor in collision and varies greatly, depending not only on species and behaviour, but also on topography, season, time of day and weather conditions. Flight distance also affects flight height, with local movements, such as between feeding and nesting or roosting areas, tending to be at low altitude. Generally a large range in flight altitudes is observed for any particular species. **Table 1** outlines the normal flight altitudes of a number of bird species as recorded at a Denmark windfarm (Noer *et al*. 2000). During migration flights most species use higher flight altitudes and are thus unlikely to be disturbed by the presence of the buildings at the proposed development site. Commuting flights between foraging grounds generally take place at a lower altitude (i.e. 0-5 metres) and thus could potentially encounter the buildings of the proposed development. At Ringaskiddy, this is likely to include Cormorants, ducks, some wader species and gulls. However flights such as this are likely to take place within the estuarine habitats (i.e. the open water or mudflats) and not over the site of the proposed development.

Table 1. Normal flight altitudes for bird species recorded at windfarm (Noer *et al*. 2000)

Species	**Flight altitudes 1- Birds which normally fly 0-5 metres; 2- Birds which normally fly 0-100 metres**	
	Migration Flights	**Foraging flights**
Divers	-	1
Grebes	1	1
Fulmar	1	1
Gannett	2	2
Cormorant	2	1
Dabbling ducks	2	1
Eider	1	1
Common scoter	1	1
Oystercatcher	2	1
Knot	2	1
Dunlin	2	1
Other shorebirds	2	1
Auks	1	1
Arctic skua	1	(2)
Terns	2	(2)

Gulls	2	1

Some attempts have been made to quantify the interspecific risk of wind turbine collision. While this is not entirely comparable to collision risk with static buildings, such as stacks, it does give some indication of relative species risk. **Table 2** lists the bird species of qualifying interest and conservation concern located within Cork Harbour SPA. The vulnerability to collision of each of these species, according to the European Commission Guidelines on Windfarms (2010) is also listed.

It is most notably the flocking species of Dunlin, Lapwing and Golden Plover which are at potential risk of impact. The higher risk identified for Common Tern is probably associated with their foraging behaviour during breeding seasons. Henderson *et al.* (1996) found that Common Terns making frequent foraging flights during chick rearing, are more susceptible to collision with overhead wires because they tend to fly closer to the structures at this time. It is speculated that the pressure to find sufficient food for chicks causes the adults to take greater risks. Other studies have also found that even among those species that are susceptible to bird-strike, not all individuals are equally at risk. Behavioural observations indicate different risk factors for birds, vary with species, age, stage of the annual cycle and behaviour (Langston and Pullan 2003; Smallwood and Thelander 2004; Everaert and Stienen 2007).

Table 2. Bird species of qualifying interest and conservation concern within Cork Harbour SPA

	Common Name	*Scientific Name*	Annex of EU Birds Directive	Vulnerability to Collision
Qualifying interests	Cormorant	*Phalacrocorax carbo*	n/a	1
	Shelduck	*Tadorna tadorna*	n/a	0
	Oystercatcher	*Haematopus ostralegus*	n/a	0
	Golden Plover	*Pluvialis apricaria*	Annex I	2
	Lapwing	*Vanellus vanellus*	n/a	2
	Dunlin	*Calidris alpine*	n/a	2
	Black-tailed godwit	*Limosa limosa*	n/a	1
	Bar-tailed godwit	*Limosa laponica*	n/a	0
	Curlew	*Numenius aquata*	n/a	0
	Redshank	*Tringa tetanus*	n/a	0
	Common tern	*Sterna hirundo*	Annex I	3
Special Conservation Interest	Little grebe	*Tachybaptus ruficollis*	n/a	0
	Great crested grebe	*Podiceps cristatus*	n/a	2
	Grey heron	*Ardea cinerea*	n/a	0
	Wigeon	*Anas Penelope*	n/a	0
	Teal	*Anas crecca*	n/a	0
	Pintail	*Anas acuta*	n/a	0
	Shoveler	*Anas clypeata*	n/a	0
	Red-breasted merganser	*Mergus serrator*	n/a	0

	Grey plover	*Pluvialis squatarola*	n/a	0
	Black-headed gull	*Larus ribundus*	n/a	0
	Common gull	*Larus canus*	n/a	0
	Lesser black-backed gull	*Larus fuscus*	n/a	0

4 = Evidence on substantial risk of impact, 3 = Evidence or indications of risk or impact, 2 = Potential risk or impact, 1 = small or non-significant risk or impact, but still to be considered in assessments, 0 = no risk.

3.5 Season

There appears to be a significant connection between season and bird-strike. This relates mainly to the seasonal movements of birds, with large mortality events often occurring during peak migration periods (Crawford and Engstrom 2001). Higher mortality at this time is perhaps also due to the lack of familiarity of migrant and over-wintering birds with the locations of obstacles, compared with resident individuals (Alonso and Alonso 1999a). This view is supported by studies at power lines, which show relatively low or even no fatalities among resident species (Alonso and Alonso 1999a), though not by other studies of collisions at wind turbines, which show that resident populations are also at risk (Hunt 2002; Hunt and Hunt 2006). Clearly, determining risk based on migrant versus resident status is not straightforward, and mitigating factors, such as familiarity with the presence of structures, must be weighed against factors, such as period of exposure and species (or individual) susceptibility. For some species, mortality is greater during the post-breeding period, when there are increased numbers of young and relatively inexperienced birds. For example, Grey Herons are more likely to collide with power lines in August–December, when first-year birds comprise more than 71% of the recorded mortality (Rose and Baillie 1989). Fischer and Kamal (2020) found that long-and short-distant migrants made up the bulk of bird-window collisions (85%) compared to resident species (15%) with the highest collision rates during autumn migration.

4. Cumulative impacts

The assessment of cumulative effects should be an essential component of the impact assessment of development proposals. Cumulative effects may arise for example, from the development of multiple wind farms or from individual wind farms in conjunction with other types of development. Impacts may operate at different spatial scales, from an individual breeding population or colony level to the bio-geographic population or flyway scale. Even where predicted impacts at a particular site are low, this does not necessarily mean that the cumulative impacts will be insignificant, particularly in landscapes with multiple small wind farms or where there are a few wind farms comprising a large number of turbines. For example, even relatively small increases in the mortality rates of breeding adults, or decline in productivity, could be significant for populations of some bird species, especially those which are long-lived with generally low annual productivity and long adolescence, notably seabirds, waders, wildfowl, raptors and soaring birds. This is particularly the case for species which are already rare or facing a number of other pressures from environmental changes and/or anthropogenic impacts.

The ESB Power Station Stack at Whitegate is located approximately 5km east of the proposed development with a height of 152m. Currently in the Cork Lower Harbour there are three existing wind turbines, and a further turbine has planning permission, with a maximum height of 150m.

The closest turbine is located approximately 400m south of the proposed stack for the Ringaskiddy Resource Recovery centre at the DePuy facility (Loughbeg). The other constructed wind turbines are located at GlaxoSmithKline (Curraghbinny) and at Janssen (Barnahely) located 1.7km and 2.5km from the proposed Indaver stack respectively. Another permitted, but unbuilt, wind turbine has been proposed for close to the Novartis pharmaceutical plant at Barnahely, 2.5km from the proposed stack at the Indaver site. The built turbines themselves are separated from each other by distances ranging from 1.7km to 2.5km and all turbines are in excess of 5km from the ESB Power Station Stack at Whitegate. When the Novartis Turbine is constructed it will be approximately 700m from the closest existing turbine at Janssen and in excess of 5km from the ESB Power Station Stack at Whitegate. De Puy are proposing to construct a new 3MW turbine on their site at Loughbeg, Ringskiddy. The proposed turbine will be similar in appearance to the existing 3MW turbine on the site. The proposed turbine will be located to the south of the existing turbine, and approximately 1km from the Indaver site.

No previous cumulative effect has been identified in Cork Harbour area from the existing and/or permitted structures and from the ESB Power Station Stack at Whitegate. The existing turbines in the lower harbour are located a considerable distance apart from one another. The stack at the Indaver site is static in nature and therefore poses a significantly lower collision risk than the wind turbines. Therefore there will no cumulative impacts on the Cork Harbour SPA as a result of the Indaver stack.

5. Summary

A number of published reports have voiced concern over the potential of buildings to negatively impact on bird populations, directly through collision mortality and indirectly through disturbance and displacement. Putting such bird-strike mortality in context is crucial to understanding its impact on bird populations. However, despite widespread public attention and more than five decades of research, measures of anthropogenic sources of mortality for birds remain speculative.

Several unique factors have been identified which affect the risk of bird-collision with manmade structures. These include building height, lighting, and location of structure, season and interspecific behavioural differences.

Although there are few published studies of the effect of tower height, there is evidence to suggest that towers lower than 60 m to 150 m pose a lower risk to migrating birds. Tower lighting also appears to be a significant variable, however evidence for the effects of red versus white lights is contradictory. In spite of general consensus to the contrary, few or no published papers or recent databases can substantiate that white strobe lights are less of a collision risk than other colour or types of light. A number of studies suggest that light intensity and flash duration are more significant than colour: the longer the period between flashes of light, the less likely birds are to be attracted or disoriented. It is likely that any light source visible to humans is also visible to birds and may therefore represent a potential hazard.

Recent radar studies at Cork Lower Harbour have identified a number of distinct flight patterns between local bird foraging grounds. The location of the proposed structure, although adjacent to the Cork Harbour SPA, is not located within a distinct flightpath.
However a number of species which use the Cork Harbour SPA are vulnerable to collision. These include Dunlin, Lapwing, Golden Plover and Common Tern.

6. Conclusions

Based on the above the final conclusions of this report are as follows.

i. The location of the proposed stack at Ringaskiddy Resource Recovery centre, is located 500m from the Cork Harbour SPA and is not a significant roosting area, flight line or migratory path for the birds using the SPA.

ii. The proposed stack height is relatively low, at just 75m OD (height of 70m), a height which has been shown to pose less collision risk than higher wind turbines and communication towers. Migratory flights over the area, would generally be at a height too great to encounter the stack, thus reducing the collision risk.

iii. The static nature of the stack, compared to wind turbines, means it would pose a much lower risk of collision.

iv. The top of the stack will be indicated by white strobe (flashing) obstacle warning lights. The lights will be incandescent or of a type visible to Night Vision Equipment. The lights will emit light at the near infra-red (IR) range of the electromagnetic spectrum specifically at or near 850 nanometres (nm) of wavelength. Light intensity to be of similar value to that emitted in the visible spectrum of light.

The literature review indicates that, while any light source has the potential to attract birds and therefore increase collision risk, flashing lights are involved in significantly fewer collisions that continuous lights. There is also some indication that white lights are less attractive than red lights, although the results to date are inconclusive. While bird vision does differ from human, on the lower UV end of the spectrum, IR light is also invisible to birds. Therefore the proposal for a combination of white flashing and IR lights on the stack, is the most favourable choice and is unlikely to pose a significant collision risk to birds. However, it is noted that all lighting increases collision risk.

v. The existing turbines in the lower harbour are located a considerable distance apart from one another. The stack at the Indaver site is static in nature and therefore poses a significantly lower collision risk than the wind turbines. Therefore, there will no cumulative impacts on the Cork Harbour SPA as a result of the Indaver stack.

vi. Based on the findings of the literature review and the details of the proposed development, the overall collision risk posed by this development is low and will not have a significant effect on the qualifying interests of the Cork Harbour SPA.

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