AN BORD PLEANÁLA

Ref 04.PA0045

REPORT REGARDING AVIATION SAFETY AT PROPOSED WASTE TO ENERGY PLANT

RINGASKIDDY, Co CORK

PREPARED AT THE REQUEST OF: INDAVER

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1. BRIEF CURRICULUM VITAE

1.1. My name is Graham Liddy. I am a self-employed consultant in the area of aviation safety. I hold a Dip Eng, awarded by Dublin Institute of Technology in 1969 and an MSc in Air Transport Safety and Accident Investigation awarded by Cranfield University in 2011. I am a Chartered Engineer and Fellow of Engineers Ireland, a Fellow of the Royal Aeronautical Society of London and a member of the International Society of Air Safety Investigators. After graduation in 1969, I joined SPS as a research engineer and was later promoted to Technical Manager. In 1973, I joined the Air Corps as an aeronautical engineering officer. I held a wide variety of technical positions in the Air Corps and retired in 1995 with the rank of Commandant. On leaving the Air Corps, I joined the newly-formed Air Accident Investigation Unit of the Department of Transport. While with the AAIU, I was the Investigator-in-Charge of more than 100 accidents and serious incidents investigations and I participated in more than 400 other investigations, including the Poolbeg event referenced in the DoD submissions. When I retired in 2012, I was the Deputy Chief Investigator and Chief Engineer of the Unit. Since then, I have been a self-employed aviation consultant. Starting the 1960's I was a glider pilot for some 25 years, attaining the rating of Chief Flying instructor.

2. INSTRUCTIONS

2.1. On 15 April 2017, I was contacted by Indaver and requested to review An Bord Pleanála's Request for Further Information and the submissions made by the Department of Defence (DOD) in relation to aviation safety issues with regard to a proposed waste to energy plant at Ringaskiddy, Co. Cork.

2.2. I visited the Indaver waste to energy plant near Duleek, Co Meath on 20 April 2017 and the site of the of the proposed plant at Ringaskiddy, and the surrounding area, on 21 April 2017.

3. INTRODUCTION

3.1. BACKGROUND

3.1.1. Indaver have applied for permission to construct a waste to energy plant at Ringaskiddy Co Cork. An Bord Pleanála is currently considering the application and has made a request for further information.

3.1.2. I have been asked to give my expert opinion regarding aviation safety specifically in response to An Bord Pleanála's letter, dated 20 March 2017, and the two DOD submissions, dated 22 April 2016 and 11 May 2016.

4. SUMMARY

4.1. Based on my years of involvement in aviation, helicopter operations and aviation safety investigation, it is my opinion that the proposed waste to energy plant at Ringaskiddy does not pose a threat to the safety of Air Corps helicopter operations conducted in the area of the Naval Service (NS) base at Haulbowline, Co. Cork and near Spike Island in Cork Harbour.

4.2. I believe that, the DoD's objections notwithstanding, the proposed facility poses no threat to aviation navigation or safety.

4.3. The key finding of my report are:

- There are no circumstances which would require a landing or departing helicopter to fly through the dangerous section of the Indaver plume.
- The dangerous section of the plume from the proposed stack is of very limited extend, being only 3.5 meters both horizontally and vertically, and would not be entered into by a helicopter using normal obstacle clearance precautions.

- There are already significant limits on NS operations in this area of this plant, caused by existing obstacles, No-fly zone (see Appendix G) and the unsuitability of the terrain in the event of an emergency. The proposed plant will not require the imposition of any further operating restrictions on helicopter operations at the NS base

4.4. I will also address the specific points raised by An Bord Pleanála in their letter of 20 March 2017 to Indaver Ireland (ref 04.PA0045)

4.5. There are other matters in relation to these objections which will demonstrate that helicopter operations can be safely conducted in the general vicinity of exhaust stacks such as that in the proposed waste to energy plant.

4.6. I will also introduce other matters which may assist An Bord Pleanála in reaching a decision.

4.7. Finally, I will include a personal statement which I consider to be of some importance in this case.

DOD SUBMISSIONS

5. DOD SUBMISSION 22 April 2016

5.1. I have attached this DOD submission with my own referencing system superimposed as Appendix A to this report, as the original paragraph numbering in this submission was incomplete.

5.2. Section 1. Exhaust Plame Danger

5.3. Para 1

5.3.1. The proposed stack is of relatively power low output (18.5 MW). As a result, the amount of emitted exhaust gases, in relation to exhaust stacks generally, and other stacks within the general area of the NS base, is relatively low. For example, the stacks

at Aghada and Whitegate, 4 km for the NS base, have a power output of 435 MW and 445 MW respectively[1], which is 23 and 24 times larger than that of the proposed stack. The Stack Actual Volume Flow output of these stacks is 14 and 21 times larger than that of the proposed stack. Appendix B shows the source document for these figures. These is no record of a DOD objection to either of these stacks or that they put in place a safety restriction zone around them for aviation safety reasons.

5.3.2. It should also be noted that the outputs of NS ships are of the same order of magnitude as the proposed plant, with LE Eithne having an output of 5.1 MW and LE Samuel Becket having an output of 10 MW, which is 30% and 55% of the proposed plant output, respectively. Air Corps helicopters operate in close proximity to these ships both at the NS base and elsewhere, on a routine basis. Admittedly, the ships will probably not be operating at full power during such operations, but the helicopter will approach within 10 meters horizontally and 5 meters vertically of the exhaust stacks on these ships, even when carrying underslung loads. Such operations are discussed in greater detail in Appendix C.

5.4. Para 2: accident at Poolbeg ESB power Station on 11 Sept 2002

5.4.1. This paragraph refers to an accident resulting from the engine stoppage of a Agusta JetRanger, registration EI-BKT, which occurred at Poolbeg ESB power Station on 11 Sept 2002. I am very familiar with this event as I was the Inspector-in-Charge (IIC) of the Air Accident Investigation Unit (AAIU) investigation and I was responsible for investigating this event. As IIC, I received a copy of the movie camera on board the helicopter which recorded the entire event. This film clearly showed that the helicopter approached very close to the top of the stack, being in the worst possible position, less than 40 meters horizontally and 10 meters vertically above the stack when the engine stopped. Furthermore, it should be noted that the JetRanger is a

[1] The power output of a generation station is a general indication of the amount of fuel it consumes, which in turn is a general indication of the volume of the output of exhaust gases.

small single engine helicopter powered by a very small gas turbine engine (420 Horse Power (HP) vs two engines each of 1,531 HP on the Air Corps 139 helicopter). Such smaller gas turbines are more susceptible to engine stoppage due high moisture intake and depleted oxygen levels.

5.4.2. The power output of the Poolbeg stack is 13 times that of the proposed plant, which means that the emissions are of a far greater scale.

5.4.3. I interviewed the pilot of this helicopter after the event. As clearly stated in the report, he was under the mistaken impression that the stack was not in operation at the time of the event, and I believe that he would not have made this close approach if he was aware that it was active.

5.4.4. Approaching the physical obstruction of the Poolbeg stack this close was a violation of the Irish Aviation Authority (IAA) Rules of the Air and is discussed in Para 5.5.2.

5.5. Para 3

5.5.1. The first three sentences of this paragraph are correct. However, there is no evidence to support the last sentence. In particular, the statement that "*a helicopter pilot would have to assume a danger area around a chimney and up to 1,000 ft above a chimney*" is incorrect. In neither my report as published on the AAIU web site[2] (Appendix D) nor in the Irish Aviation Authority (IAA) Aeronautical Information Circular (AIC) Nr 4/03 01 Jan, which can be found at the end of Appendix D, were any clearance figures given. Because of the huge variation in stack size and emission levels, I deliberately abstained from being prescriptive in my report of the time, as regard to recommended separation distances. In this regard, it may be noted that the stack at Poolbeg (Stack B in Appendix B) has much taller than the Ringaskiddy proposal (207 meters vs 70 meters), has a power output 13 times that of Ringaskiddy and has more than 5 times

[2] The AAIU report can be found at: http://www.aaiu.ie/sites/default/files/report-attachments/4571-0.pdf

the Stack Actual Volume Flow. The very fact that the Poolbeg helicopter was able to approach to within 40 meters of the stack before developing a problem, clearly indicates that the 1,000 ft (300 meter) figure used by DOD is not correct.

5.5.2. The DOD submission did not include the final line in the IAA AIC which states (and is very important): "*Encounters with such gas plumes should not occur where the aircraft is otherwise in compliance with the Rule of the Air in relation to vertical and horizontal separation from structures."* This means that the IAA consider that if the separation clearance of 150 meters (500 ft) is maintained from stacks, then the aircraft will be safe. Part II, Para 3 section 1b of the IAA S.I. No. 72/2004 - Irish Aviation Authority (Rules of the Air) Order, 2004. (Appendix E) details the required Rules of the Air separation. Therefore the 1,000 ft figure given in the DOD submission is incorrect. I suspect that they have misapplied Rule 3.1(a)(ii), whereas Rule 31(b)(i) was the IAA's intention. This is because the potential danger posed by a stack is independent of its location in congested or other areas (Ref Appendix E). The IAA requirement is that 500 ft is the general obstacle clearance requirement, not the 1,000 ft limit for congested areas. DOD have incorrectly applied the 1,000 ft limit criteria.

5.5.3. In this regard, it may be noted that the IAA have a low-level corridor across Dublin City for Visual Flight Rules (VFR) air traffic. The eastern end of this corridor starts at the Poolbeg chimneys. This means that the IAA considered it safe to fly by these stacks when the standard clearance of 500 ft was observed. It may be noted that it was impossible to fly over these stacks with the 1,000 ft clearance indicated in the DOD submission, because the stacks are 678 ft high and the maximum permissible altitude for VFR air traffic in this area was 1,500 ft, (in the years when the stacks were operational) giving a maximum legal clearance of only 822 ft. Given that the outputs of these stacks were several multiples of the Ringaskiddy proposal, the logical deduction must be that the it would be safe to approach considerably closer to the Ringaskiddy stack.

5.5.4. It is also noted that the IAA have not found it necessary to impose a no-fly restriction, other than the normal 500 ft required for obstacle clearance under the Rules of the Air

around/above any stack in Ireland, notwithstanding that the output of some of these stacks is 24 times more than that of the proposed plant. This indicates that the IAA do not consider the exhaust plumes from such stacks to be a hazard if the Rules of the Air obstacle clearance limits are observed.

5.6. Para 4

5.6.1. The DOD summarisation of the United States of America (USA) Federal Aviation Agency (FAA) Report[3] is not representative of the finding of the study. The findings of the study are best summarised in the opening abstract of the report, which states in the penultimate sentence: "*As a result of this assessment, the risk associated with plumes is deemed acceptable without restriction, limitation, or further mitigation."* The final sentence advises training and awareness of this acceptable risk: "*However, to further lower the already acceptable risk associated with the overflight of vertical plumes, the team recommended the continuance of training and awareness programs that have been successful with similar hazards of acceptable risk levels"* The full page containing the report abstract is shown in Appendix F.

5.6.2. I wish to refer to specific points raised in this study

5.6.3. The FAA Study considered there be an accident possibility below 1,000 ft for high velocity stacks, (second para, page 15). The stack velocity of Ringaskiddy is relatively low, compared to other stacks in Ireland (ref Appendix B). There are stacks in the USA where the vertical stack velocity exceeds 150 meters per sec (10 times that of Ringaskiddy). Thus, the scale of the potential problems facing pilots in the USA is much greater.

5.6.4. In this regard, it should be noted that vertical velocity is not the only factor affecting the potential vertical extent of exhaust plumes. The thermal buoyance of the emission

[3] Safety Risk Analysis of Aircraft Overflight of Industrial Exhaust Plumes; Safety Study Report DOT-FM-AFS-420-06-1 Dated Jan 2006. This document is available at: http://www.tc.faa.gov/its/worldpac/techrpt/afs420-6-1.pdf

and the momentum of the plume, which in simple terms dictate how above/far from the stack the plume will be of significance, are influenced by a range of factors including the power output, stack diameter etc. In Appendix B, the relative thermal buoyancy and momentum flux of the Ringaskiddy plant are compared to other Irish stacks, including the nearby stacks at Aghada and Whitegate. The two right-hand columns of Appendix B clearly show that the Ringaskiddy plant would not be considered a significant hazard in relation to other Irish stacks and definitely not of importance in terms of the FAA report.

5.7. Para 5

5.7.1. The FAA Report states that the current risk (without amending procedures) from exhaust plumes is of the order of 10^{-9} (1 in 1,000,000,000) The acceptable risk is aviation is internationally accepted at 10^{-7} (1 in 10,000,000). The FAA recommendations are aimed at making a potential hazard, which is currently 100 times safer than the requirement, even safer (Page iv Ref 1). The FAA report does not consider exhaust plumes to be an unacceptable hazard. In this regard, it must be noted that aviation is a hazardous activity. Safety is ensured by controlling the risk to an acceptable extent. The FAA Report, (Reference 10.1) has concluded that this acceptable level, is achieved and exceeded by a factor of 100 in relation to exhaust plumes. The FAA Report specifically refers to the hazard posed at airports. The distinction between airports and helipads is an important point, which will be dealt with in detail, when considering the second submission from DOD, ref Para 6.25.

5.8. Para 6

5.8.1. The NS have already imposed local restrictions on helicopter operations over the Maritime College, (which is adjacent to the proposed plant), Cobh, Aghada, Whitegate and other areas in Corks Harbour. Air Corps helicopter detachment commanders have informed me that they were given a briefing map which showed a number of no fly zones in the Cork harbour area. These included the Maritime College area, Cobh, Aghada and Whitegate villages among others. These restricted areas are shown as the white bound areas in Appendix G, which is an approximation of the extend of these

areas, based on the recollections of these detachment commanders. The actual current map of the zones could be obtained from DOD. The purpose of these restricted areas may be to avoid noise disruption in these area, to prevent underslung loads being jettisoned down onto an inhabited area in the event of helicopter instability when carrying underloads, or to prevent a helicopter crashing onto inhabited areas in the event of a serious failure. I cannot see how approval for this plant would restrict operations further than they are already.

5.8.2. There are already a multitude of other hazards in the area of the proposed plant, as shown in Appendix O, which already makes it an area to be avoided by helicopter pilots. In my expert opinion, the area is a safety hazard and to be avoided in the interest of aviation safety. I have discussed the matter with retired Air Corps pilots who have extensive experience of operations with the NS at the Naval base and Spike Island. They were adamant that the area in question was a recognised safety hazard and to be avoided in the interest of aviation safety. Their prime concern was the numerous existing obstacles in the area, especially the profusion of power lines, the nearby wind turbines, the Maritime College and the total unsuitability of the area for performing a survivable forced landing, in the event of an in-flight emergency. Consequently, this area is already a no-go area for helicopter pilots. Therefore, I cannot understand DOD objection regarding a restricted area around the proposed plant, when one already exists nearby by virtue of the already imposed restricted area around the Maritime College, and also the avoidance of this area already imposed by pilots due to air safety considerations in respect to the current obstacles and configuration of the area.

5.9. Para 7

5.9.1. This refers to obstacle lighting of the exhaust stack. This has already been agreed by Indaver. Therefore, I see no reason for further discussion. However, in this respect it is

worth noting that DOD made no objection to the nearly Wind Turbine A[4]. While the central pylon on this turbine features an obstruction light, there are no lights on the 50-meter radius blades mounter on this pylon. Consequently, these is a large rotating obstacle, completely unlit, located only 389 meters from the proposed stack. As these blades extend 75 meters above the top of the stack (twice the height of the stack), it is difficult to rationalise DOD objections policy in terms of aviation safety, i.e. their failure to object to the wind turbine, especially as it is a largely unlit obstruction, with their objections to the current proposal, on aviation safety grounds.

5.10. Para 8

5.10.1. Not an aviation issue. No comment

6. DOD SUBMISSION 11 May 2016

6.1. I have attached this DOD submission with my own referencing system superimposed as Appendix I to this report.

6.2. Para 1

6.2.1. Nothing relevant to this paper

6.3. Para 2

6.3.1. Again, little of relevance to the substance of this paper, except to note that according to the international classification for helicopters, the Agusta 139 is not a large helicopter. The international classification for helicopters, and the relevant source of this information, is shown in Appendix J. From this, the Air Corps Agusta 139, with a

[4] Wind Turbine A is the large wind turbine located south of the proposed plant. It's Grid Reference is 79230, 63850. It is 1,528 meters south of the Main Square at Haulbowline. The blades of this wind turbine are twice the height of the stack of the proposed plant. It is one of 3 large turbines currently located on the mainland, in the sector of south to west of the NS base. Permission has been given for 2 more. These turbines are shown in Appendix O.

maximum operating weight of 6,400 kg in standard configuration (or 6,800 kg in cargo operations), is significantly below the minimum criteria for inclusion in the large category (9,000 kg), and should be considered as a medium class helicopter.

6.4. Para 3

6.4.1. There are many inaccuracies in this paragraph, and dealing with them will be somewhat lengthy.

6.4.2. It is inaccurate to imply that the Main Square is the main landing area at Haulbowline. The operational helipad is the Football Field at the eastern end of the Island. This is the helipad that is used for most operational helicopter missions conducted at the base. The reason for this appears to be a local instruction. Consequently, the Main Square is mainly used for overnight parking of the helicopter. This is because DOD has not provided a hangar at the main landing site, and overnight security of the helicopter is an issue at this location which is remote from other installations and centres of personnel location at the base. Therefore, the helicopter, if overnighting at the base, has to be flown from the operating area, the Football Field, to the Main Square. It is then normally flown back to the Football Field each morning. It is noteworthy that not even rudimentary helicopter facilities (the provision of a white circle with a large "H" at the centre or a windsock) are provided at the Main Square, in contrast with many other DOD installations throughout the county. Appendix K clearly demonstrates this. Consequently, it is inaccurate to presentation of the Main Square as an example of routine helicopter operations at the base.

6.4.3. The *"high recce*" is a standard procedure when approaching an unfamiliar landing area. However, I would not agree with the figures given, and they do not conform with observed Air Corps practice.

6.4.4. In relation to the *"high recce*, I will firstly give my own experience with regard to selecting a suitable site for landing in unknown areas. I have considerable experience as a glider pilot, having held a full instructor's rating and holder of the Irish altitude record. During my gliding years, I was faced with the difficulty of landing at strange locations at the end of a cross country flights or for other reasons, on upward of 25

occasions. Part of the procedure for performing such "out-landings" was a reconnaissance of the selected landing field. Initially a general area of potentially suitable fields was selected at a height of 2,000 ft. At 1,500 ft, a specific field was selected and a commitment made at 1,000ft. The next step was to ascertain:

- terrain slope,
- obstacles in the field,
- obstacles on the approach,
- the surface condition of the field
- The adequacy of the size of the field in the prevailing wind conditions.

6.4.5. In a glider, there is only one opportunity to do this recce adequately, there being no facility to do a go-around for a second attempt. The procedure was to fly across the top of the field (usually the upwind side of the field) then a downwind leg past the field, a cross wind leg downwind end of the field and then a turn onto the final landing heading. Throughout these 4 legs, the field was continually accessed. There 4 legs of the recce were conducted at 300 to 500 meters from the field. The reason was that it is simply impossible to make a realistic assessment from a distance further out. Consequently, I see little point in the recce circle conducted at a distance of 800 to 1,000 meters as described in the DOD submission.

6.4.6. I have examined and plotted a number of Air Corps air ambulance flights flown in recent days. These plots are shown in Appendix L. The cases in point include a mission to pick up a young boy who had been knocked off a bicycle in Quilty, Co Clare on 22 April 2017 and the second was another air ambulance mission flown to Knockalough near Kilmihil, Co Clare, on 23 April 2017, following a car accident. I also plotted the arrival of the first mission into Limerick Regional Hospital.

6.4.7. In both cases the casualty was picked up from road-side field, which would not have been previously reconnoitred by the Air Corps. In both cases the helicopter performed a series of concentric orbits similar to the procedure outlined in the DOD submission.

However, in both cases, the orbits were performed much closer in than that described in the DOD submission. Using the Google earth scale, the outer circles at Quilty was found to be conducted at a maximum radius of 460 meters and the inner orbit conducted at a radius of 205 meters. At Knockalough, the outmost point of the approach orbit was 620 meters and the two inner orbits were 400 meters from the landing point. This clearly shows that when confronted with landing in an unknown area, the recce circles are conducted much closer in than specified in the DOD submission, obviously for the same reasons that the glider approach was conducted at 400-500 metres – at a greater distance one is simple too far away to make meaningful observations. Therefore, the DOD contention that these orbits are conducted at 800-1,000 meters out from the landing area is at variance with what the Air Corps actually does in practice.

6.4.8. By contrast, it's worth considering the significantly different approach to the landing at a site with which the crew is familiar. For example, the approach to the landing pad at Limerick Regional Hospital. Here the helicopter was approaching a helipad with which the crew would be familiar, very like their familiarity with NS base at Haulbowline. In the Limerick case, presumably because they were familiar with the helipad, no recce circle was performed. This clearly demonstrates that the wide circling recce described in the DOD submission, does not in practice, occur when using landing areas that are familiar to the crew. If there were any cause for concern with a familiar helipad (clearly not the case in the Limerick landing) a close in recce may be conducted, to ensure that the area was free of small obstacles such as grass cutting machines, cars, etc. However, a recce which would bring the helicopter near the proposed plant would be ineffective (because would be too far out from the landing area), is not normally required because of aircrew familiarity with the NS base, and not standard Air Corps practice (in terms of the size of the circles flown), as evidenced by the landings at Quilty and Knockalough.

6.4.9. The statement in the DOD submission that take-offs and landings are made into wind is correct. However, the implication that they have to be made directly into wind is inaccurate. This is clearly demonstrated by Air Corps operations at their home-base aerodrome at Casement. Casement has two runways, giving four take-off directions,

230°/050° and 290°/110°. The wind can be as much as 60° off the runway heading (if the wind direction is 170°). As fixed-wing aircraft traffic is limited to runway heading, helicopters taking off and landing in other directions would lead to converting traffic and the possibility of collision. To avoid this, helicopters, in the course of normal operations, use the runways, or more frequently the parallel taxiways, for take-off and landing. Thus, normal operations are not operated directly into wind unless the wind direction happens to coincide with the actual runway/taxiway heading.

6.4.10. The Agusta 139 Flight Manual sets down the limits within which the 139 must be operated for full CAT A[5] procedures and normal take-offs and landings. With respect to take-off and landing, the relevant limits are zero tailwind and a maximum crosswind component of 20 Kts[6]. The standard take-off procedure is to observe the 20 kts crosswind component until an airspeed of 50 kts is achieved. When 50 kts airspeed is achieved, the helicopter can turn in any direction, irrespective of wind direction. This means that if the windspeed is 20 kts or less, the helicopter has an acceptable take-off sector of 180°, with the limiting factor that a tailwind must be avoided. If the windspeed is more than 20 kts, the appropriate crosswind factor must be applied. The chart for calculating the crosswind component, from wind speed and direction data, is given in Appendix M. From this the pilot can calculate how far off the wind direction he can fly, while still remaining within the crosswind limit. The table in Appendix M shows this information in tabular form. If taking off in a windspeed of more than 40 kts, the critical airspeed of 40 KIAS take-off safety speed (Vtoss) is already achieved while in the hover. Thus, in theory a pilot can depart the hover in any direction such wind conditions, but in practice, he will maintain a heading generally into the wind direction. If a general heading into the wind direction is maintained, the resulting climb angle will

[5] CAT A performance guarantee the helicopter can either safely land back at the take point in the event of a failure before the Take-Off Decision Point (TDP) or continue the take-off to a safe altitude in the event of an engine failure after TDP.

[6] Kts means Knots or Nautical Miles per hour. 1 kt equals 1.15 mph or 1.8 km/hr

be quite steep, due to the low forward ground speed in strong wind conditions. This considerably enhances the obstacle clearance capability, as shown in Appendix N.

6.4.11. It should be noted that a modest turn away from the direct into wind situation has little effect on the headwind component. A turn of 20° off the direct wind will only reduce the headwind component by 6.1%. Yet this turn of 20° would mean that a helicopter would be more than 400 meters clear when passing an obstacle which was 1,175 meters directly in front of the helicopter at take-off. 1,175 meters is the distance from the Main Square to the proposed stack. The distance from the Football Field to the stack is 1,350 meters.

6.4.12. The most limiting crosswind situation is when taking off into a wind just below 50 kts, where the crosswind component will rise to 20 kts (the limiting value), when the helicopter turns 21° off the wind direction. Thus, if the wind was coming directly from an obstacle directly in front of the helicopter, the helicopter can head 21° left or right of the obstacle. This means that the helicopter would be, 450 meters laterally clear of an obstacle, as it passes it, if the obstacle was 1,175 meters in front of the helicopter's take-off point. This minimum clearance would, in practice, be increased due to the headwind component reducing the forward component of the helicopter's ground speed, and the crosswind component, induced by not flying directly into wind, causing lateral drift away from the obstacle. The extent of this increased clearance cannot be exactly calculated as it is dependent on acceleration rates, the actual ground speed achieved and the rate at which ground speed increases.

6.4.13. It must also be noted that when there is a strong headwind component, the climb angle on departure is increased, as the same vertical speed of climb is maintained, but at a lower ground speed is reduced by the headwind. This is shown graphically in Appendix N.

6.4.14. The same arguments apply to landing. Again, landing directions at Casement are normally dictated by the heading of the runway in use, rather than the actual wind direction. Also, the crosswind limits permit quite a wide sector of acceptable approaches, while remaining within the within the prescribed crosswind limits.

6.4.15. In summary, as demonstrated by the operations at Casement, helicopters are not required to take off and land directly into the wind. Even in the worst-case situation (headwind of 49 kts), the pilot has very ample scope to avoid upwind obstacles by lateral deviation up to the crosswind limit. It is accepted that in a perfect world, take-off and landing directly into wind is preferable, but as the Flight Manual demonstrates, the Agusta 139 is well capable of operation outside the perfect world scenario, without risk increase. Helicopter pilots would also like to operate in a totally flat environment in a countryside free of electricity pylons, tall aerials and other obstacles. Helicopter manufacturers have successfully developed aircraft which can operated with safety in the real world, within a realistic operating envelope.

6.4.16. The final line of this paragraph of the DOD submission states that "Approx. 1-2 km is required for the departure climb-out, depending on wind strength." It is not correct that a clear run of 1 to 2 km is required for a safe departure climb out, as I will demonstrate:

6.4.16.1. Helicopter Flight Manuals give a great amount of performance data which shows how far after take-off an obstacle of a given height can be cleared. However, it should be noted that there are a very large number of variables involved. These include:

- Atmospheric temperature and pressure,
- Altitude above sea level (air density altitude)
- Helicopter weight
- The clear nature of the ground in front of the helicopter (how far along the take-off run it can remain in ground effect)
- Headwind component
- Crosswind component
- Terrain gradient

- Optional external equipment fitted (floatation bags, winch, engine filters, etc) which increases the drag and adversely effects performance.

- Etc etc

As a measure of the complexity of this issue, the CAT A performance supplement (No 12) to the Agusta 139 Flight Manual extends to 422 pages.

6.4.16.2. Due to all these variables, it has been found necessary to introduce simplified criteria so that pilots can determine if safe take-off can be accomplished. I do not have details of the current procedures laid down in the Air Corps ARM, as DOD has not made these available to the public. However, the UK Joint Helicopter Command, which covers helicopter operating standards for the Royal Air Force, the Royal Navy and the UK Army, has published such a simplified code with regard to take-off obstacle clearance, which they have found to be successful and safe. Note that this standard covers all helicopters operated by the UK armed services, including both medium helicopters of a similar size to the Agusta 139 and large helicopters, such as the Chinook.

6.4.16.3. The UK Joint Standards require that no obstacle within 500 meters of a take-off point should penetrate a 6° cone which starts at the take-off point. This is shown diagrammatically in Appendix P, which clearly shows that the Indaver stack is in compliance with these requirements. This standard is based on the principle that by the time the helicopter has reached the 500-meter point it now has sufficient height and speed to avoid any obstacle that lies beyond the 500-meter point. This procedure ensures that a helicopter will achieve a minimum altitude of 52 meters (172 ft) when it reaches the 500-meter point. If there is a headwind component, it will achieve a greater height by the time it reaches the 500-meter point.

6.4.16.4. For information, Appendix O shows the extent of 500-meter radius circles centred on the Main Square and Football Field respectively. These circles are significant in that, within the circles, the 6° cone must be clear (as per the Joint Standards), and when the helicopter has reached the 500-meter circle, it is capable of turning in any

direction to avoid obstacles outside the circle. It is clear that there is a large clearance between these circles and the proposed stack.

6.4.16.5. It may be noted that this 500-meter circle used by the Joint Standards encompasses the actual recce circles, as practiced by the Air Corps (ref Para 6.4.6), as opposed to the 800 – 1,000 meter recce circles described in the DOD submission.

6.4.16.6. If a helicopter continues at a 6° climb to a point 1,175 meters (the distance from the Main Square in Haulbowline to the proposed stack) from a take off point, it will achieve an altitude of 405 ft, plus the TDP altitude of 180 ft, giving a total of 585 ft, over the stack. As the stack is only 246 ft high, it will clear the physical obstacle of the stack by 339 ft. When it reaches the wind turbine (which is 1,528 meters from the Main Square) on the same climb out angle, it will be at an altitude of 526 ft plus 180 ft for TDP giving a total of 706 ft, giving a clearance over the blades of 214 ft. This is only 63% of the clearance achieved over the stack. While operation outside the 500-meter point is not part of these departure requirements, the point does clearly demonstrate that the wind turbine is the critical physical obstacle, not the proposed stack.

6.4.16.7. The distance from the centre of the Football Field to the ESB pylon on Rocky Island is 577 meters and the height of this pylon is 47 meters OD[7]. A take-off from the centre of the Football Field would start at a height of approximately 5 meters over Datum (OD). Consequently, a helicopter taking off from the centre of the centre of the Football Field would have to climb 42 meters in 577 meters to just clear the pylon. This represents an angle of 4.2°. From the centre of the Football Field to the proposed stack is 1350 meters and it is 75 meters OD. This gives a climb angle of 3.0°. This shows that the Rocky Island pylon is the significant obstacle, giving a steeper required climb angle, not the proposed stack. However, both are clear, being below of the 6° minimum climb gradient used by the Joint Standards

[7] OD means Over Datum, or, effectively, above sea level

6.4.16.8. When a plume safety distance of 3.5 meters (as per Para 6.27) from the top of the stack is considered, it is obvious that the plume effect makes no significant addition to the size of the obstacle formed by the stack.

6.4.16.9. Because of the very small danger area of the plume extending, at a maximum, 3.5 meters vertically and horizontally from the stack, a helicopter would have to be so close to the stack that the rotor blade tips would be in imminent danger of striking the actual stack. No extensive plume, that would be a danger to a helicopter, would be produced from this stack. Therefore, regardless of wind direction and helicopter flight path, a helicopter would not be at risk from the plume unless it was in imminent danger of physically colliding with the stack.

6.4.16.10. When the wind is from the south, the small plume from the proposed plant will be totally enclosed by the 5D turbulence zone coming from Wind Turbine A, as shown in Appendices O and P.

6.4.16.11. It should be noted that it is already impossible to fly up to 2 km (as per the final line of the DOD submission in their para 3) south of the Main Square, at this time. Such a flight, if operated at a shallow climb angle from TDP (less than 3.4°), would collide with the Wind Turbine A.

6.4.16.12. The photo below, looking generally south from the area of the Football Field, gives an indication of the present obstacles that are encountered when taking-off from the Football Field towards the general area of the proposed plant. Wind Turbine A can be seen, as can the high pylon on Rocky Island. The photo also shows the clear area of water in the left, towards the south-east, (which lies between the Ringaskiddy area and Spike Island) which would be the natural, obstacle-free flight path that a pilot would use when operating from the Football Field:



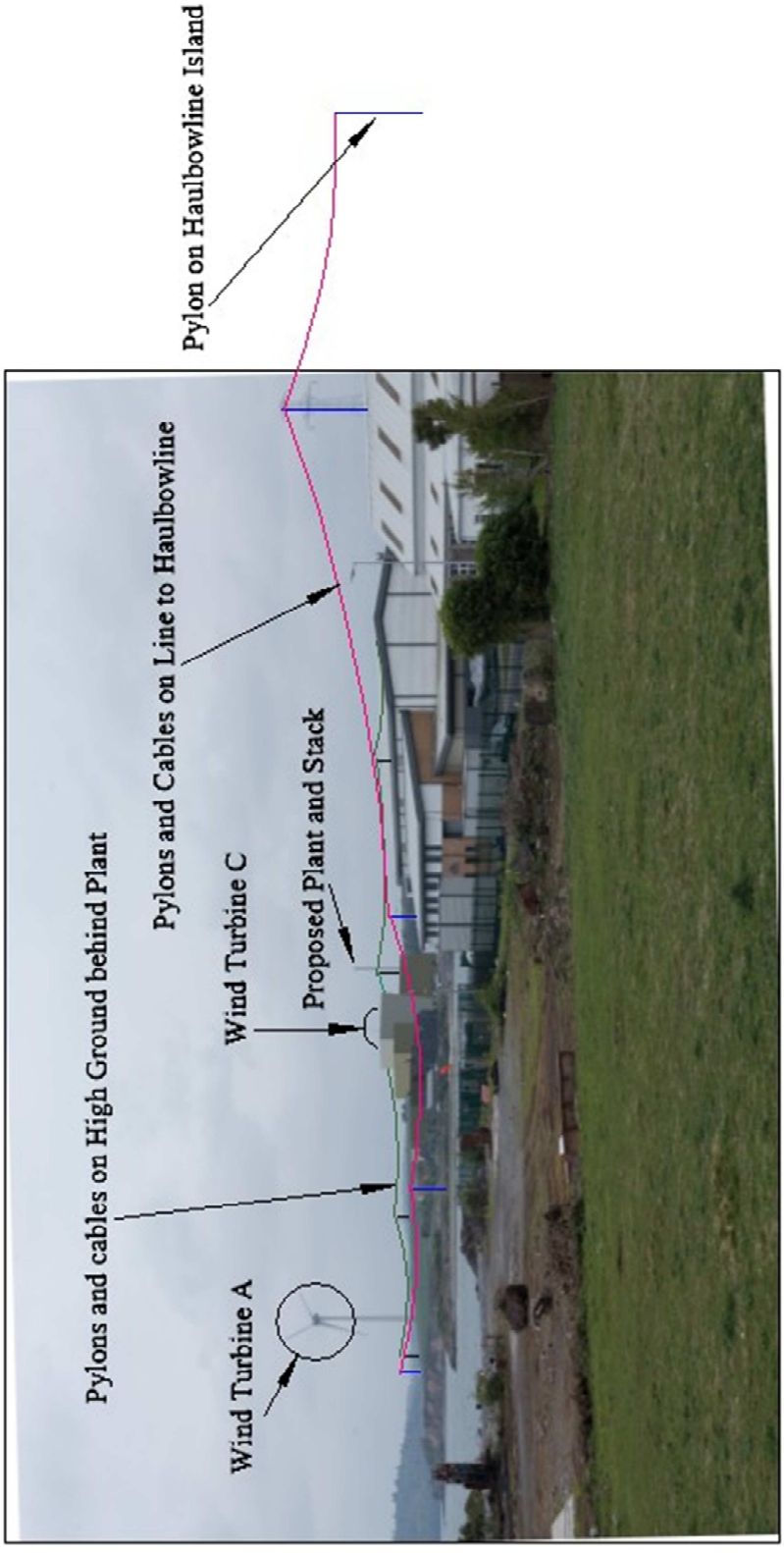
6.4.16.13. Below is a similar photo, but with a narrower view, also taken from the Football Field, which show the obstacles in the area of the proposed plant somewhat more clearly.



6.4.16.14. This is the same phots as that above, but with the proposed plant inserted to scale.



6.4.16.15. This is the same picture, but with the current obstacles enhanced for visibility. The location of all these obstacles can be seen in the image in Appendix O and the plan view diagram in Appendix P.



6.5. Para 4

6.5.1. The matter of engine failure is covered in detail in Para 7.2.2.2 below. This clearly shows that in the most critical situation, a vertical take-off from the Main Square location, that the Agusta 139 has no difficulty in clearing the proposed stack, even in the event of an engine failure.

6.5.2. The point regarding a shallower climb angle with one engine is factual, but as explained in Para 7.2.2.2, the stack does not present a problem even in the single engine configuration. However, the DOD submission does not take into account the existing Wind Turbine A directly behind the plant, which is the major obstacle on a take-off flight path toward the proposed stack. Not only is this turbine much higher than the stack (150 vs 75 meters), it is also poses a very wide obstacle (the diameter of the blade disk being 100 meters). Furthermore, it can produce dangerous turbulence extending closer to the NS base than the proposed stack. The matter of the unsuitability of this take-off direction is further increased by other factors. There is another obstacle posed by the power lines running at right angles to the flight path on the high ground behind the proposed plant. This will be further explored in Para 7.2.2 of this paper. Appendix P shows the situation diagrammatically.

6.6. Para 5

6.6.1. NS restrictions regarding operations from the Main Square means the under-slung load operations are not normally conducted from the Main Square. However, if they were conducted from that location, the prohibition on operations over the Maritime College, the procedure regarding slinging over built-up areas, the power lines behind the proposed stack, the wind turbine (both as a physical obstacle and a generator or turbulence) and the general unsuitability of the terrain in the area of the proposed plant in the event of an emergency, would ensure that no pilot would consider conducting underslung load carrying near the proposed plant.

6.6.1.1. Under-slung load operations from the Football Field would not head towards the area of the proposed plant for many reasons, which will be discussed in the following paragraphs.

6.6.1.2. The high power lines running from the mainland, from a point east of the proposed plant, to Haulbowline, and particularly the high pylon on this line located on Rocky Island, are much closer to the Football Field and required a much higher climb angle to clear them, compared to the more distance plant stack, as discussed in Para 6.4.16.7. This is clearly shown in Appendix P. The difficulty of seeing the connecting power cables on this line of pylons would require that these pylons and the cables be afforded an even wider clearance. It should be noted that when crossing these power lines, the standard procedure would be for the pilot to fly directly over the pylon, rather than the cables attached to pylons, notwithstanding that the cables dip somewhat. This is because a pilot can clearly see the pylon but the cables are much more difficult to see and it is also more difficult to determine distance from cables. By aiming to fly directly over the pylon and clearing it, the pilot can be certain that he is clearing all associated cables.

6.6.1.3. The row of pylons, running almost at right angles to a departing flight path towards the stack, located on the high ground immediately behind the proposed stack, and which are close to the stack height, present a very wide obstacle. The stack is a single point obstacle, whereas this line of pylons and their cables form an obstacle across the flight path and therefore cannot be avoided by a modest turn left or right.

6.6.1.4. The very high Wind Turbine A is located 343 meters further along the same flight path. If the helicopter's flight path is sufficiently shallow to have difficulties clearing stack, it will be impossible to clear the turbine blades.

6.6.1.5. Safety considerations indicate that conducting underslung load operations over Ringaskiddy or the Maritime College, which is very close to the proposed plant, should be avoided due to the possibility of having to jettison the load (with the consequent danger to life on the ground). I understand that the ARM cautions that underslung loads operations over built up areas are to be avoided where possible. Also, this area should be avoided to prevent the noise nuisance caused by the low, shallow, climb. This area is already a prohibited area for helicopter operations because of a local NS order. Therefore, a helicopter would never take-off with an intended flight path over the proposed plant due to the current obstacles in this area.

6.6.1.6. Turbulence from the wind turbine is a significant factor in the prevailing wind direction. Studies[8] indicate that the danger area, which extends 500 meters downwind of the turbine, should avoided and that turbulence can be expended up to 1,600 meters downwind of the turbine. The 500-meter turbulence zone which is 100 meters wide, completely encompasses the area of the proposed stack (Appendix Q). Turbulence is of particular concern during underslung load operations, as it can induce swings and oscillation of the load. This in turn leads to instability in the helicopter and poses a very sever threat to the helicopter. The only solution to this condition is to jettison the load.

6.6.1.7. Ref 10.3 also states that the turbulence from a turbine can extend up to 16 turbine diameters downwind of the turbine. While the turbulence from the 5-diameter point to the 16-diameter point is unlike to pose a danger to the helicopter, it has the potential to induce instability when conducting underslung load operations, which could result in jettisoning the load. As this 16-diameter zone extends right over the NS base, and thus this poses a much greater hazard to under-slinging operation compared to the stack exhaust.

6.6.1.8. For the above reasons, I am confident in believing that underslung load operations would not be conducted in the area of the proposed plant or that departures or approaches with underslung loads would not be made towards the site of the proposed plant, due to these existing restrictions and hazards.

6.7. Para 6

6.7.1. The proposed stack is directly south of Haulbowline. Therefore the exhaust plume would past a significant distance to the east of Haulbowline Island is the prevailing

[8] UK Civil Aviation Authority publication CAP 764 Policy and Guidelines on Wind Turbines. This document can be found at:
https://publicapps.caa.co.uk/docs/33/CAP764%20Issue6%20FINAL%20Feb.pdf
In this document, Page 33 indicates that a danger area of 5 rotor diameters exists for turbines of less than 30 meters' diameter, and states that research is still ongoing for turbines of greater than 30 meters diameter. In the absence of concrete research, the best estimate is that the danger area around a 100-meter diameter wind turbine would also be of the order of 5 diameters or 500 meters.

wind which is 37° West of due South. As has been previously explained, it is not a requirement to approach to land or to take-off directly into wind, as implied in the DOD submission. Furthermore, as explained in Para 6.27 of this paper, the plume will cease to be a threat to helicopters at a distance of 1,171 meters from Main Square in the worse possible case, i.e. when the wind is coming directly from the stack towards Haulbowline and the plume is at its maximum horizontal extent for oxygen depletion (3.5 meters from the stack).

6.8. From this point onwards, I will use the paragraph referencing notation used by DOD in their submission of 11 May 2016

<u>ARUP Report</u>

6.9. ARUP Report Para 1

6.9.1. This matter is already settled as noted in Para 5.9.1 above.

6.10. ARUP Report Para 2

6.10.1. The DoD stated that none of the existing obstacles affect landings or take-off from Haulbowline. This is not accurate. The Wind Turbine A, for example, is an obstruction much higher and wider than that of the proposed stack. The turbulence plume danger zone (500 m) from the wind turbine overshadows the exhaust plume of the proposed plant. The possible risk turbulence zone from the wind turbine (1,600 m) can extend completely over Haulbowline Island in a southerly wind and completely over Spike Island (the other area of concern noted by DOD) in south westerly wind.

6.10.2. The wind turbines also poses a significant hazard to Night Vision Goggles (NGV's used by the Air Corps in night operations. While the top of the proposed stack will be lit, only the central pylon of the wind turbine (at a height of 100 meters) is lit. There is no lighting on the blades, which extend 50 meters above, below and to either side of the central pylon. NGV's do not provide depth perception, so even if the unlit blades are visible on the NVG's, the pilot has no perception of how far away the blades actually are. In addition, there are many areas of lighting in the area behind the turbine. The blades will largely appear on the NGV's as dark surfaces moving in front of large

number of light pinpoints behind them. This will further increase the difficulties in seeing the blades and assessing the distance that they are away from the helicopter.

6.11. ARUP Report Para 3a

6.11.1. The DOD submission that the IAA Rules of the Air with regard to minimum en-route height clearance do not apply to military aircraft is correct. The applicable clearances are laid down in the Air Corps Air Regulations Manual (ARM). Having been involved in the investigation of accidents involving Air Corps aircraft, I have had access to the ARM. I can state that the height clearance limits in the ARM are generally in accordance with the Rules of the Air. The DOD contention that none of the Rules of the Air are applicable to the Air Corps is not correct. Rules about equipment required to be carried when entering controlled airspace, the requirement to get permission to enter controlled airspace, rules regarding which side of a ground feature a pilot must navigate along, are just some examples of rules of the Air that the Air Corps pilots must observe, as users of airspace that is inhabited jointly military and civilian aircraft.

6.12. ARUP Report Para 3b

6.12.1. The DOD submission is correct in its statement here. However, it must be stated that it is the pilot's responsibility, when taking off or landing, to avoid collision with obstacles or potential danger emanating from such obstacles.

6.13. ARUP Report Para 4

6.13.1. The adoption of a 1,000 ft clearance area around the stack is not warranted. The required clearance, when taking off and landing, is to remain outside the danger zone as discussed in para 6.12.1. The DOD describes the Agusta 139 as a large helicopter, which is not supported by the international classification for helicopters (see Para 6.3.1 and Appendix J). As discussed elsewhere in this report, the proposed stack and its exhaust plume does not pose a threat or restriction to Air Corps operations at the NS base. The points regarding take-off and landing requirement are dealt with para 7.2.2 and the issue of underslung loads was discussed in Para 5.6.

6.14. ARUP Report Para 4

6.14.1. There is a contradiction in the DOD submission in this paragraph. On one hand, they argue that the 500 ft clearance limit does not apply because the aircraft is taking off or landing, and because they are military and are not subject to the 500 ft clearance Rules of the Air requirement. Yet they advocate for the application of a significant safety clearance of 1,000 ft around a hazard.

6.14.2. Furthermore, the DOD does not adhere strictly to either the 1,000 ft or the 500 ft clearance. For example, Finner Camp in Donegal they erected a tall (approximately 45 meters [147 ft] high communications tower located only 290 meters short of the threshold of their runway and 100 meters to the right of the runway centre line. This means that an aircraft approaching the runway on a standard 3° glideslope was at only 50 ft high at the point where it passes by and 100 ft below the top of the aerial which was 100 meters to its side. This aerial is also only 150 meters from the designated helicopter pad at Finner. The aerial top is at an angle of 16° up from the helipad thereby piercing the 6° clearance cone used by the Joint Standards, ref para 6.4.16.3, and therefore it fails to meet the requirement of these standards. Similarly, the landing area at the Main Square at Haulbowline is surrounded on two sides by four high communications aerials with interconnecting cables, and a wire-stayed flag pole on high ground just behind the landing area. These examples clearly show that the DOD themselves do not observe the obstacle clearance limits that they wish to impose on other builders of infrastructure.

6.14.3. Furthermore, the Air Corps does operate regularly within a few meters of exhaust stacks which have an output of the same order of magnitude as the proposed plant. If DOD applied the stack clearance limits that they seek to apply here to their own ships, the missions that they now conduct with the NS would be impossible. The past capability of safely landing routinely on LE Eithne (with Dauphin 365FI helicopters, which had significantly more limited power reserves) would also have been impossible. I cannot see how, in view of these current and past operations, that DOD can argue that an avoidance zone of 1,000 ft *“is in fact very necessary”.*

6.14.4. The UK Royal Navy (RN) has a long history of mentoring the NS in ship-borne helicopter operations arising out of the development of the helicopter-carrying LE Eithne. The RN operates a large carrier, HMS Ocean, which can carry up to 18 helicopters ranging from smaller attack helicopters, to large helicopters including Merlins and Chinooks (ref Appendix C). This ship has two engines of a total power output of 35.6 MW, almost twice that of the proposed plant. The two engines exhaust into a single stack, with the top of the stack located half way along one side of the heli deck, approximately 18 meters above it. The RN has operated this vessel since 1998 and will continue to do so until 2019. The RN obviously have no safety concerns about operating these helicopter at close proximity to this stack. In light of this RN experience, the DOD stance on a 1,000 ft safety zone is untenable.

6.14.5. Appendix C shows relevant pictures.

<u>Access</u>

6.15. Para 6

6.15.1. Not an aviation issue. No comment

6.16. Para 7

6.16.1. Not an aviation issue. No comment

6.17. Para 8

6.17.1. Not an aviation issue. No comment

6.18. Para 9

6.18.1. Not an aviation issue. No comment

<u>WFAC Report</u>

6.19. Para 10

6.19.1. This matter has already been discussed in para 6.11 above.

6.20. Para 11

6.20.1. The DOD is not correct in the assertion that the *IAA's considerations do not apply to the DOD submissions.* The IAA are charged with the responsibility of the safety of all Irish airspace. The IAA define and publish airspace zones, act against infringements etc. The IAA do consider any special requirements formulated by the military. The IAA have issued special, unique, criteria to protect the airspace around Casement from drone activity. Drone operation in the Dublin Controlled Traffic Region (CTR), commonly referred to as a Control Zone, is permitted up to 50 ft in much of the Dublin CTR but only to 25 ft in R16 (the airspace zone surrounding Casement)[9]. The IAA has also created a very large area of restricted airspace, covering several counties, to protect military aviation training west of Dublin. Therefore, to dismiss the IAA consideration of the proposed plant, and their lack of objection to it, on the grounds stated in the DOD submission, is not correct.

6.20.2. The IAA and Cork Airport both have a legal duty to ensure that controlled airspace is maintained free of hazards, to the extent that a pilot observing the Rules of the Air with regard to minimum operating height and standard obstacle clearance limits will not be at risk. The Cork Control Zone extends over the area of the NS base and further east to a significant degree. Thus, the IAA and Cork Airport have an obligation to object to a project which would be a hazard to a pilot observing these limits. That neither the IAA or Cork Airport have objected is indicative that they do not consider aircraft to be at risk, from either the proposed stack, or its plume, if the aircraft is operated in conformity with the Rules of the Air obstacle clearance limits.

6.21. Para 12

6.21.1. Haulbowline lies well within the Cork CTR which extends, in a 15 nautical mile radius circle, centred on Cork Airport, from surface level to 5,000 ft. Consequently, Cork Airport and the IAA are responsible for all risks to all aviation within this block of

[9] Ref IAA Aeronautical Notice U.04 Issue 9 dated 20-12-2016

controlled airspace. They must consider other users of the airspace in the harbour area, including other helicopter operators. The Cork Airport authorities did not object to the proposed facility.

6.22. Para 13

6.23. The Rules of the Air issue has already been discussed in Para 6.11.1 above.

6.24. Para 14

6.24.1. The issue of the clearance limits, when an aircraft is taking off or landing, has already been discussed in Para 6.4.9 and subsequent Paras. The implication that a particular wind direction will require a helicopter to fly through the dangerous section of the exhaust plume was already been shown to be incorrect in Para 6.4.10 and subsequent Paras. Consequently, this point is inaccurate as there are no circumstances which would require a landing or departing helicopter to fly through the very small danger zone (extending 3.5 meters from the top of the stack) of the Indaver plume.

6.25. Para 15

6.25.1. This quote from the FAA comments refers to “Airports” and “patterns” as noted in the extracted quotation. The hazard identified is particular to airports, which by definition, have runways, which in turn define the approach and departure paths taken by landing and departing aircraft. On the approach, an aircraft is required to descend to the runway down a tight cone which extends vertically (“glide slope” which is nominally set at 3°) and laterally (localiser). As the aircraft approaches the runway, the cone narrows, so the actual physical distance that an aircraft can deviate from the ideal approach steadily reduces. By the point the aircraft is at approximately 1,200ft, it must be fully stabilised on the approach path. If the pilot has to make a lateral deviation from the flight path (for instance, to avoid flying through an exhaust plume close to/directly overhead the stack) the approach has become unstabilised and he must abort the landing and execute a go-around. Because the next approach will encounter the same problem, the pilot will not be able to land from subsequent approaches and must divert to another airport (or another runway at the same airport if one is

available and within his crosswind limits). What I have described here is a typical instrument approach. Similar difficulties would be encountered with a visual approach.

6.25.2. Similar restrictions apply to take-off. Standard practice is to maintain the runway heading until a height of at least 1,000 ft is attained. In the case of commercial aircraft, the go-around (aborted approach) procedure is to maintain the runway heading until 3,000 ft is attained.

6.25.3. The term "pattern" used in this FAA document refers to the controlled flight paths that aircraft must follow at such airports. Again, a pilot is not authorised to depart from these "patterns" or designated tracks. Therefore, if a pattern directs a pilot into a plume, the scope to avoid it is very little/non-existent.

6.25.4. The same tight lateral restrictions do not apply to a helicopter making an approach to a helicopter pad or taking off from one. As previously discussed in Para 6.4.10 and subsequent Paras, the pilot can use a wide sector when taking-off and landing, which is defined by the crosswind limits.

6.26. Para 16

6.26.1. This section of the DOD submission refers to a FAA Position Paper[10]. The conclusion in this paper is significant: *"After a thorough analysis, the FAA has determined the overall risk associated with thermal exhaust plumes in causing a disruption of flight is very unlikely. However, the FAA determined that thermal exhaust plumes in the vicinity of airports may pose a unique hazard to aircraft in critical phases of flight and therefore are incompatible. We recommend that airport owners, in cooperation with local communities, follow the guidance outlined in Advisory Circular (AC)150/5190-4, Airport Land Use Compatibility Planning."* The underline emphasis is mine. The FAA states that

[10] FAA position paper on Safety Concerns of Exhaust Plumes. The document can be found at http://www.aopa.org/-/media/Files/AOPA/Home/News/All-News/2015/FINAL2--AOSC-Position-Paper-Exhaust-Plumes.pdf

the risk is very unlikely and that the identified potential hazard is in relation to airports, not helipads (for the reason previously discussed in Para 6.25).

6.26.2. The above FAA document also refers to another FAA document[11]. This document contains the following: "*C. Section III should only include the airport zones applicable to the airport being zoned. An approach zone is applied to each end of each runway based upon the type of approach available or planned for that runway end. The most precise type of approach, existing or planned, for either end of the runway determines the primary surface width. Heliports do not have horizontal or conical zones. Other zones to accommodate the areas covered in FAR Par 77.23(a)(2) and (3) may be added."* Again, the underline emphasis is mine. The relevant point is the distinction that the FAA document makes between airports and helipads.

6.26.3. The DOD submission accepts that their helicopter would not hover over the stack, but argues that at approach speed 40 kts airspeed, the helicopter is almost hovering. The concept that 40 kts (46 mph or 73.6 km/h) is almost stationary is implausible. The only condition that an approach ground speed may approach zero is during strong wind conditions. However, the FAA doc Ref 3 states: "*The conditions which create the largest risk area are calm winds, low temperatures, and neutral or stable stratification of the atmosphere. The reverse is also true, windy conditions (greater than eight (8) knots) and warmer temperatures, the risk area is minimized".* Underlined emphasis is mine. Therefore, during strong wind conditions, where the approach ground speed will be reduced (ground speed equals airspeed minus windspeed when heading directly into wind), the wind will increase plume dissipation and minimise the risk. This situation occurs when the ground speed is less than 32 Kts (37 mph or 59 km/h) according to the FAA document (40-8=32). Therefore, if the helicopter is slowed down by a strong headwind, the rate of plume dissipation will also increase, minimising the

[11] FAA Objects around airports. This document can be found at:
http://www.nh.gov/dot/org/aerorailtransit/aeronautics/sasp/documents/TRappendixAC.pdf

risk. While this is perhaps of academic interest, it must be recalled that for the reason stated previously, helicopter pilots would not make approaches over the area of proposed plant, even if the plant was never constructed. This is because of the existing obstacles and hazards in the area. However, as the dangerous section of the plume only extends for 3.5 meters in all directions, and in all weather conditions (as per para 6.27.1), the point made here in the DOD submission is academic.

6.26.4. The case of the JetRanger at Poolbeg has already been discussed in Para 5.4. The event referred to in the end of this paragraph of the DOD submission was due to the pilot approaching the stack to an extent which violated the Rules of the Air and contravened the obstacle clearance requirement of the Air Corps' ARM.

AWN Report

6.27. Para 17

6.27.1. In his recent paper, "Request for Additional Information[12]", Dr Edward Porter has stated in the summary of his paper that the results of the analysis are as follows:

- Oxygen Content – within 3.5m of the stack the oxygen concentration will increase above the 12% risk level for oxygen.
- Temperature – the temperature of the plume will drop to less than 50°C within 3.5 metres of the stack.
- Vertical Velocity – the critical vertical velocity of 4.3 m/s will not be exceeded beyond 3.0 metres from the stack top.

Thus, the maximum extent of the risk zone of the plume for each parameter is shown below based on five years of meteorological data covering all meteorological conditions including pressure / temperature inversions:

[12] Paper "Request of Additional Information – Plume Modelling Assessment" by Dr. Edward Porter

Risk Zone for Oxygen – 3.5m

Risk Zone for Temperature – 3.5m

Risk Zone for Vertical Velocity – 3.1m

COMBINED RISK ZONE – 3.5M

6.27.2. This means that all the requirements for a safe operating environment for a helicopter (oxygen percentage at or more than 12%, temperature at or below 50°C and vertical speed of the exhaust is less than 5 meters/second) are met when the helicopter more than 3.5 meters away from the top of the stack.

6.27.3. These latest figures from Dr Porter make the DOD calculations that a clearance height of 1,075 ft above ground would be required to clear the stack, 230 ft above ground, obsolete and no longer applicable.

6.28. Para 18

6.28.1. The DOD submission only takes some extracts from para 7-5-15a of the Aeronautical Information Manual[13]. The full text is:

Flight Hazards Exist Around Thermal Plumes. Thermal plumes are defined as visible or invisible emissions from power plants, industrial production facilities, or other industrial systems that release large amounts of vertically directed unstable gases. High temperature exhaust plumes may cause significant air disturbances such as turbulence and vertical shear. Other identified potential hazards include, but are not necessarily limited to, reduced visibility, oxygen depletion, engine particulate contamination, exposure to gaseous oxides, and/or icing. Results of encountering a plume may include

[13] The US Department of Transport Aeronautical Information Manual can be found at: https://www.faa.gov/air_traffic/publications/media/AIM_Basic_4-03-14.pdf

airframe damage, aircraft upset, and/or engine damage/failure. These hazards are most critical during low altitude flight, especially during take-off and landing." The underlined emphasis is mine. The stack temperature of the Ringaskiddy is on a par with other stacks, while the stack velocity is lower. As already discussed in Para 6.27, vertical velocity and temperature of the Ringaskiddy plume reduced very quickly above the top of the stack. Therefore, the risk area is confined to a small area both above and laterally from the stack, and it will not pose a threat to helicopters operating from the NS base.

6.29. Final Comments and Conclusion

6.29.1. Rather than reiterate the specific point raised in this paragraph of the DOD submission, all of which I have dealt with individually previously in this paper, I wish to take an overview approach. As already pointed out, the area near the proposed plant is already an unsuitable area for helicopters operating from the NS base, for aviation safety reasons already outlined in this paper. Furthermore, the NS have already prohibited helicopter activity near this area.

6.29.2. Therefore, limits on NS operations in this area already exist and this plant will not require the imposition of any further operating restrictions on helicopter operations at the NS base. Therefore, the DOD contention that the plant would restrict operations at the base, that aviation activities including *"the areas of marine counter terrorism, joint Naval Service/Air Corps exercises including simulated attach, cargo slinging for the replenishment of ships at sea and so on"* would be compromised by the proposed plant, is without factual foundation. The argument, that due to aviation safety considerations, that this this plant would pose a threat to the security of the State is groundless.

6.29.3. The FAA approach in Reference 11.2 does not address the size of the stack, or the output rate of the facility. Again, the FAA approach in their later document[14]

[14] FAA Memorandum date 24 Sept 2014: Technical Guidance and Assessment Tool for Evaluation of Thermal Exhaust Plume Impact on Airport Operations. This document can be found at:

references indirectly (via the linked Mitre site) to the Martin Power Station near Morgantown, WV, which has (in 2005) a power output 23 times that of the Ringaskiddy proposal. As clearly shown in Appendix B, the proposed plant output at Ringaskiddy is quite small in comparison with other stacks (Aghada and Whitegate) within 5 km of the NS base and other stacks (including Poolbeg) in Ireland. All Irish stacks are small in comparison with the large facilities in the USA. Therefore, the Ringaskiddy plant would be tiny in comparison to the stacks considered by the FAA, such as the Martin Power Station. The particular concern of the FAA was the turbulence effect of an exhaust plume. The vertical exhaust velocity, allied with the thermal flux and momentum flux, of a plume are the best indicators of the potential of a plume to create turbulence. In this regard, as clearly shown in Appendix B, the vertical velocity of the Ringaskiddy plume, at the stack top, is about 50% of that of many other Irish stacks, including those at Aghada and Whitegate. However, when the other factors, the relative thermal buoyancy and the momentum flux (right hand columns Appendix B) are also considered, the ability of the Ringiskiddy to create turbulence is very low in comparison with other Irish stacks. The net effect of these three low values (initial vertical velocity, thermal buoyancy and momentum flux) means that the vertical velocity of the Ringaskiddy will reduce and dissipate very quickly as the plume ascends from the stack. Thus, the turbulence generated by the stack will reduce very quickly above the stack (within 3.5 meters as determined by Dr Porter, as per para 6.27.1).

7. SPECIFIC ISSUES RAISED BY AN BORD PLEANÁLA

7.1. On 20 March 2017, An Bord Pleanála asked Indaver respond to four questions. Indaver passed this letter to me for my observations. The Bord Pleanála's letter invited Indaver

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https://www.faa.gov/airports/environmental/land_use/media/Technical-Guidance-Assessment-Tool-Thermal-Exhaust-Plume-Impact.pdf

to respond to the submission from DOD dated 11 May 2016, and continues *" in any response you are requested to comprehensively address all matters relating to the navigation and safety of helicopters using the naval base, but not limited to, the following:*"

7.2. The letter went on to list the four questions:

7.2.1. Question 1 *"the matters raised by the Department of Defence*"

7.2.1.1. I have responded comprehensively to the two DOD submissions in Para's 5 and 6 above.

7.2.2. Question 2 *"Low Gradient flight paths on take-off and landing at the naval base"*

7.2.2.1. This question needs to be dealt with in two parts: flights from the Main Square and from the Football Field.

7.2.2.2. <u>Flights from the Main Square:</u> The Agusta 139 is a powerful twin engined helicopter with a good power to weight ratio. This gives it good performance during a normal departure and gives it the ability to continue to fly in the event of a single engine failure. Because the Main Square is surrounded by buildings, aerials and other obstacles, the helicopter must initially climb vertically out of the Main Square. For many helicopters, even many twin engine helicopters, an engine failure during such a vertical departure would result in the helicopter descending back to the surface very rapidly and the consequence would be a serious accident. However, because of its good single engine performance, the Agusta 139 is classified as a Cat A performance helicopter. This means that in the event of an engine failure, it can either continue to take-off or land safely back at the take-off point. By adopting the following procedure, the pilot will always have the option of either landing back on the original take-off point, or flying away safety. The initial climb is done vertically. Once the helicopter is sufficiently clear of obstacles behind it, it flies slowly backwards (downwind), but still continuing to climb. It reaches the point known as Take-off Decision Point (TDP). If an engine failure occurs before TDP, the pilot has enough power on the remaining engine to make an inclined, cushioned, descent back onto the helipad and land safety. When

he reaches TDP, he now had enough height to accelerate and reach Take-off Safety Speed (Vtoss) which is 40 kts for the 139. There is always some height loss in this acceleration phase, which is one of the reasons to allow 120 ft margin above the highest obstacle. Another reason is to avoid downwash damage, where the obstacle is a building or similarly vulnerable structure. Having attained Vtoss, he continues forward and commences to climb. The climb gradient of an Agusta 139, with one engine inoperative, at a weight of 6,400 kg (maximum take-off weight) is 18 ft climb per 30 meters of horizontal flight on a hot Irish day (20°C), with zero wind. For operations in the Main Square, the normal procedure would be to climb to a height of obstacles around the helipad plus 120 ft. In the case of the Main Square, taking the height of the obstacles to be 60 ft above sea level, this would require an altitude of 180 ft at TDP. This means that in a zero wind condition the helicopter will achieve altitude of 870 ft when overflying an obstacle located 1,175 meters from the take-off point. This is actually academic, because in a zero-wind situation, he can climb away in any direction. In a 20 kts headwind, coming directly from the direction of the stack, the climb gradient will be steeper due to the reduced ground speed (in fact the climb angle would be doubled). Even this situation is academic, because at 20 kts headwind he still has a take-off sector of 180°, and no requirement to head directly to the stack. Therefore, the foregoing clearly demonstrates that even in the worse possible situation, the stack does not pose a threat to a departing Agusta 139. Appendix H shows this Take-Off Procedure diagrammatically.

7.2.2.3. Flights to the Main Square. Much the same concepts apply to a landing approach for a Cat A helicopter. Here a Landing Decision Point (LDP) will be substituted for the TDP. The LDP is a point again at height of the highest obstacle surround the Main Square (60 ft) plus 120 ft, giving an LDP of 180 ft. The LDP is located downwind of the helipad at an angle of about 45°. This allows the pilot to keep the helipad in view at all times in the approach, through the lower vision panels in the nose of the helicopter. In the event of an engine failure below the LDP, he has enough power to cushion the descent and to move the helicopter forward to land on the landing pad. Alternatively, if he is at or above the LDP, he is high enough to abort the landing and to execute the single engine fly away, as described above for the take-off situation. In order to get to the

LDP, a helicopter has a wide range to approach points and descent profiles, none of which would require him to go anywhere near the proposed stack or its plume. Appendix H shows this Landing Procedure diagrammatically.

7.2.2.4. Flights from the Football Field. Because of the lower obstacles at this location, the pilot has the option of lifting off to a height of about 5 meters and then accelerating in ground effect to V^{toss}, or conducting a full CAT A take-off as previously described. In the case of the low take-off profile, the more immediate obstacle posed by the high pylons and cable running from a point west of the proposed plant on the mainland, via the very high pylon on Rocky Island and ending with the final pylon on Haulbowline close to the end of the bridge. These pylons and cables are closer to the Football Field and would have to be cleared in any take-off from the Football Field toward the plant. Because they are closer, these obstacles will determine the minimum climb out angle, not the proposed plant. Thus, the plant will not the limiting factor in low gradient departures towards the plant site. The situation is shown diagrammatically in Appendix P.

7.2.2.5. Fights into the Football Field. The previous points made with regard to flights into the Square with respect to obstacles and terrain in the area of the plant also apply in this case. But again, the high pylons and cables running out to Haulbowline will be the critical obstacle on a low flat approach, not the proposed plant, if such an approach was made from the direction of the proposed plant. Thus, the proposed plant will not be the limiting factor in low gradient approaches to the Football Field from the direction of the plant site.

7.2.2.6. When the forgoing is considered, the proposed plant will impose no further restrictions, beyond those posed by the current obstacles and terrain on long low departures or take-offs from either location in the NS base.

7.2.2.7. In my expert opinion, take-off or landing would never be conducted towards the area of the proposed plant approaching anywhere near the plant site. Discussions with a number of ex Air Corps pilots who had extensive experience of operations at the NS base have confirmed this opinion. The current obstacles and terrain dictate that flight

safety could not be maintained in this area and consequently the only option was to avoid it. One pilot considered this to be a no-go area before Wind Turbine A was erected and that he had never flown within 300 meters of the proposed plant location. He considered the wind turbine to be a major new hazard, which renders this area even more unsafe. Given the existing tall structures and obstacles in the area, the proposed plant does not add any further hazard implications for operations or flight safety.

7.2.2.8. It may be noted that the still air single engine climb performance angle of the Agusta 139 is, in still wind, approximately 10° or 66% more than the 6° minimum requirement used by the UK Joint Standards used in their clearance calculations, reference Para 6.4.16.3 above.

7.2.3. Question 3 "*The impact of local climatic conditions including occasions of atmospheric pressure inversion in Cork Harbour on the character of the plume from the proposed stack"*

7.2.3.1. The effect of an atmospheric pressure inversion is to limit or stop the vertical movement of air that is rising as a result to its temperature difference with the ambience air temperature. As a former glider pilot, I am very familiar with the limiting effect that inversion layers have on the development of thermals used for gaining altitude by gliders. An inversion layer at or below the level of the top of the stack will have no effect on the exhaust plume. If the inversion layer is sufficiently above the stack so that the vertical moment is largely dissipated, then the plume will rise to the height of the inversion level and then travel downwind horizontally at the height of the inversion level. If the inversion level is a small height above the top of the stack, then the plume may well punch through the inversion layer, but its temperature differential with the surrounding air is reduced and so its vertical velocity will decrease. In these circumstance the plume will rise more slowly and the wind (if there is any) will tend to bend the path of the rising plume in a more downwind direction. With very rapidly rising high-energy plumes, the plume can sometimes reflect off an inversion layer laying some height above the stack plume and will then travel earthwards and may go below the level of the stack. However, this only occurs with stacks of large outputs and

where the stack velocity exceeds 15 m/s. As the stack at Ringaskiddy is of relatively low output and had a stack velocity of 14 m/s, this should not occur at this plant.

7.2.3.2. In calm conditions, an inversion level will reduce the vertical velocity of the plume and therefore reduce the turbulence danger area rising vertically from the stack. This loss of vertical velocity is likely to reduce the dissipation of the area of reduced oxygen and elevated temperate, again in the area immediately above the stack. Therefore, flying low directly over the stack should be avoided. But as explained previously there is no requirement to fly directly forwards the stack. And more to the point, helicopters would not do so because of the existing restriction on flying in this area, the current presence of more significant obstacles and hazards in this area and the unsuitability of this area in the event of an emergency.

7.2.3.3. If there is an inversion layer in windier conditions, the dispersal effect of the wind will dominate, and reduce the effect of the of the inversion layer.

7.2.3.4. The effect, therefore, of local climatic conditions including occasions of atmospheric pressure inversion in Cork Harbour, on the character of the plume from the proposed stack will not affect aviation safety or place additional restrictions on helicopter operations at the NS base.

7.2.3.5. The forgoing is of academic interest only, as the Dr Porter has determined (Para 6.27 that the extent to the plume, based on *"five years of meteorological data covering all meteorological conditions including pressure / temperature inversions*" will not exceed 3.5 metres, in either a horizontal or vertical direction.

7.2.4. Question 4 *"the possible requirement, based on international practice, for an exclusion zone around the naval base"*

7.2.4.1. I will answer this question in two parts

7.2.4.1.1. DOD made only one reference in their submissions to the need to impose a restriction area around the proposed plant. This is in para 6 of their submission of 22 April 2016 (Appendix A). I have dealt with this in some detail in Para 5.8 above. The NS have already imposed a restriction on flying in this area due to the presence

of the Maritime College. Also, the current obstacles in this area, and the obstacles on the approach to this area from the operational helipad on Haulbowline Island (the Football Field), and the totally unsuitable nature of the terrain and topography in this area in the event of an emergency, makes it an area totally unsuitable for helicopter operations and is therefore already regarded as a no-go area by Air Corps pilots.

7.2.4.1.2. As the area in question is not used for the above reasons, another formal restriction on flying in this area cannot have any further effect on Air Corps helicopter operations from the NS base.

7.2.4.1.3. With regard to an exclusion zone around the NS base, such a zone has never been requested by DOD, during 25 years for Air Corps helicopter operations with the NS (i.e. since LE Eithne was commissioned). Neither has DOD sought the IAA to designate the NS base as a Military Helipad. DOD has requested that other installations be designated as military helipads, i.e. Finner Camp in Donegal and Monaghan Barracks. DOD has requested the IAA to implement a restricted area (R22) around Finner Camp and this has been done. DOD has not requested such a restricted zone around Haulbowline, even during the period of frequent detachment of helicopters to LE Eithne, as I know from personal experience. There are other military facilities which currently have much more military helicopter activity than Haulbowline, which function without the provision of a restriction zone. The actual level of military helicopter activity around the NS base is quite low on an annual basis, as I know from personal experience. Finally, the NS base is already within controlled airspace, the Cork CTR, which extend from the surface to 5,000 ft and extends for 15 nautical miles from Cork Airport, to a point 7 nautical miles east of the base. This zone effectively controls all air traffic in the area of the base and requires all air traffic entering the zone to contact the local ATC centre at Cork Airport. Consequently, I see no justification of a restricted zone around the base.

7.2.4.2. There is no such thing as an "exclusion zone" in Irish Air Law. In Appendix R, I have detailed the various types of restricted areas that could be understood as exclusion zones.

7.2.4.3. Notwithstanding the foregoing, the erection of the stack would, when considered in conjunction with the Rules of the Air, effectively creates an exclusion zone for civil aviation for a distance of 500 ft around and above the stack top. As stated in Para 6.20.2, the IAA must have determined that there is no hazard to aviation from this plant outside these limits. The Air Corps has a policy of observing best international safety practice. The IAA's Rules of the Air and obstacle clearance limits are in conformity with best international practice. If the Air Corps observes these limits, then following the logic of the IAA position, operations which do not transgress these limits, with regard to approaching the proposed stack, will be safe.

7.2.4.4. When a 500 ft (152 meter) clearance circle is drawn on top of the proposed stack, it is notable that it does not extend north of the Maritime College or significantly East of line joining the power lines running out to Haulbowline Island and continuing towards Wind Turbine A. Therefore the 500 ft zone lies within an area that is already, effectively, a no-go area for the reasons outlined in Para 7.2.4.3 and elsewhere in this paper. Consequently, it is difficult to see how the presence of the proposed plant can have any adverse effect on operations from the NS base.

7.2.4.5. At its nearest point, the restricted 500 ft diameter area around the stack is over 1 km from the take-off point on the Main Square (twice the clearance distance required by the UK Joint Standards) and even further from the Football Field. Appendix O slows the extent of this 500 ft zone in relation to the other obstacles in the Cork Harbour area. For information, it also includes a 500-meter circle centred on either landing area (the Joint Standard clearance requirement).

8. OTHER MATTERS THAT MAY ASSIST AN BORD PLEANÁLA

8.1. Wind Turbine A was not objected to by the Department of Defence. Yet it poses a large threat to aviation operations at Haulbowline. This obstacle is much higher and wider, largely unlit, comprising of huge rotating masses, compared to the proposed plant.

Furthermore, it can create major dangerous turbulence, 100 meters in diameter, extending 500 meters downwind, and a zone of significant turbulence extending 1,600 meters downwind. The extent of these turbulence zones, compared to the effects of the plant exhaust plume, is shown in Appendix Q. It can, in certain meteorological conditions, produce a local misting effect, again extending several hundred meters, which would make the turbine, and other obstructions in the area difficult/impossible to see and avoid, as also shown in Appendix Q. As previously noted, the wind turbine poses a significant hazard during NGV operations. From the foregoing, it is very difficult to explain why DOD did not lodge a planning objection to this wind turbine, if aviation safety was an utmost concern.

8.2. The organisation representing other ranks in the Defence Forces, PDFORA, have submitted a list of objections to this project. PDFORA represents the rear flight crew on Air Corps helicopters and the majority of Defence Forces personnel who would be carried in Air Corps helicopters during operations at the NS base. This submission was prepared by a PDFORA member with qualifications in the Health and Safety area. In a lengthy submission, no threat to aviation safety and/or to PDFORA members engaged in this activity, arising from this proposed plant, was mentioned or identified.

8.3. Similarly, RACO, the organisation representing commissioned officers, including Air Corps pilots, have not made a submission in relation to aviation safety matters and this project.

8.4. The General Office Commanding the Air Corps, who has overall responsibility of the safe conduct of military aviation in Ireland has not registered any objection to the project.

8.5. DOD did make reference to abandoned approaches in prevailing wind direction in the event of an engine failure, i.e. single engine operation. The effect of the loss of one engine, and its power, is to reduce the climb angle that the helicopter can achieve. As previously discussed, particularly in 7.2.2, the area of the proposed plant is already totally unsuited for use as a low angle departure route. In the event of an engine

failure, a pilot would be even more conscious of the total unsuitability of this area as a suitable flight path from an abandoned approach.

8.6. The implication that flight directly into wind must be maintained during an aborted approach in a single engine configuration is inaccurate and incorrect.

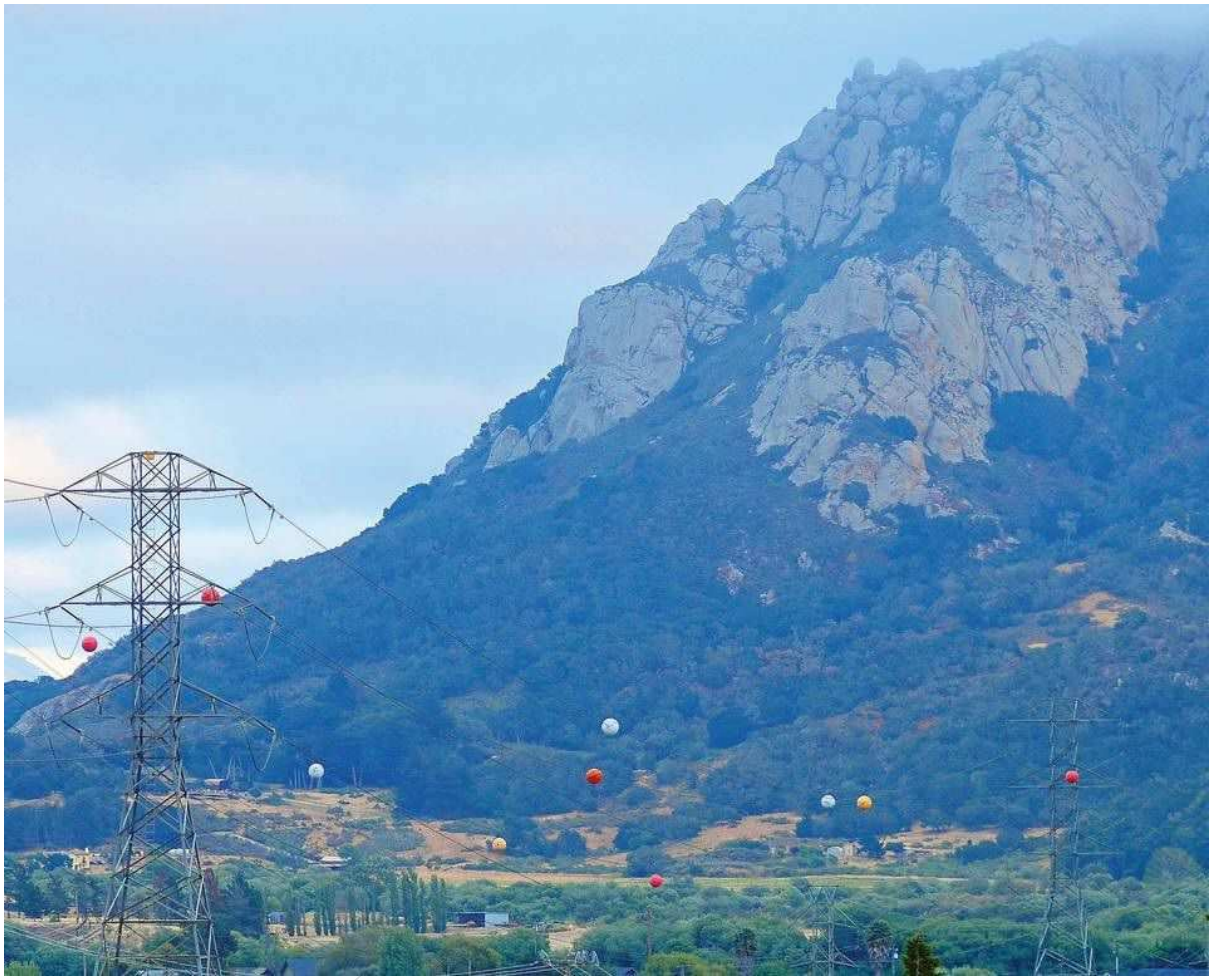
8.7. The failure of DOD to object to Wind Turbine A is consistent with low levels of expenditure and commitment to the development of the aviation facilities at Haulbowline. They have not had the base designated as a military helicopter pad (as they did and continue to do with Finner, notwithstanding that a helicopter has not been based there for many years). Such designation would ensure that they are notified by the local authority of planning applications which might adversely affect operations. They do not have a marked designated helicopter landing area on the Base (white circle with a large "H") notwithstanding that many Defence Force facilities are so equipped. There is not even a windsock, which would assist a pilot to determine wind direction and speed before take-off, at the Main Square location. They have not provided a helicopter landing pad meeting the criteria they impose on hospitals for helipads to be used by Air Corps helicopters. Thus, their objection to the proposed plant is not consistent with their heretofore policy of minimal development of the aviation infrastructure, including safety, at the NS base.

8.7.1. It is also noted that DOD have not sought the ESB to put large marker balls on the line running over Rocky Island to Haulbowline or the line running along the high ground located to the rear of the proposed plant. These balls are designed to aid pilots of low flying aircraft, especially helicopters, to see and avoid power line cables, which can be very difficult to see (especially from helicopters as the high vibration level affects the sharpness of eye focus, and the ability to see thin objects such as wires and cables). Striking such cables has caused numerous accidents in Ireland, including a fatal helicopter accident in 2009[15]. Such marker balls are found in the area of the Air Corps

[15] The report of this accident, AAIU Formal Report Number 2010-009, can be found at http://www.aaiu.ie/sites/default/files/upload/general/12603-REPORT_2010_009-0.PDF

base at Casement, and several other sites around the country. I can think of only two explanations as to why DOD has not initiated such an elementary safety aid at Haulbowline. The first possibility is that DOD has not perceived or understood the need for such an elementary safety feature at the base. The alternative is the Air Corps helicopter pilots have not made an issue of these cables, for the simple reason that when operating from the Football Field, they never fly in the directions of these pylons and cables, and by implication, never towards the proposed plant, due to the very unsafe nature of this path for the reasons outlined in Para 5.8.1 above. And when operating from the Main Square, again these cables would be a significant obstruction to the east of the flight path. That pilots rapidly turn west after take-off from the Square, away from these cables and the Maritime college (and again, by implication, away from the proposed plant), is the probable reason that pilots have not made an issue regarding marking of these cables, with regard to take-offs and landings in the Main Square.

8.7.2. This photo clearly shows the usefully of such balls. The cables themselves are almost invisible.



8.8. The Air Corps has had much experience of operation in very close proximity (less than 10 meters) to exhaust stacks (deck landing on LE Eithne). They evolved and implemented procedures to accomplish this safely, and did so for many years without incident. Unfortunately, the vast majority of pilots trained and engaged in such operations have left the service, and the Air Corps no longer operates a helicopter type which is capable of landing on LE Eithne. As a consequence, the Air Corps currently has no pilots qualified for such operations, as operational currency for such operations must be renewed on a regular basis. One must consider that the concerns raised in the DOD submission are as a result of this loss of expertise and operational currency. The junior Minister for Defence has alluded to the loss of Air Corps expertise in the Dáil.

8.9. The Air Corps currently operate vertical resupply missions to NS ship. Such missions are conducted to the rear deck of these ship. This also requires approaching very close to the stacks of these ships, from astern of the ship. Yet Air Corps helicopter pilots have no difficulty in conducting such missions when reasonable precautions are taken, and good airmanship practised.

8.10. The Royal Naval use Devonport as the main base for their helicopter support ships and associated helicopter activities. They operate medium and large size helicopters from these facilities, and ships, even when moored alongside. They have permitted a similar sized waste to energy plant, almost identical to the proposed plant at Ringaskiddy, to be built only some 525 meters from the closest point where these ships are tied up. That the Royal Navy, with all their considerable experience, permitted this facility to be built and that they continue to operate safely alongside this plant, is start contrast to the concerns raised in the DOD submission.

8.11. The Air Corps 139 helicopters are also used in a water bomber role, in which they drop large quantities of water on forest and gorse fires. This work is to assist local fire fighters contain such fires. The technique is to lower a large "bucket", slung under the helicopter, into a local lake or other water source, then carry it to the scene of the fire and deposit the load onto a location of the fire specified by the local fire service. The action is then repeated until the fire is under control. This work requires the helicopter to overfly the fire at low altitude and low speed, frequently into the rising fumes of the fire, in order to accurate deposit the water where required. Each bucket contains 1,200 litres of water. In a fire event in Donegal in 2011, over 200 of these flights were flown, depositing 250,000 litres of water onto gorse fires threatening lives and property. The photo[16] below shows an Air Corps 139 involved in this operation.

[16] "Forest Fires in Ireland Impacts on Industry, Environment and Emergency Services" by Bobbie Mc Menamin, Chief Fire Officer, Donegal Fire Service.



8.11.1. During these operations, the helicopter is exposed to the turbulence of the fire, the heat from the fire, and is operating in an atmosphere which is oxygen depleted due to the burning of the fire. The turbulence from the fire can pose a severe risk to the helicopters and aircraft.

8.11.2. The photo shows that the Agusta 139 is capable of near-hover speed operations in this very hostile environment, surrounded by exhaust gases and high temperature plumes from the fire, and being buffeted by the rising hot gases generated by the fire, even when carrying a very heavy underslung load.

8.12. The FAA Study (Ref Para 11.1) sums up the situation succinctly: "*Our interpretation of available data is not so much that plumes are not hazards or present zero risk, but that pilots and controllers operating within the NAS have been and will continue to apply prudence and common sense skills to constantly "see and avoid" any potential hazard. These mitigating techniques are employed everyday throughout NAS through timely communication, training, and procedures for operating near hazardous weather, forest*

fires, large sporting events, volcanic ash, migratory bird activity, antenna towers, and overhead wires."

9. PERSONAL STATEMENT

9.1. I have been actively involved in aviation, in both a personal and professional level, starting at the age of 15. Since then I have lost some 40 people, family, friends, work colleagues and acquaintances in aviation accidents. I worked in air accident investigation for 17 years and I have seen the trauma and desolation that aviation accidents have caused to the families and colleagues of victims. I have always had the highest commitment to aviation safety throughout my career. I worked in the Air Corps for 22 years, as did my father before me and my eldest son subsequently. I would not be party to any action that would endanger lives of airmen, or be to the detriment of the Air Corps in particular and the Defence Forces in general. I am also conscious that invoking aviation safety issues, in a case where it is not warranted or supported by the facts of the matter, works against the long-term goal of improving aviation safety.

10. CONCLUSION

10.1. It is my opinion, based on consideration to the foregoing, that the proposed waste to energy plant at Ringiskiddy does not have an aviation safety effect of helicopter operations at the Naval Service base at Haulbowline or at Spike Island.

11. REFERENCES

11.1. AAIU report of Accident involving Agusta JetRanger, EI-BKT, at Poolbeg on 11 Sept 2002. The AAIU report can be found at: http://www.aaiu.ie/sites/default/files/report-attachments/4571-0.pdf

11.2. Safety Risk Analysis of Aircraft Overflight of Industrial Exhaust Plumes; Safety Study Report DOT-FM-AFS-420-06-1 Dated Jan 2006. This document is available at http://www.tc.faa.gov/its/worldpac/techrpt/afs420-6-1.pdf

11.3. UK Civil Aviation Authority publication CAP 764 Policy and Guidelines on Wind Turbines. This document can be found at: https://publicapps.caa.co.uk/docs/33/CAP764%20Issue6%20FINAL%20Feb.pdf

11.4. IAA Aeronautical Notice U.04 Issue 9 dated 20-12-2016. The notice can be found at: https://www.iaa.ie/docs/default-source/publications/aeronautical-notices/u---unmanned-aircraft/u-04-issue-10.pdf?sfvrsn=38

11.5. FAA position paper on Safety Concerns of Exhaust Plumes. The document can be found at http://www.aopa.org/-/media/Files/AOPA/Home/News/All-News/2015/FINAL2--AOSC-Position-Paper-Exhaust-Plumes.pdf

11.6. FAA Objects around airports. This document can be found at: http://www.nh.gov/dot/org/aerorailtransit/aeronautics/sasp/documents/TRappendixAC.pdf

11.7. Paper "Request of Additional Information – Plume Modelling Assessment" by Dr. Edward Porter

11.8. The US Department of Transport Aeronautical Information Manual can be found at: https://www.faa.gov/air_traffic/publications/media/AIM_Basic_4-03-14.pdf

11.9. FAA Memorandum date 24 Sept 2014: Technical Guidance and Assessment Tool for Evaluation of Thermal Exhaust Plume Impact on Airport Operations. This document can be found at: https://www.faa.gov/airports/environmental/land_use/media/Technical-Guidance-Assessment-Tool-Thermal-Exhaust-Plume-Impact.pdf

11.10. AAIU Formal Report Number 2010-009, involving a Schweizer model 269C-1 helicopter near Kilshanchone, Co Kildare, on 1 April 2009 can be found at: http://www.aaiu.ie/sites/default/files/upload/general/12603-REPORT_2010_009-0.PDF

12. STATEMENT OF TRUTH

12.1. I confirm that insofar as the facts stated in my report are within my own knowledge I have made clear which they are and I believe them to be true, and the opinions I have expressed represent my true and complete professional opinion.

Signature:____*Graham Liddy*_____

Graham Liddy
Dip Eng, Eur Ing, CEng FIEI, M.ISASI, MSc, FRAeS

Date: 21 May 2017_____

NOTE Diagrams in Appendices

Many of the diagrams in the appendices included in this report are reduced from much larger originals. This small size can make these diagrams difficult to read in the report. Full size large scale hardcopies of these diagrams will be submitted with the physical report.

Appendix A DOD Submission of 22 April 2016 with referencing system

An Roinn Cosanta
Department of Defence

DEPARTMENT OF DEFENCE SUBMISSION

Waste to Energy Facility, Ringaskiddy, Co Cork (Ref: 04.PA0045)

The Department of Defence following consultation with the Air Corps and Naval Service has the following observations on the Ringaskiddy Resource Recovery Centre planning application.

1. Exhaust Plume Dangers

PARA 1 The proximity of the stack of the waste-to-energy facility to the approach paths of Haulbowline Naval Base and Spike Island is a matter of concern. This is due to the fact that this stack will be emitting significant amounts of exhaust gases and is seen as a potential hazard as it may render approaches by Air Corps helicopters into Haulbowline and Spike Island as unsafe.

PARA 2 The Air Accident Investigation Unit (AAIU) Report No 001-2004 describes a helicopter accidently flying through an invisible exhaust plume in Dublin, following which the helicopter suffered an immediate engine failure and was forced to make an autorotation forced (engine-off) landing, resulting in significant damage.

PARA 3 As a result of the AAIU recommendations from this report the Irish Aviation Authority (IAA) published Aeronautical Information Circular (AIC) No 04/03 entitled "Air Navigation Hazard - Exhaust Plumes". This AIC warns pilots of the dangers of operating in proximity to exhaust plumes with respect to engine flame-outs. They also warn that under certain conditions the exhaust plumes may not be visible. Under calm conditions therefore, a helicopter pilot would have to assume a danger area around a chimney and up to 1,000 feet above a chimney.

PARA 4 The US FAA Safety Risk Analysis of Aircraft Over flight of Industrial Exhaust Plumes Report 2006 states that hazards from plumes "taken individually or cumulatively, could possibly result in the loss of the aircraft or fatal injury to the crew". The report recommends that crew do not fly through the plume, however, it is known that plumes are often invisible and therefore cannot be seen to be avoided (see AAIU and AIC Report above).

PARA 5 The FAA Report further recommends that over flight of an exhaust plume less than 1,000 feet is to be avoided, and indeed recommends FAA permanent flight restrictions for overflying such plants.

PARA 6 Given the location of the site to the South and West of Haulbowline and Spike Island and the prevailing winds, If the proposed resource recovery centre is developed the Air Corps may be forced to impose a local no-fly restriction around the site with an additional restriction on operations to Haulbowline Naval base and Spike Island which would result in no possible operations to the Naval Base during Southerly Wind conditions.

...../

Cuirfear fáilte roimh chomhfhreagras i na Gaeilge. Bóthar an Staisiúin, An Droichead Nua, Contae Chill Dara. Station Road, Newbridge, Co. Kildare.

Teileafón / Telephone: (045) 492000 Glao Áitiúil / LoCall: 1890 25 1890 R-Phost / E-mail: customer@defence.ie Láithreán Gréasáin / Web: www.defence.ie

PARA 7

2. Lighting Requirements

If permission is granted, the development should be fitted with obstruction lighting in accordance with ICAO documents:

1. (i) Annex 14, Volume 1 (Aerodromes), Chapter 6
2. (ii) ICAO document 9157 (Aerodrome Design), Chapter 14.

Obstruction lights used should also be incandescent or of a type visible to Night Vision Equipment (NVE). Obstruction lighting fitted to obstacles must 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.

PARA 8

In addition, Haulbowline Island is accessed by road as a sort of *cul de sac* to the Ringaskiddy Road. The proposed incinerator is to be built adjacent to this road, before Haulbowline. Therefore, in the event of any accident at the incinerator, road access to and from Haulbowline is threatened. For example, if an accident at the incinerator necessitated local area evacuation, the evacuation of Haulbowline would be denied. This cannot be an acceptable situation for those that work at or visit Haulbowline nor for the necessary functioning of a fully operational Naval Base therein.

Department of Defence
22nd April 2016

Appendix B Dr E. Porter's Table of Emission Data

Summary

Emission Source	MW	Stack Height (m)	Stack Diameter	Stack Temperature	Stack Actual Volume Flow	Stack Actual Velocity	Stack Oxygen Content	Stack Moisture Content	Thermal Buoyancy	Momentum Flux	Thermal Buoyancy (Relative)	Momentum Flux (Relativ e)
Ringaskiddy	18.5	70	2.30	418.15	208,663	13.95	6.40	20.00	58.4	174.3	1.0	1.0
Aghada CCGT	435	65	5.50	357.25	3,005,600	35.14	13.20	7.36	540.5	7401.8	9.3	42.5
Whitegate CCGT	445	60	6.88	359.25	4,400,031	32.88	11.70	10.27	808.1	10081.2	13.8	57.8
Moneypoint A1&A2 Combined	610	220	6.89	345.15	3,884,174	28.94	7.58	8.07	605.0	8153.1	10.4	46.8
Moneypoint A3 Combined	305	220	6.89	345.15	1,942,087	14.47	7.58	8.07	302.5	2038.3	5.2	11.7
Poolbeg CCGT	231 (X 2)	75	5.20	394.75	3,800,000	49.70	15.41	10 (estimate)	931.5	11978.7	15.9	68.7
Poolbeg Stack A	271	207	3.96	378.15	1,110,500	25.05	3.00 (estimate)	10 (estimate)	241.9	1841.4	4.1	10.6
Poolbeg Stack B	240	207	6.24	407.15	1,110,500	10.09	3.00 (estimate)	10 (estimate)	293.2	688.8	5.0	4.0

Appendix C Helicopter operations with Naval Service ships

This photo shows the Naval Service flagship, LE Eithne. It was originally designed as a helicopter equipped patrol vessel. The helicopter landing deck can be seen clearly on the stern of the ship. The helicopter hangar is located immediately forward to the landing deck, beneath the two main engine exhaust stacks which can be seen at the rear end of the hangar flat roof. The helicopter landed with its main rotor directly over the centre on the white circle on the helideck. The helicopter was equipped with a harpoon which clamped itself to a grid in the centre of this circle. This meant that the entire forward section of the helicopter extended forward of this point. Consequently, the engine intakes, located forward of the main rotor, were quite close to the exhaust stacks as the helicopter came into land. The Air Corps no longer operated the Dauphin 356FI helicopter that the Eithne was designed to operate with and the Air Corps Agusta 139 is not equipped for deck landings, However, vertical ship supply operations are carried out with the 139, which required the helicopter to hover over the rear deck, with an underslung load. During these operations, the helicopter is hovering approximately level with the top of the exhaust stacks. The power output of the two engines are 30% of the proposed plant at Ringaskiddy, when the ship is developing full power.



Below is LE Samuel Beckett. This is one of the newer, more powerful and faster additions to the NS fleet. The Agusta 139 is used for vertical supply of this ship also. The area for depositing the underslung load is the stern (aft) deck. As can be seen, this is quite close to the single exhaust stack. During these operations, the helicopter is hovering approximately level with the top of the exhaust stack. At full power these engines have an output of 55% of the proposed plant at Ringaskiddy.



This photo shows HHS Ocean, a Royal Navy helicopter support ship, from which up to 18 helicopters operate. On deck can be seen Apache attack helicopters, with Merlin's and Chinook's transport helicopters. The main engines exhaust stack can be clearly seen in the centre of the "island" on the starboard side of the helicopter deck, with a thin exhaust plume just visible. The output of this stack, at full power, is almost twice that of the proposed plant at Ringaskiddy. Helicopters take-off and land on all areas of the deck, including the aft section, to the rear of the exhaust stack.



Appendix D AAIU report JetRanger EI-BKT

FINAL REPORT

AAIU Synoptic Report No: 2004-001
AAIU File No: 2002/0047
Published: 16/1/2004

In accordance with the provisions of SI 205 of 1997, the Chief Inspector of Accidents, on 12 September 2002, appointed Mr Graham Liddy as the Investigator-in-Charge to carry out a Field Investigation into this occurrence and prepare a Synoptic Report.

Aircraft Type and Registration:	Agusta B206 Jetranger EI-BKT
No. and Type of Engines:	1 x Rolls Royce Allison 250
Aircraft Serial Number:	8562
Year of Manufacture:	1978
Date and Time (UTC):	11 Sept 2002 @ 11.42 hrs
Location:	Dublin Port
Type of Flight:	Aerial work - photography
Persons on Board:	Crew - 3 Passengers - 0
Injuries:	Crew - 0 Passengers - 0
Nature of Damage:	Heavy landing damage
Commander's Licence:	ATPL(H)
Commander's Age:	58
Commander's Flying Experience:	10,034 hours of which 4,000 were on type
Information Source:	Pilot's Report and AAIU Field Investigation

1 FACTUAL INFORMATION

1.1 Background

EI-BKT was being used as a camera platform for a television documentary about the Irish landscape. The required permissions for this type of flight had been sought and received. The pilot did not work for the helicopter owners but they had been requested to obtain his services by the documentary producers, because of his considerable experience in this kind of work.

1

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1.2 History of the Flight

On this flight, one of the proposed camera shots was of Dublin City, looking west, with the top of two tall chimneys of a major power station in the close foreground. The chimney tops are located 691 ft above sea level and 684 ft above ground level. Weather conditions at the time were excellent, with clear sky and a light wind from the south. The pilot approached the chimneys from the west, along a path parallel to the two chimneys and just to the north of the chimneys, with the intention of circling around the chimney area to get the required shot. The helicopter was flying slightly higher than the tops of the chimneys. As the helicopter passed the second chimney, it briefly entered the exhaust plume from the chimney. The engine suddenly lost all power and ran down. The pilot immediately lowered the collective and set up an autorotation. The tide was out at the time, exposing a large area of beach immediately south of the power station, and the pilot landed on this beach. As the beach area was wet and soft, the pilot opted for a vertical landing with little forward airspeed, as he was concerned that the skid undercarriage would dig in and cause the helicopter to pitch-over in a forward direction. As the helicopter touched on, the skids did start to dig in and the pilot raised the collective to counteract the forward pitch-over.

The helicopter was operating at the high end of the permissible weight envelope at the time of the autorotation. As a result the rate of descent was high, which produced a high rotor autorotative RPM. Consequently the pilot raised the collective during the descent to prevent rotor over-speed.

After landing, the pilot inspected the helicopter and found no damage. He initially spun the engine in the ventilation mode and found it rotated freely. He then started the engine, without difficulty, and found that it performed normally. At this time he was concerned that the incoming tide would immerse the helicopter. He therefore decided to take-off, with the camera crew still on board, and he flew the helicopter to the owner's facility at Dublin Airport, without further incident. On this flight he avoided flying over areas of population. On further inspection at Dublin Airport, the helicopter was found to have suffered significant damage, consistent with a low rotor RPM heavy landing.

1.3 Other Information

1.3.1 This helicopter is equipped with a spike under the main gearbox, which contacts a striker plate on the transmission platform in the event of excessive vertical or fore-and–aft movement of the main gearbox. This feature is designed to facilitate a quick inspection of the helicopter in the field after a suspect landing, in order to determine if excessive gearbox movement has occurred. On the subsequent inspection at Dublin Airport it was found that the spike had forcefully hit the striker plate. This inspection did not find any damage or defect in the engine.

1.3.2 The Investigation obtained the tape from the camera that was running during the incident. This shows that the helicopter flew into the plume of the second chimney. The plume is only barely visible on the tape during the approach to the chimney. It only becomes noticeable immediately before the helicopter enters it.

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When the helicopter enters the plume the camera lens briefly mists over and then clears during the subsequent autorotation. The tape also shows the subsequent landing, which appears to have been well executed, and the landing does not appear exceptionally heavy. However this is somewhat difficult to determine, as the camera was held low on the side of the helicopter. The cameraman, who had considerable experience of helicopter filming operations, subsequently stated: "*there was nothing particularly rough about the landing.*"

1.3.3 The pilot subsequently stated that the entire windscreen of the helicopter misted over after entering the plume and this obscured his vision significantly in the early segment of the autorotation.

1.3.4 One of the camera crew subsequently stated that he could not see an exhaust plume as the helicopter approached the chimney. A photograph was taken of the landing area shortly after the landing. The chimneys are clearly visible in the background and no plume is visible in the photograph (ref **Appendix A**).

1.3.5 On 18 September 2002, the Investigation informed the Irish Aviation Authority that:

"*Preliminary indications are that the helicopter flew into the exhaust plume of the power station chimneys, and that the flame-out was due to the ingestion of the plume. The presence of a large volume of oxygen-depleted combustion by-products, the very high temperature of the emitted gases or the presence of large amount of water vapour in the emissions, or a combination of these factors was, in all probability, sufficient to cause the flame-out. It is noteworthy that one of the camera crew stated that there was no visible plume at the time.*

Subsequent research indicates that this was not a unique event. Similar flame-outs have occurred as result of;

- *Flight over power stations, even when there was no visible plume.*
- *Flight over forest fires.*
- *Flight over burning buildings.*
- *Flight over volcanoes.*
- *Approaching oil/gas rigs from a downwind direction when natural gas was being vented or flared.*

It appears that the dangers of operating in such environments may not be generally appreciated.

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The Investigation also issued the following Interim Safety Recommendation:

"Interim Safety Recommendation:

The Irish Aviation Authority should issue an AIC (Aeronautical Information Circular) *alerting pilots and operators of helicopters of the dangers of engine flame-outs as a result of operating in environments of contaminated atmosphere, high temperature and/or combustion by-products, such as plumes from power stations, forest fires, burning buildings, or oil/gas rigs when natural gas was being vented or flared. The AIC should note that flame-outs can occur even when no plume is visible. (SR 25 of 2002)"*

1.3.6 The IAA responded to this Interim Safety Recommendation by issuing AIC No 4 of 2003 on 1 January 2003 **Air Navigation Hazard – Exhaust Plumes** (ref **Appendix B**).

1.3.7 The Investigation was given excellent assistance by the operator of the power station. It was determined that the first (westerly) chimney encountered by the helicopter was not operating at the time, as the appropriate power units were undergoing maintenance. The second chimney served a steam boiler power unit of 270 Megawatts, which was running at about 75% capacity at the time of the occurrence. The fuel being used at this time was natural gas, the exhaust of which has a greater tendency to condense at or near ambient temperatures, compared to oil firing. The oxygen levels at the discharge point were estimated to be 4-5%. Oxygen levels of at least 12% are considered essential for the safe running of aircraft turbine engines.

1.3.8 An additional comment was made by the power station operator. In addition to exhaust plumes emitting from chimneys or stacks, there is also another hazard due to the fact that power stations may at any time experience a sudden emission of large quantities of steam, caused by the operation of safety valves. Such releases would pose a considerable hazard to low flying helicopters and aircraft. The power station operator also pointed out that there is the possibility of explosive debris emission from safety valves when they open suddenly.

1.3.9 The engine on this particular model of the B206 is not equipped with auto-ignition. Auto-ignition is designed to automatically re-ignite the engine in the event of a flame-out.

1.3.10 The power station chimneys are a Visual Flight Rules (VFR) reporting point within the Dublin Control Zone. Consequently low-level air traffic is frequently directed into this area.

2. ANALYSIS

2.1 When the helicopter entered the plume, it entered an environment of very high ambient temperature, with very high water vapour content and depleted oxygen content. The combined effect of these factors was to produce an atmospheric condition that quenched the flame in the combustion chamber of the engine. This caused the engine to run-down and stop.

2.2 The plume only became visible on the camera tape when the helicopter came very close to the chimney. The fact that the plume was located, from the pilot's view-point, close to the horizon, would have made visual detection of the plume more difficult. It is also noted that one of the camera crew on the aircraft stated that he did not see the plume and that the plume was not visible in the subsequent photograph (Appendix A).

2.3 The action, by the pilot, of raising the collective on landing, to prevent pitch-over, was both appropriate and necessary. However it had the secondary effect of suddenly lowering rotor RPM and thus caused the blades to flap. This in turn caused the gearbox to rock and was the prime cause of the damage to the helicopter.

2.4 The contents of the camera tape show that the flame-out, and subsequent autorotation and landing, were ably handled by the pilot. The available height, when the engine shut down, was also a significant factor in the successful autorotation.

2.5 Given that the chimneys are a VFR reporting point, frequently used by low level air traffic, a recurrence of this event may be more likely than generally perceived.

2.6 The plume from power stations is frequently invisible, particularly when the station is being powered by natural gas. In this case, neither the evidence of witnesses, the video tape nor the photograph taken after the event (Appendix A) indicate any discernable difference between the active and the inactive chimneys. Therefore the absence of a visible indication of an exhaust plume does not mean that no hazard exists.

3 CONCLUSIONS

3.1 The engine suffered a flame-out as a result of the helicopter being flown into the plume of an active power station.

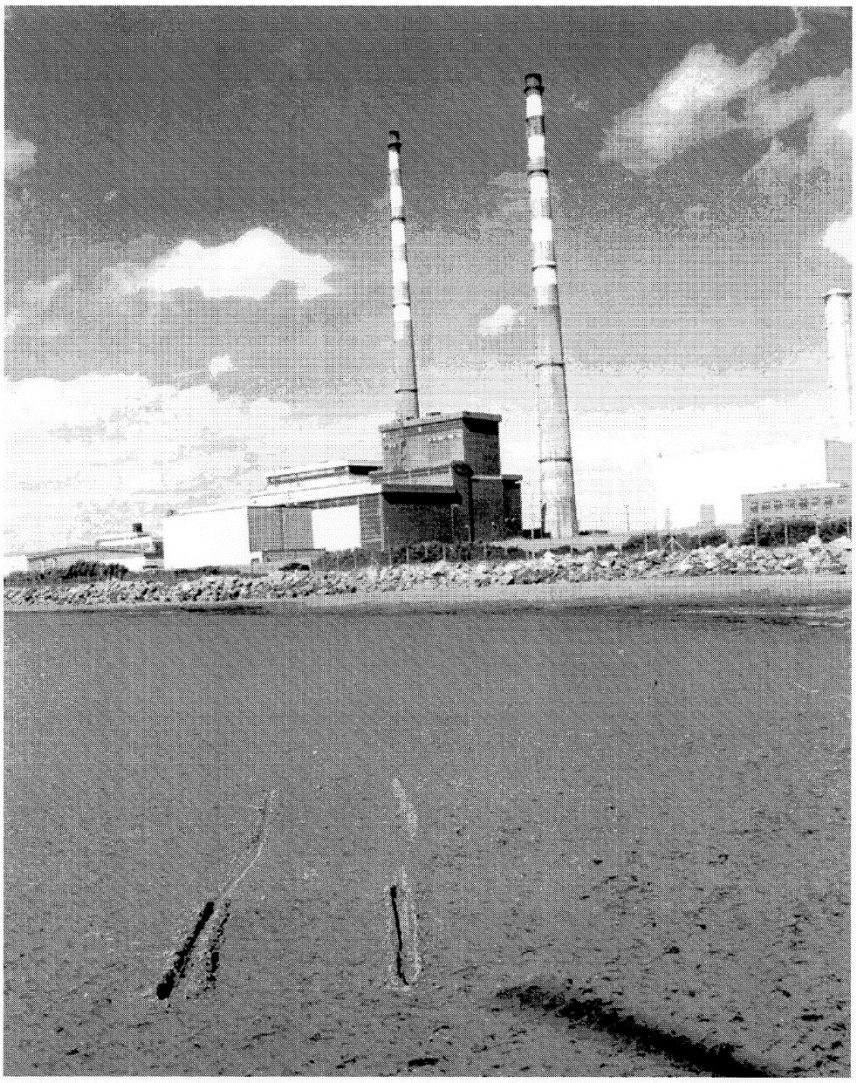
3.2 The flame-out was caused by a combination of the high temperatures, the high moisture content and the depleted oxygen levels found within the plume.

4 SAFETY RECOMMENDATIONS

4.1 The IAA should review the use of the chimneys feature as a Reporting Point, with the objective of minimising the risk of low-level VFR traffic suffering engine stoppage due to plume ingestion. **(SR 1 of 2004)**

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Appendix A



Photograph of the landing area, which was taken shortly after the event. The helicopter had restarted and moved a short distance away from the landing point. The ground marks were made during the landing, which took place towards the camera. The chimneys can be seen in the background. The inoperative chimney is on the left and the chimney that produced the exhaust plume is on the right. It is noteworthy that the plume is not visible in this photograph.

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FINAL REPORT

Appendix B

IRELAND

AIC

AERONAUTICAL INFORMATION SERVICES
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CONTROL TOWER
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Nr 4/03
01 JAN

AIR NAVIGATION HAZARD – EXHAUST PLUMES

The purpose of this AIC is to bring to the attention of aircraft operators the potential hazards of engine flame-outs as a result of operating in close proximity to environments which emit high temperatures (i.e. up to 540°C) and combustion by-products.

These emissions are associated with but are not limited to, Power Stations, Industrial Chimneys, Oil/Gas Rigs and Shipping. Operators are advised that due to certain atmospheric conditions this exhaust plume may not be visible.

The consequence of entering such a gas plume may be the immediate flame-out of gas turbine powerplant(s) combined with a dramatic loss of lift due to increase in local density altitude.

Encounters with such gas plumes should not occur where the aircraft is otherwise in compliance with the Rules of the Air in relation to vertical and horizontal separation from structures.

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Appendix E Part II, Para 3 section 1b, S.I. No. 72/2004

Irish Aviation Authority (Rules of the Air) Order, 2004.

"Visual Meteorological Conditions" means meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling equal to or better than the minima specified in Rule 34 of this schedule;

"VMC" means the symbol used to designate Visual Meteorological Conditions;

"way-point" means a specified geographical location used to define an area navigation route or the flight path of an aircraft employing area navigation.

PART II

GENERAL FLIGHT RULES

Protection of Persons and Property

Rule

2. ***Negligent or Reckless Operation***

An aircraft shall not be operated in a negligent or reckless manner so as to endanger life or property.

3. ***Minimum heights***

(1) Except as permitted by the appropriate authority or as hereinafter provided aircraft shall not be flown:

(a) over congested areas of cities, towns or settlements or over an assembly of persons, at less than:

(i) a height of 450 metres (1,500 ft) above the ground or water, or

(ii) a height of 300 metres (1,000 ft) above the highest obstacle within a radius of 600 metres from the aircraft, or

(iii) such other height as would permit, in the event of the failure of a power unit, a safe forced landing to be made,

whichever height is the greatest.

(b) elsewhere:

(i) closer than 150 metres, (500 ft) to any person, vehicle, vessel or structure, or

(ii) at a height less than 150 metres (500 ft) above the ground or water,

(c) over or in the immediate vicinity of any place within the State, where a large number of persons is assembled in the open air in connection with any event of public interest or entertainment, save when:

(i) such flights are made with the written consent of the Authority and of the organisers, if any, of the event and are in accordance with any conditions or limitations specified by the Authority, or

(ii) the aircraft is passing by in the normal course of navigation and flying at a height in compliance with subparagraph *(a)* of this paragraph.

(2) Subject to subparagraph (b) of this paragraph and subparagraph 6 (2) (a) of Rule 6 of these Rules, paragraph (1) (a) of this Rule shall not apply to a Performance Class 1 or Class 2 helicopter which is being flown without undue hazard to persons or property, except with the permission of the appropriate authority and in accordance with any conditions specified therein, a helicopter shall not be flown:

(a) over congested areas of cities, towns or settlements at less than:

(i) such height as would enable it, in the event of the failure of a power unit, to make a safe forced landing;

(ii) a height of 300m (1,000 feet) above the ground or water,

whichever height is the greater;

(b) The Authority may, in the interest of safety, prescribe areas, routes, heights and flight visibility's for helicopter flights and a helicopter shall conform thereto.

(3) Paragraph (1)*(b)* of this Rule shall not apply to:

(a) an aircraft while it is landing or taking-off in accordance with normal aviation practice at an aerodrome or heliport;

(b) an aircraft when it is in use for aerial application or aerial work with the permission of the Authority and is operated in accordance with any conditions or limitations specified with such a permission;

(c) a helicopter conducting training for life-saving operations or demonstrations of such operations;

(d) a glider while it is hill soaring;

(e) an aircraft flying with the permission of the Authority for the purpose of picking up or dropping tow ropes, banners or similar articles at an aerodrome.

Appendix F Page 3, Safety Study Report DOT-FM-AFS-420-06-1

1. Report No. DOT-FAA-AFS-420-06-1	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Safety Risk Analysis of Aircraft Overflight of Industrial Exhaust Plumes		5. Report Date January 2006
6. Author(s) Gary L. Powell, Mark A. Reisweber, Dr James Yates, Alan B. Jones, Paul McCarver, John Holman		7. Performing Organization Code
8. Performing Organization Name and Address Flight Procedure Standards Branch, AFS-420 6425 S. Denning, Room 104 Oklahoma City, Oklahoma 73169		9. Type of Report and Period Covered Safety Study
10. Sponsoring Agency Name and Address Federal Aviation Administration Mike Monroney Aeronautical Center P.O. Box 25082, Oklahoma City, OK 73125		
11. Supplementary Notes		

12. Abstract

The Flight Procedures Standards Branch (AFS-420), Flight Technologies and Procedures Division (AFS-400), was tasked by the Director of Flight Standards Service (AFS-1) of the Federal Aviation Administration (FAA) to perform a risk analysis of overflights of vertical plumes. These thermal *"plumes,"* visible or invisible, are generally associated with exhaust from the smoke stacks of power generating facilities, industrial production facilities, or other systems which could have the ability to release large amounts of pressurized or otherwise unstable air. AFS-420 organized and led a safety risk analysis team consisting of FAA subject matter experts (SME) and civilian contract personnel. The SME from various disciplines including: aviation safety, risk analysis/assessment, human factors, aeronautical engineering, air traffic control (ATC), statistical analysis, military/civil and commercial aviation each provided a high level of experience and expertise to examine the issue. Team members are identified in Appendix A. The team determined that the FAA Safety Risk Management (SRM) methodology contained in the FAA Safety Management System (SMS) Manual would be an appropriate vehicle to perform their analysis. The underlying presumption is that high efflux temperature or velocity from industrial facilities may cause air disturbances via exhaust plumes. Two hazards were identified during brainstorming sessions by members of the safety risk analysis team. The first hazard recognized turbulence that may be associated with plumes that could result in possible airframe damage and/or negative affects on aircraft stability in flight. The second hazard discussed was the possible adverse effects of high levels of water vapor, engine/aircraft contaminants, icing, and restricted visibilities produced by these plumes. These hazards taken individually or cumulatively, could possibly result in the loss of the aircraft or fatal injury to the crew, as well as substantial damage to ground facilities. The SME team considered these situations to be most critical for general aviation (GA) aircraft flying at low altitudes during the takeoff and/or landing phase when an aircraft is in close proximity to an airport. The safety risk analysis team performed their analysis of the predictive risks associated with the plumes and determined the effects of the hazards as low, or in the green section of the risk matrix. As a result of this assessment, the risk associated with plumes is deemed acceptable without restriction, limitation, or further mitigation. However, to further lower the already acceptable risk associated with the overflight of vertical plumes, the team recommended the continuance of training and awareness programs that have been successful with similar hazards of acceptable risk levels.

13. Key Words	14. Distribution Statement
Plumes, Smoke Stacks , Aircraft overflight of industrial exhaust plumes, Powerplants, Power generating facilities	Controlled by AFS-420
15. Security Classification of This Report Unclassified	**16. Security Classification of This Page** Unclassified

Appendix G Restricted areas in Cork Harbour

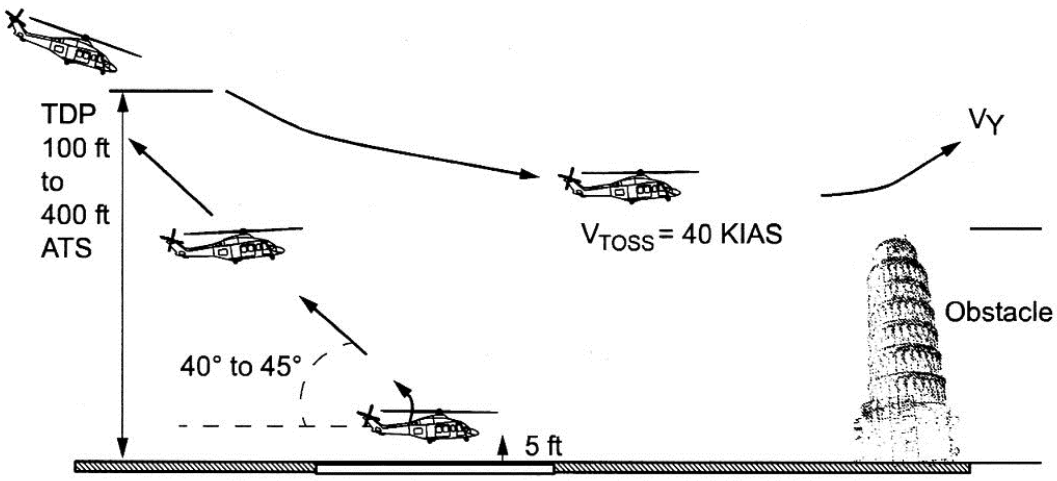
This shows the areas that are classified by the Naval Service as No Fly Zone for Air Corps helicopter operations in the Cork Harbour area. The diagram is an approximation as to the extent of these areas, based on the recollections of retired Air Corps Helicopter Detachment Commanders.



It clearly shows a restricted NO FLY ZONE area immediately adjacent to the proposed Indaver site at Ringaskiddy

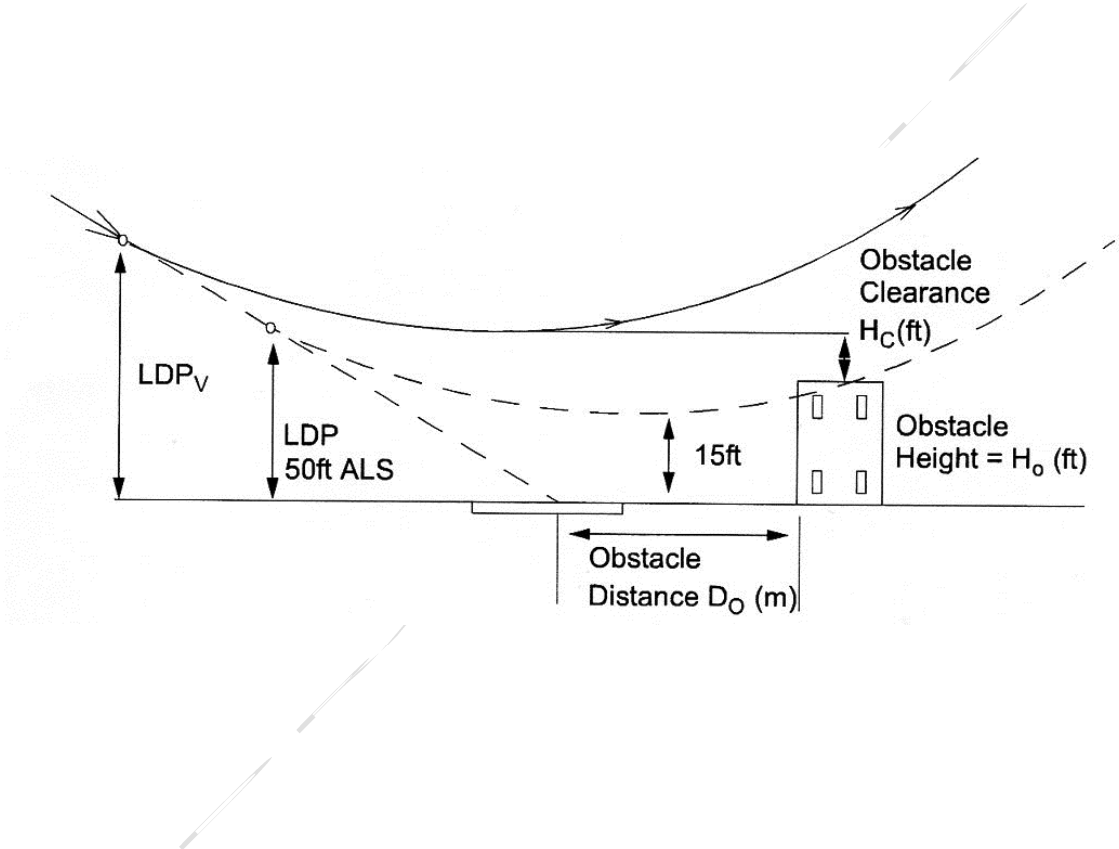
Appendix H CAT A Take-off and Landing Procedures

This diagram shows the general format of a Cat A take-off from a confined area. The helicopter takes off into low hover, climbs vertically to clear obstacles behind it, plus a safety margin, then flies slowly backwards, continuing to climb until it reaches the Take-Off Decision Point (TDP) height. During the rearward climb, the climb angle is 45°. In this diagram, there is no obstacle behind the helicopter so it can start the rearwards climb directly from the low hover. This is not the case in the Main Square at Haulbowline, where there are obstacles behind the helicopter, in virtually every take off direction. If the helicopter suffers single engine failure during this phase, it lands back at the take-off point. Once TDP is achieved, it can accelerate forward. If the engine fails at or above TDP, it can be seen that there is a loss of height as the helicopter noses down (normally 10° for the Agusta 139) to gain speed. This loss of height must be factored into the TPD height, which must be sufficient to clear the obstacle in front of the helicopter, allowing for a safety margin, and the loss of height during the initial acceleration phase.



The next diagram shows the landing situation. An engine failure at or before Landing Decision Point for vertical landings (LDP_V), the helicopter still has to nose down to achieve

sufficient forward speed for a safe fly-away, and this results in a height loss. The LDP must be chosen to allow for this height loss but must also allow for an obstacle clearance height (H_c) which is the required clearance between the lowest part of the nose-down manoeuvre and the obstacle in front of the helicopter. The normal LDP of 50 ft is for landing where there is no obstacle in front and the LPD is chosen so that the minimum height on the fly-away will clear the ground by 15 ft. The consequence of using the normal LDP when there is an obstacle in front of the helicopter is shown by the dotted line which collides with the obstacle. This is why LDP_V has to be higher than the normal LDP. An engine failure below the set LDP required the helicopter to continue the descent to land on the helipad.



Appendix I DOD Submission of 11 May 2016 with referencing system

DEPT OF DEFENCE REPLY TO INDAVER REPORTS

An Bord Pleanála Hearing – Waste to Energy Facility, Ringiskiddy, Co. Cork

11 May 2016

PARA 1 The Dept of Defence would like to acknowledge the efforts that were made in the compilation of the three response reports presented on 04 May 2016, recognising the significance of the concerns expressed by the Dept of Defence and Defence Forces in the oral submission of 22 April 2016.

PARA 2 The Dept of Defence welcomes the opportunity to respond to the three reports and provide clarification where required. In order to put this reply into context, it is perhaps beneficial to briefly describe in broad, non-technical layman's terms how a large helicopter (such as a 6.8 tonne Air Corps AW139 helicopter) performs an approach to land, take-off, departure and climb-out. Some other activities the Air Corps performs with the Naval Service and Army at Haulbowline will also be briefly mentioned.

PARA 3 As a helicopter arrives in the general vicinity of the intended landing site (in this case the Main Square at Haulbowline), the approach phase commences with a "high recce". The high recce is a large orbit of the landing area at approx 500-1,000 feet above ground level (depending on cloud height). The orbit is performed using a radius of roughly 800-1,000 m from the landing site. The high recce is used to assess the wind and likely directions of approach and departure, and to ensure the general approach area, landing area and departure area is clear. The helicopter then descends down to approx 200-300 feet above ground level (depending on local obstacles) in order to perform a "low recce". The low recce is performed closer to the landing area, again in an orbit, and is used to confirm wind direction, and confirm that the landing area is clear, amongst other things. The helicopter then climbs back up to approx 500 ft above ground level while positioning out to a point approx 2 km from the landing site in order to perform the final approach, which is always performed into wind. During the final approach the helicopter descends from 500 feet to ground level, with speed gradually reducing to 40 knots and then much slower during the latter stage of the approach to land. For take-off, the helicopter will initially perform a vertical climb clear of the obstacles (buildings around the Main Square) and then depart into wind. The helicopter must be maintained into wind during the departure and climb-out until a safe speed is reached which will allow the helicopter to continue flying on one engine should a single-engine failure occur during take-off. Approx 1-2 km is required for the departure climb-out, depending on the wind strength.

PARA 4 During the approach into a landing site, if an engine failure occurs the helicopter is still able to fly on the remaining good engine. Unless very low when it occurs, the landing is aborted and the helicopter is flown back up to a safe altitude. During this emergency manoeuvre the climb back to altitude is performed with a shallow climb gradient, as it takes much longer to climb on only one engine due to less power.

PARA 5 If the Air Corps are cargo-slinging with heavy loads hanging underneath the helicopter, for example moving heavy equipment or replenishing ships, the approach is performed with a much flatter gradient, that is the helicopter must descend earlier, further out and a flat approach is flown. The same is true of a departure with an under-slung load. As well as cargo-slinging, the Irish Air Corps also operates with the Naval Service and Army at Haulbowline in tasks ranging from marine counter-terrorism (Haulbowline is used as the staging base for counter-terrorism training and operations for the Kinsale Gas Fields and commercial shipping into Cork harbour), air-sea rescue winching, sea-going tests and evaluations of Naval Service vessels for simulated air attack, helicopter training of Naval Service personnel, and so on.

PARA 6 At Roches Point, just south of Haulbowline, and at Cork Airport, the last 10 years of Met Eireann data shows the mean wind direction to be 217 degrees, or South-South-West. Therefore helicopters make approaches in a SSW direction to Haulbowline most of the time, with the plume from the proposed Indaver facility blowing towards Haulbowline, ie. into the path of a landing / taking-off aircraft.

With the above in context the three response reports will now be addressed.

ARUP REPORT

1. The Dept of Defence welcomes Indaver's commitment to install lighting as per the Dept of Defence submission, should the proposed facility be constructed.

2. The ARUP response is correct in stating that there are a number of existing industrial facilities in the Cork Lower Harbour area, and other obstacles in the general area of Haulbowline. However none of the existing facilities or obstacles affect approaches/departures from Haulbowline, as the existing stacks are between 2-3 km from Haulbowline, and all other obstacles are relatively low-level and are easy to see and avoid. However as previously stated (and listed as a contributory factor in the helicopter engine-failure accident in Dublin in the 2004 AAIU Report), the emissions coming from the proposed Indaver facility may not be visible at all times, and therefore the ability to see and avoid the plume may not be possible. This difficulty is compounded when Night Vision Goggles are in use. The proposed Indaver facility is located far closer (900m) to Haulbowline than other existing stacks, and therefore is

within the distance required for approaches, departures and other operations into Haulbowline.

3. Various references are made to the Irish Aviation Authority Rules of the Air Order (SI 72/2004) requirement to avoid obstacles by 150m / 500 feet, and considerable effort is made in the report to identify various buildings, pylons and other structures in vicinity of Haulbowline, stating that they all must be avoided by 500 feet. There are two major flaws with this assessment:

   a. The Irish Air Corps is a military aviation organisation as the aviation arm of the Irish Defence Forces. In accordance with the Air Transport & Navigation Act (1946) and the Irish Aviation Authority Act (1993), the Irish Aviation Authority Rules of the Air Order (SI 72/2004) does NOT apply to military aircraft. The Irish Air Corps therefore is in no way bound by the Irish Aviation Authority's civil aviation rules, and therefore the above mentioned requirements do not apply to Irish Air Corps military aviation activities. The Irish Air Corps operates under the direction of the Director, Military Aviation and is bound by the Irish Air Corps Air Regulations Manuals under the Defence Acts. However, it is the policy of GOC Air Corps to operate to best practice civil aviation rules when possible.

   b. The 500 ft requirement in SI 72/2004, in accordance with paragraph 3(a) of that Order, does not apply to an aircraft while it is landing or taking-off. The concern of the Irish Air Corps relates to helicopters that are landing and taking-off at Haulbowline, and therefore the 500 ft requirement to avoid obstacles as mentioned throughout the Arup report is not applicable.

4. The report states that when a 1,000 ft avoidance area is applied to the proposed Indaver stack, there is still 695m from this avoidance area to Haulbowline. As described above, a large helicopter requires much more than 695m for landing and taking-off, especially if under-slung load operations are being performed.

5. Finally the report states that a "1,000 ft avoidance zone is unnecessary" due to the risk height above the stack reaching to 100m (330 feet) while a 500 ft limit is in place for obstacles clearance. Aside from the fact that as already stated the 500 ft limit does not apply to aircraft landing or taking-off, such as occurs at Haulbowline, it is considered best safety practice to apply a safety margin above a known high-risk hazard. Thus, if the high-risk zone of the plume rises to 100m (330 ft) above the stack (as estimated by Indaver), it would be reckless to operate an aircraft anywhere close to that high-risk zone, and therefore a safety margin is applied. This safety margin or safety buffer is applied from the top of the high-risk zone, ie. it is treated as if it were a solid obstacle.

To explain this by way of an analogy, it would be possible in theory to fly from A to B at 2 feet off the ground. In theory this would be safe as an aircraft would be 2 feet clear of obstacles. However in reality flying at 2 feet above obstacles would be extremely dangerous. Therefore in aviation a safety margin is applied, and in the case of Irish civil aviation this margin is 500 feet, ie. even though in theory it would be possible to fly at 2 feet above the ground, in order to ensure safety an aircraft is not permitted to fly lower than 500 feet above the ground. Relating this back to the Indaver stack, if the known height of the high-risk band extends to 330 feet above the chimney top, this is considered the top of the obstacle height, and to ensure safety a safety margin or buffer must be applied above this. It is accepted that now that as the actual height of the high-risk zone is known (as per Dr Porter's report), the standard obstacle clearance height of 500 ft may be applied to the top of the plume high-risk height. Therefore the avoid area would be the stack height (245 ft) + plume risk height (330 ft) + obstacle clearance (500 ft) = 1,075 feet. Therefore it is the opinion of the Dept of Defence that the avoidance zone of 1,000 ft as originally submitted is in fact very necessary.

Access

6. The statement in the Indaver response "there are no scenarios for which the evacuation of Haulbowline would be required" appears to avoid the kernel of the matter. That being that in the event of an accident at the proposed facility where the area becomes hazardous, the sole route of travel from the Naval Base would be towards the hazard.

7. Of paramount importance is the necessity for the Naval Base to remain fully operational 24/7. If for some reason the sole egress route from the Naval Base was inaccessible even for a short period due to a hazard, Naval Operations would be negatively affected, for example the NS Diving Team is on call 24/7 for missing persons searches and must have road egress from the base throughout to fulfil their operational duties.

8. There are over 1,000 personnel whose place of work is at the Naval Base including approx 200 personnel who reside on the base. There is concern that the workers, duty personnel and inhabitants of Haulbowline would have to be constrained on the Island while a hazardous situation is being dealt with.

9. It should also be noted that lack of a designation for the proposed facility as a SEVESO establishment does not mean that there is zero risk of a possible need for evacuation from the vicinity of the plant. Indaver themselves have identified this very scenario in the Natura Impact Statement, Appendix 13: Hazard Identification and Risk Assessment, when it is stated that a major leak from the ammonia tank would require people in the vicinity to either take shelter or evacuate the area. The south of the Naval Base is within

thermal exhaust plumes in the vicinity of airports may pose a unique hazard to aircraft in critical phases of flight (particularly takeoff, landing and within the pattern) and therefore are incompatible with airport operations." Haulbowline Naval Service base is not an airport but is used as such by the Irish Air Corps when required, with helicopters conducting takeoffs, landings and visual circuits (patterns), amongst other activities. Therefore the proposed location of the Indaver stack would be considered as creating a hazard to aircraft according to this Federal Aviation Administration publication.

16. The report also fails to refer to the FAA Position Paper issued in 2014 which preceded the 2015 Memorandum, in which it states "*The study indicates exhaust plumes can create hazards for aircraft in a limited area above the stack in terms of turbulence caused by upward motion of the plume and reduced oxygen content inside the plume. The reduced oxygen is not a danger to pilots, but could cause failure of helicopter engines if hovering over the plume. It also indicated that weather conditions are an important factor in the size of the risk area. The conditions which create the largest risk area are calm winds, low temperatures, and neutral or stable stratification of the atmosphere.*" While it would not be envisaged that a helicopter would be hovering over the stack, on final approach the airspeed of the helicopter would be reduced from 140 knots to 40 knots indicated airspeed (V_{BLSS} for a Performance Class 1 approach) in the vicinity of the stack, which in terms of helicopter speed over the ground is almost akin to a hover, placing the helicopter at risk of engine failure, in a similar manner as occurred to the helicopter in Dublin in the 2004 Air Accident Investigation Unit report. In addition, weather conditions in the vicinity of Cork harbour have already been described to this Hearing by other parties, and the conditions described above which create the largest risk area are frequently met in the Ringaskiddy/ Haulbowline area.

AWN Report

17. The Dept of Defence welcomes the AWN report by Dr Porter, as it reinforces the position expressed by the Dept in the oral hearing submission. The report states that the high-risk area rises to a height of 100 m (approx 330 ft) above the chimney. As the report states, this is based on computer modelling developed by the MITRE Corporation, and using computer-generated weather conditions (ie. it is not based on testing an actual jet engine above a chimney). As previously mentioned, in order to apply safety risk mitigation, this computer-generated high-risk zone up to 330 ft must have a safety margin applied to ensure safe separation from the known high-risk zone. Such a safety margin allows for un-modelled environmental effects (eg. the known meteorological inversion which occurs in the Cork area) and inaccuracies with the computer-generated data. As detailed earlier in this reply, now that the height above the stack of the high-

risk area is known, the standard aviation safety margin of 500 ft may be applied between the top of the plume risk-height and safe aircraft operating height, which comes to 1,075 feet above ground level.

18. This also supports the updated (April 2014) official US Dept of Transport Aeronautical Information Manual, which states in para 7-5-15 a. "Flight hazards exist around thermal plumes.... These hazards are most critical during low altitude flight, especially during takeoff and landing."

Final Comments & Conclusion

The Dept of Defence position on the Indaver facility has not changed. The construction of such a facility in such close proximity to Haulbowline Naval Service base creates a flight safety hazard to Irish Air Corps helicopter operations. Risk management involves controlling the risks created by hazards where uncertainty exists. Uncertainty surrounds the potential effects on helicopter jet-engines operating in the vicinity of the proposed Indaver stack. Considering the catastrophic consequences of a helicopter suffering a double engine failure with 15 people on board, in the light of such uncertainty, robust risk controls would need to be introduced to ensure safe military aviation operations at Haulbowline. Such risk control measures will impact on the Irish Air Corps' ability to operate helicopters into Haulbowline, depending on local weather conditions. Haulbowline is the Naval Service's only base in Ireland; if the wind is blowing in an unfavourable direction, it is not possible to choose another base. As previously outlined, Haulbowline is an important strategic location for the Irish Defence Forces, with aviation activities performed there including marine counter terrorism, joint Naval Service / Air Corps exercises including simulated attack, cargo-slinging for replenishment of ships at sea, and so on. Therefore restrictions on the Irish Air Corps' ability to operate with the Naval Service at Haulbowline is not just a local issue but carries strategic implications for the State.

This concludes the Dept of Defence reply to the Indaver reports.

Appendix J Classification of helicopters

The generally accepted classification of helicopters is by maximum gross weight, and has four categories. It should be pointed out these are not recognised terms used by European Aviation Safety Agency (EASA). However, the table below, from Global Aircraft Market is generally accepted, internationally. At a maximum gross weight (normal operations of 6,400 kg or 6,800 in the cargo sling mode, the Air Corps version of the Agusta fits in the medium class, in this classification.

WEIGHT TITLE	**Maximum Take-Off Weight (MTOW)**
LIGHT HELICOPTER	≤ 3,175 kg (7,000 lb)
INTERMEDIATE	> 3,175 kg, but ≤ 5,700 kg (12,500 lb)
MEDIUM	> 5,700 kg, but ≤ 9,000 kg (20,000 lb)
HEAVY	> 9,000 kg (20,000 lb)

Appendix K Provision of marked heli pads at military installations

Main Square Haulbowline: no marked helicopter landing point



Main Square, Collins Barracks, Cork

The helicopter “H” can be seen at the centre of the Square



Main Square Sarsfield Barrack, Limerick

Here the helicopter “H” can just be made out on the south side of the Main Square



Appendix L Plots of Air Corps Recce flights

NOTE: There are relatively few areas of the country where Secondary Surveillance Radar (SSR) coverage extends to a sufficiently low altitude to allow these low-level recce circles to be captured, as shown in the following diagrams. Because both these examples are in Co Clare, and the Limerick area also, which is well covered by the Gallows Hill SSR, it was possible to capture these events. The poor national coverage, allied with other technical problems in capturing such data, is the reason why only these examples were found, within the available time frame, for inclusion in this report.

Air Corps Agusta 139, callsign AC112, tail number 276, approach to Quilty, Co Clare 22 April 2017



Air Corps Agusta 139, callsign AC112, tail number 276, approach to Quilty, Co Clare 22 April 2017 and landing site recce.

The red circle has a radius of 500 meters



Air Corps Agusta 139, callsign AC112, tail number 276, approach to Knockalough near Kilmihil, Co Clare on 23 April 2017 and landing site recce.

The red circle has a radius of 400 meters



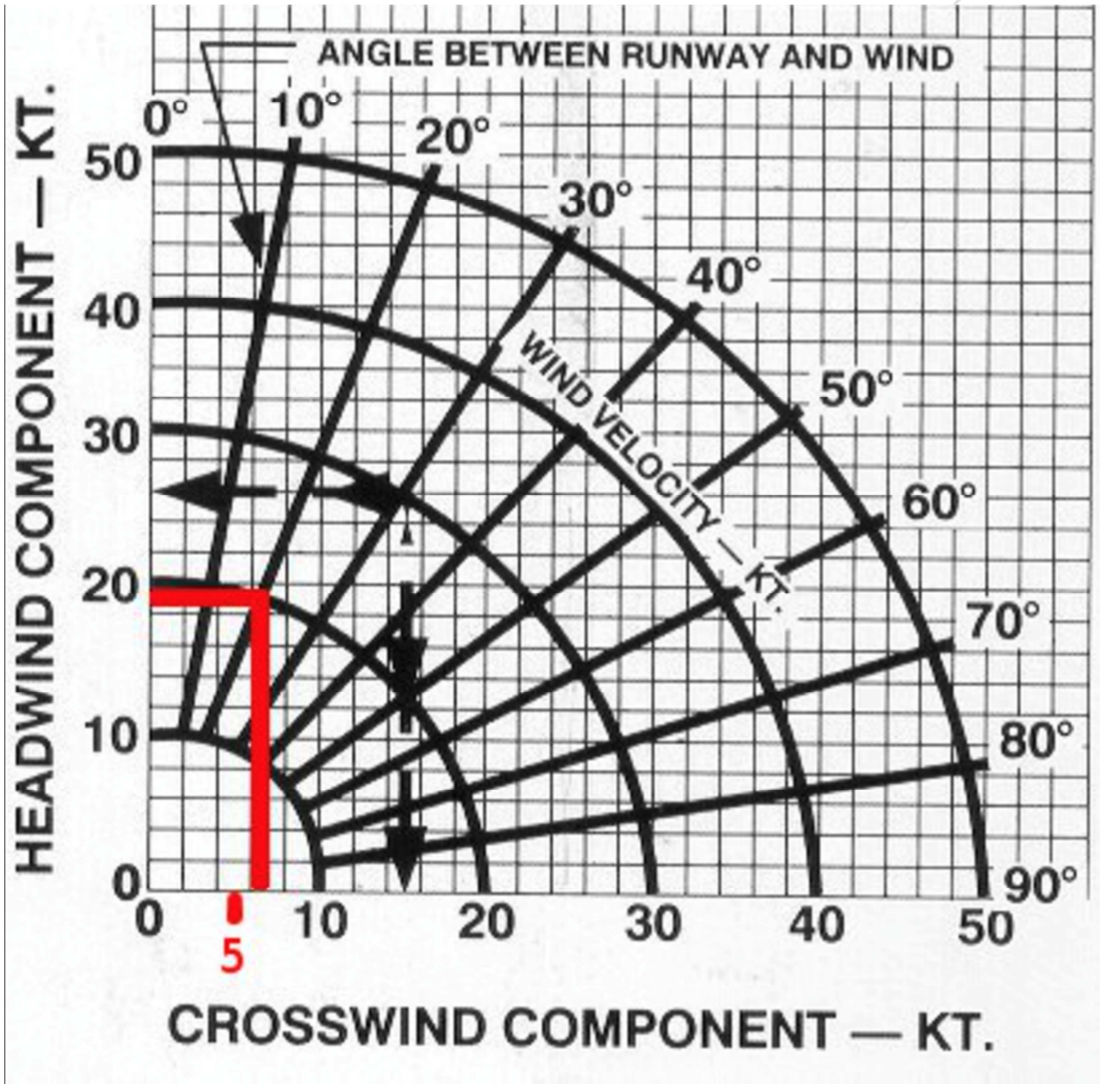
Air Corps Agusta 139, callsign AC112, tail number 276, approach to Limerick Regional Hospital on 22 April 2017, standard positioning for into wind landing, without conducting a close in recce.

The red circle has a radius of 1,250 meters



Appendix M Crosswind component

This chart is used for calculating the cross-wind and head-wind components. In the red lined case below, if the wind speed is 20 kts and it is 20 degrees off the take-off or runway heading, then the resulting cross-wind component is 6 kts and the head-wind component is 19 kts.



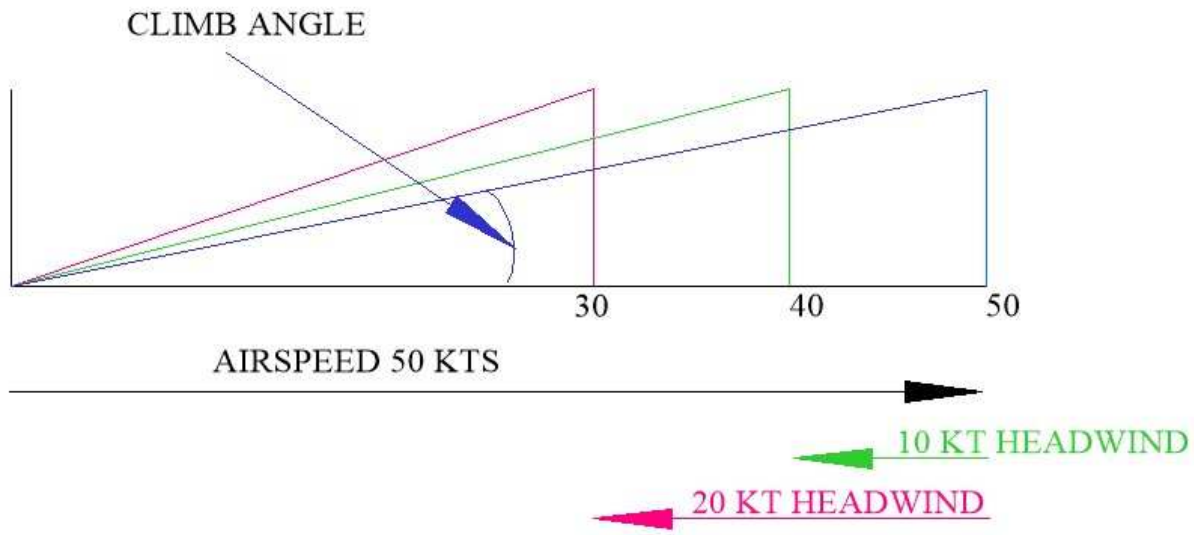
AGUSTA 139 AVAILABLE TAKE-OFF SECTOR VS WINDSPEED

Using this Chart, the angular width of useable take-off sector, within which the cross-wind component will not exceed 20 kts, (the limit for the Agusta 139) can be obtained. The results are shown below:

WIND SPEED	WIDTH OF USEABLE TAKE-OFF SECTOR
50	48°
40	61°
30	180
20	180°
10	180°
0	360°

Appendix N Effect of Headwind on Climb Angle

The diagram below shows the effect of a headwind on a climb angle. If the helicopter is flying at 50 kts with zero headwind and a rate of climb of 1,000 ft per minute, the climb angle will be as indicated by the blue line (approx. 11°). If the helicopter is flying at 50 kts airspeed but with a headwind of 10 kts, the ground speed will be 40 kts and the climb angle will be the green line (approx. 14°). If the helicopter is flying at 50 kts airspeed but a headwind on 20 kts, the ground speed will be 30 kts and the climb angle will be the red line (approx. 18°).



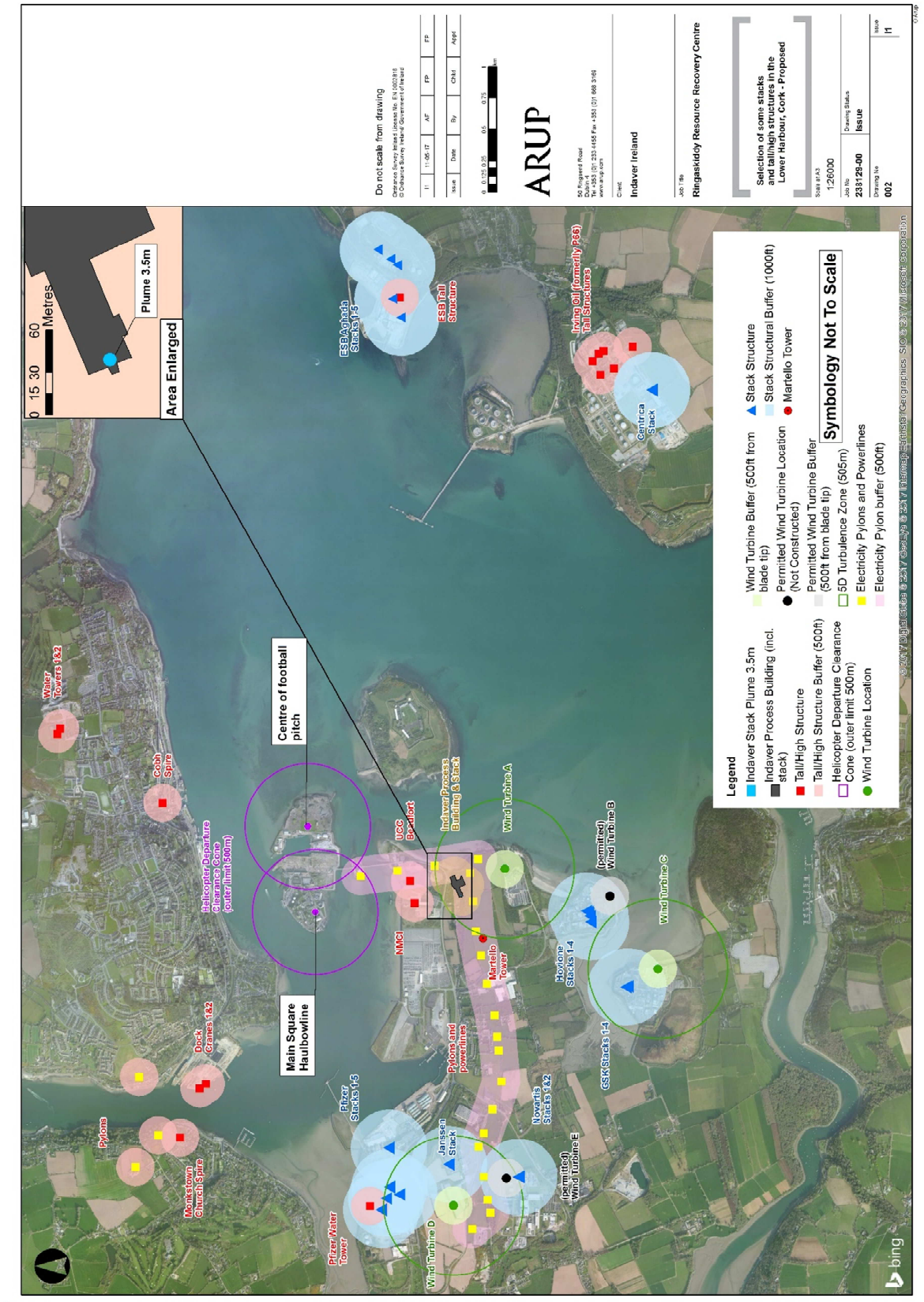
Appendix O Cork Harbour with 500 ft Radius Area and 500 meter Circles

This Appendix shows all the significant obstacles in the Cork Harbour area, with an orange pink circle representing, to scale, the extent of a 500 ft obstacle clearance circle drawn around the top of the stack of the proposed plant. The Appendix also two green circles centres on the Main Square and the Football Field respectively. These circles have a radius of 500 meters and represent the limit of the 6° cone used by the UK Armed Services Joint Standards, whichis used in helicopter operations as described in Para 6.4.16.3, et al, above. These circles are significant in that, within the circles, the 6° cone must be clear, and when the helicopter has reached the 500-meter circle, it is capable of turning in any direction to avoid obstacles outside the circle. The image shows that the pylon on Rocky Island is the only obstacle within these circles, and as show in Appendix P, it does not impinge into the 6° cone.

The 500-meter circle is also significant with regard to the circling recce, in that in the two cases noted in Para 6.4.4, (Quilty and Knockalough) the actual Air Crops recce circles were conducted within a 500-meter circle of the landing point, as opposed to the 800 – 1,000 meters claimed in the DOD submission.

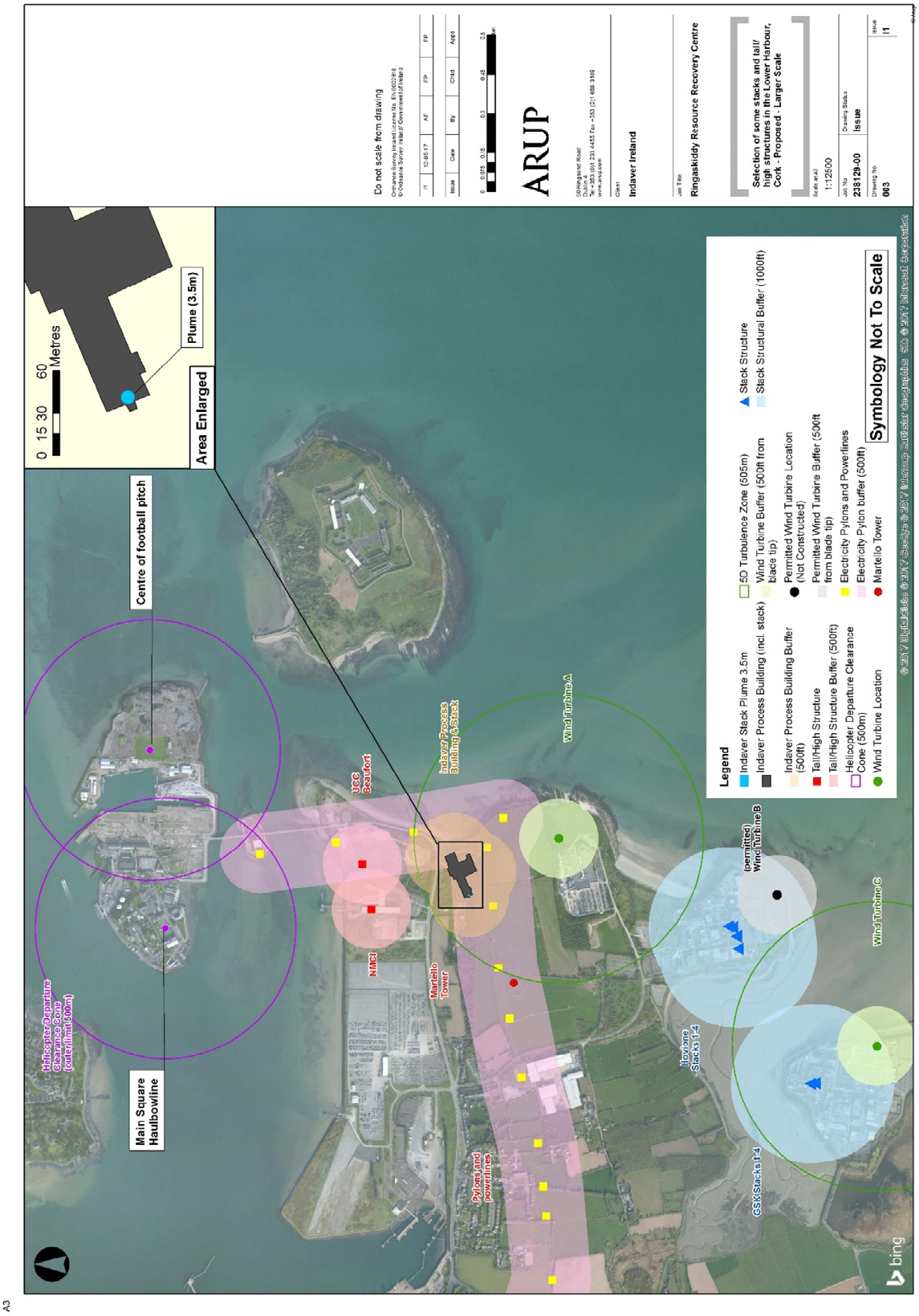
The image shows the 3 existing wind turbines located in the sector south to west of the NS base and also 2 new turbines which has been granted permission.

As can be seen on this image, the area around Ringaskiddy, had a very high density of obstacles, several of which are much higher than the proposed stack. The area is clearly not suitable, in its current configuration, for low level helicopter operations. The proposed plant would not place any further restrictions on the operations of helicopters in this area.


Do not scale from drawing
ARUP
Indaver Ireland
Ringaskiddy Resource Recovery Centre
Selection of some stacks and tall/high structures in the Lower Harbour, Cork - Proposed
Area Enlarged
Plume 3.5m
0 15 30 60 Metres
Centre of football pitch
Main Square Haulbowline
Legend
Symbology Not To Scale
Indaver Stack Plume 3.5m
Indaver Process Building (incl. stack)
Tall/High Structure
Tall/High Structure Buffer (500ft)
Helicopter Departure Clearance Cone (outer limit 500m)
Wind Turbine Location
Wind Turbine Buffer (500ft from blade tip)
Permitted Wind Turbine Location (Not Constructed)
Permitted Wind Turbine Buffer (500ft from blade tip)
5D Turbulence Zone (505m)
Electricity Pylons and Powerlines
Electricity Pylon buffer (500ft)
Stack Structure
Stack Structural Buffer (1000ft)
Martello Tower
Water Towers 1&2
Cobh Spire
Helicopter Departure Clearance Cone (outer limit 500m)
Dock Cranes 1&2
Pylons
Monkstown Church Spire
Pfizer Water Tower
Pfizer Stacks 1-5
Janssen Stack
Wind Turbine D
Pylons and powerlines
Novartis Stacks 1&2
(permitted) Wind Turbine E
GSK Stacks 1-4
Novartis Stacks 1-4
(permitted) Wind Turbine B
Wind Turbine C
Wind Turbine A
Indaver Process Building & Stack
UCC Beaufort
MMCI
Martello Tower
ESB Aghada Stacks 1-5
ESB Tall Structure
Irving Oil (formerly P66) Tall Structures
Centrica Stack
bing

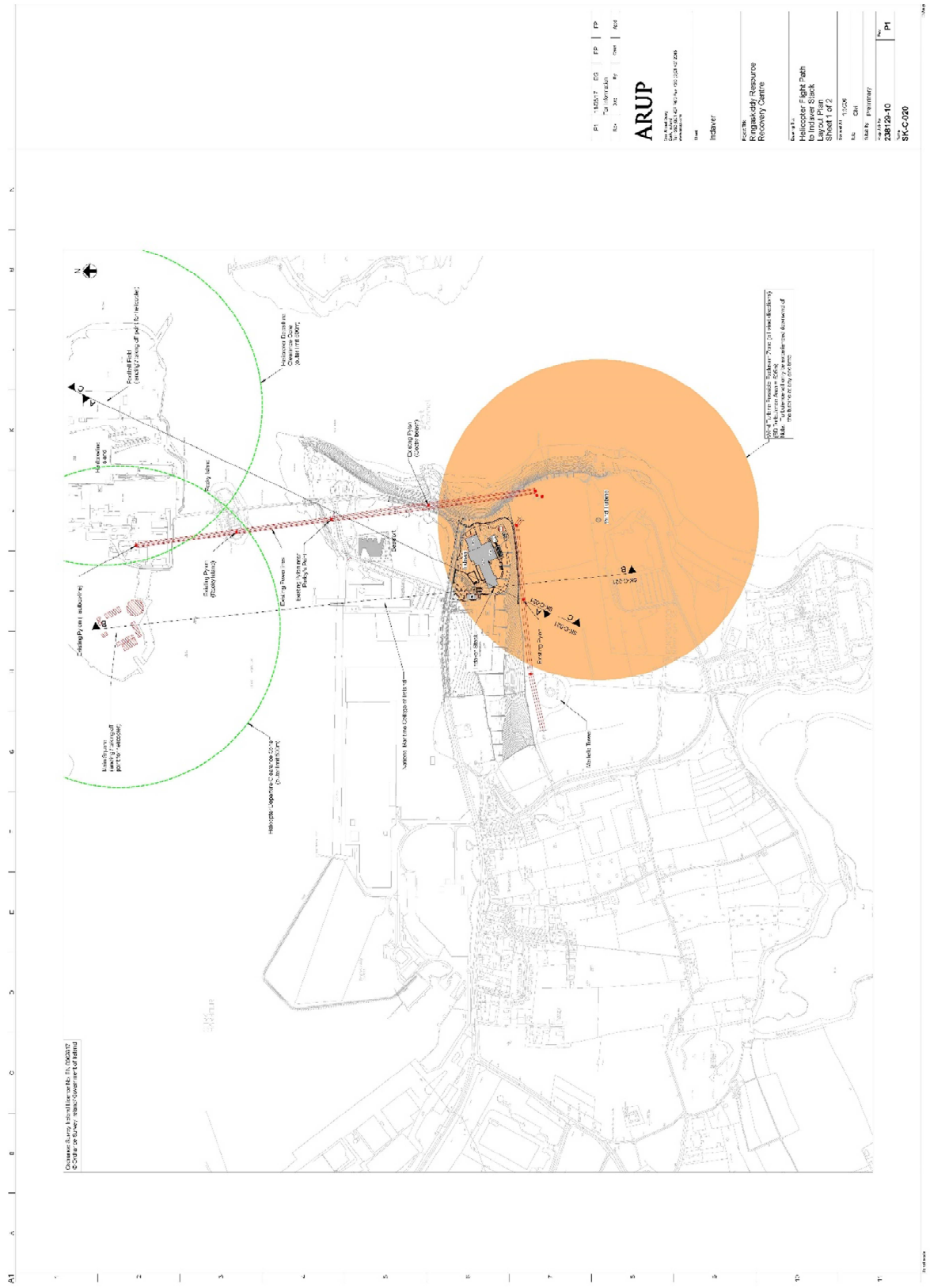
The next image shows the NS base area in close up, and clearly shows that a significant clearance exists between the 500 meter radius limits of the 6° clearance cone and the proposed plant, and between these radius limits and a 500 ft obstacle clearance area around the plant.

The inset in the top corner, is the proposed plant shown at an increased scale. The blue circle in this enlarged inset is the 3.5 meter radius circle showing the maximum possible extend of the possible dangerous area surrounding the top to the proposed stack, as discussed in Para 6.27.1. The corresponding small blue circle in the main diagram clearly shows the very limited extend of this danger area in relation to the NS base and other obstacles in the area.


Do not scale from drawing
ARUP
Indaver Ireland
Ringaskiddy Resource Recovery Centre
Selection of some stacks and tall/ high structures in the Lower Harbour, Cork - Proposed - Larger Scale
1:12500
218129-00
Issue
003
Area Enlarged
Plume (3.5m)
0 15 30 60 Metres
Centre of football pitch
Main Square Haulbowline
Helicopter Departure Clearance Cone (outer limit 500m)
UCC Beaufort
NMCI
Martello Tower
Indaver Process Building & Stack
Wind Turbine A
(permitted) Wind Turbine B
Wind Turbine C
Pylons and powerlines
GSK Stacks 1-4
Bioyione Stacks 1-4
Legend
Indaver Stack Plume 3.5m
Indaver Process Building (incl. stack)
Indaver Process Building Buffer (500ft)
Tall/High Structure
Tall/High Structure Buffer (500ft)
Helicopter Departure Clearance Cone (500m)
Wind Turbine Location
5D Turbulence Zone (505m)
Wind Turbine Buffer (500ft from blade tip)
Permitted Wind Turbine Location (Not Constructed)
Permitted Wind Turbine Buffer (500ft from blade tip)
Electricity Pylons and Powerlines
Electricity Pylon buffer (500ft)
Martello Tower
Stack Structure
Stack Structural Buffer (1000ft)
Symbology Not To Scale
bing

Appendix P Helicopter 6° Take-Off Cone

This diagram shows the flight paths from the Main Square to the proposed plant, and from the Football Field to the proposed plant. The red line is the high power line leading from the mainland, over Rocky Island to the NS base on Haulbowline, , which continues on a line east-west on the high ground directly south of the proposed plant. The orange circle is the 5D circle from the existing Wind Turbine A, which is the area in which severe turbulence from the wind turbine may be expected. The diagram shows that the wind turbine turbulence danger zone completely envelopes the proposed stack and plant.


ARUP
Ringaskiddy Resource Recovery Centre
Helicopter Flight Path to Indaver Stack
Layout Plan
Sheet 1 of 2
238129-10
SK-C-020
P1
Indaver
Helicopter Operations Area (Daytime Only)
Existing Chimney Stack
Existing Turbine Hall
Existing Tipping Hall
Existing Tipping Floor
Existing Control Room
Existing Workshop
Existing Switchroom
Existing Transformer
Existing Lighting Mast
Existing Fencing
Existing Gate
Existing Road
Existing Footpath
Existing Boundary
Existing Building
Existing Tree
Existing Hedge
Existing Wall
Existing Fence

The next diagram shows the elevation views on the flight path lines from the NS base to the proposed plant. The 6° clearance cone used by the UK Joint Standards, and the 500 meter limit of this cone, is also shown in these elevations.

Section AA is the elevation from the flight path, from the Football Field to the proposed stack, looking to the north-west, i.e. to the right of the flight path.

Section CC is the elevation from the flight path, from the Football Field to the proposed stack, looking to the south-east, i.e. to the left of the flight path.

Section BB is the elevation from the flight path, from the Main Square to the proposed stack, looking to the east, i.e. to the left of the flight path.

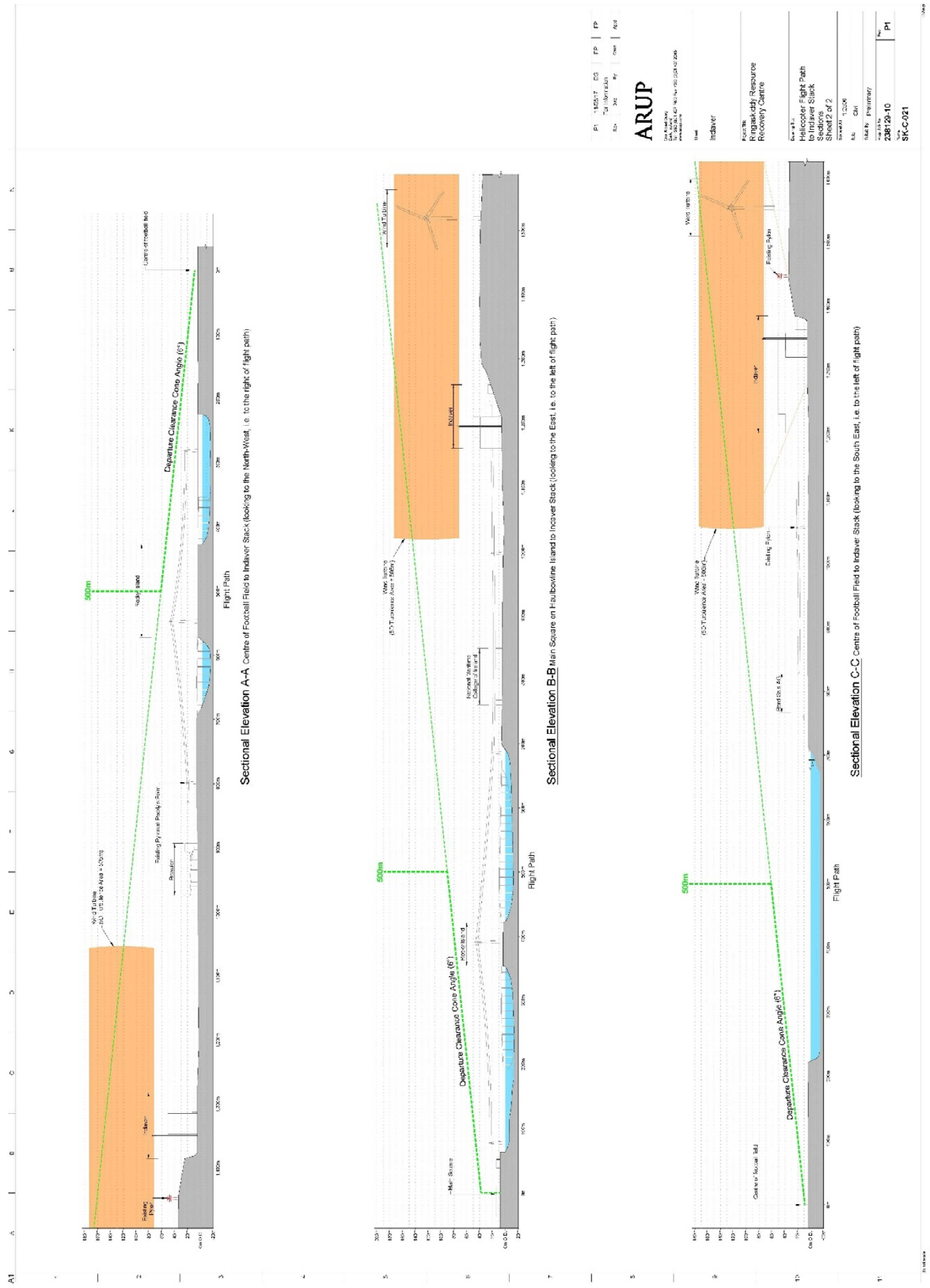
The elevations clearly show that:

There is no obstacle which penetrates the clearance cone. The high pylon on Rocky Island comes closest to penetrating the cone.

The proposed stack is well clear of the extended 6° cone.

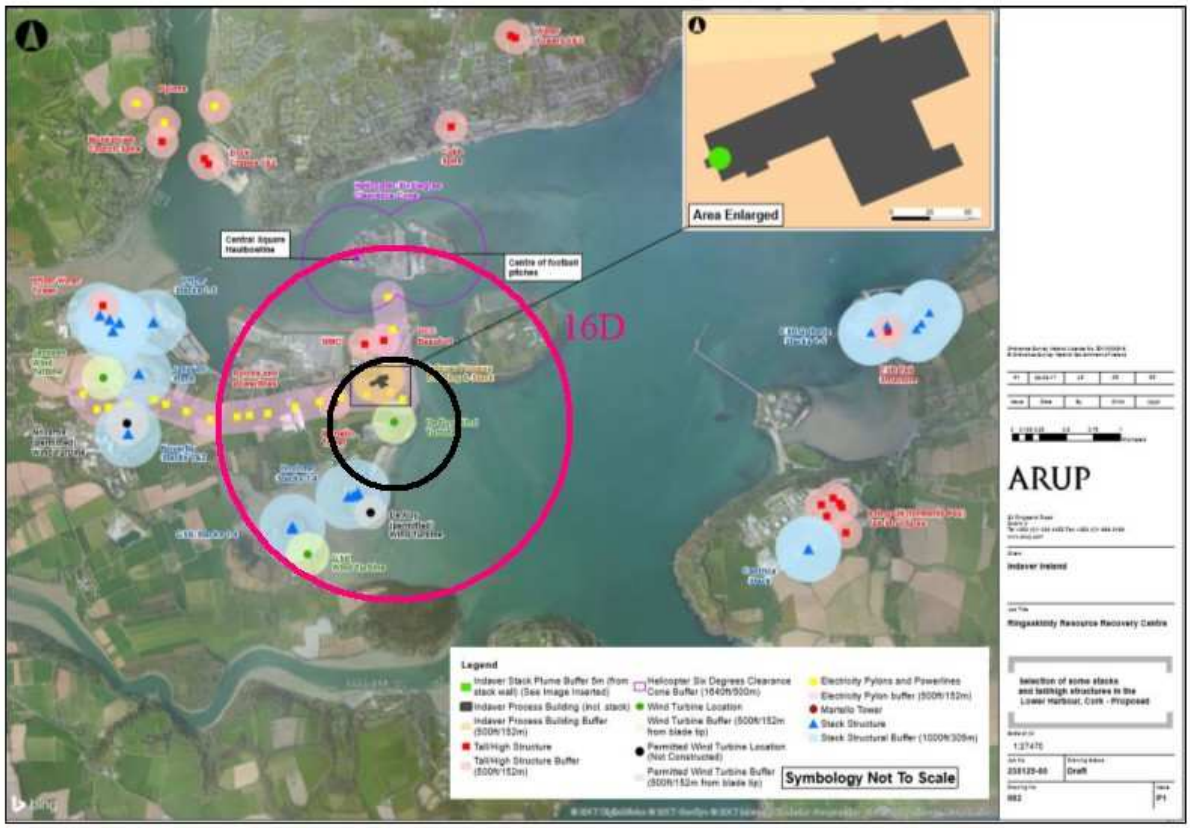
Wind Turbine A comes close to penetrating the extended cone.

The 5D turbulence danger zone from Wind Turbine A completely envelopes the proposed stack and plant, and is, by far, the dominant hazard in the area.


ARUP
Indaver
Ringaskiddy Resource Recovery Centre
Helicopter Flight Path to Indaver Stack Sections Sheet 2 of 2
238120-10
SK-C-021
P1
Sectional Elevation A-A Centre of Football Field to Indaver Stack (looking to the North-West, i.e. to the right of flight path)
Sectional Elevation B-B Main Square on Haulbowline Island to Indaver Stack (looking to the East, i.e. to the left of flight path)
Sectional Elevation C-C Centre of Football Field to Indaver Stack (looking to the South East, i.e. to the left of flight path)
Departure Clearance Cone Angle (6°)
Flight Path
500m
Existing Pylon
Existing Poles
Existing Pylons
Wind Turbine
Existing Poles
Centre of Football Field
Main Square
Haulbowline
Naval Base
Spike Island
Rocket
Rocket
Wind Turbine
Wind Turbine

Appendix Q Turbulent area due to wind turbine

This image shows the horizontal limits of the turbulence zones from Wind Turbine A. The black circle indicates the 5D limit where dangerous turbulence can be expected, while the red zone indicated the 16D limit where turbulence can be expected. The 16D limit indicates and area where the turbulence would not be dangerous, but could be problematical when conducting underslung load operations.



This photo shows the eddies, turbulence and misting effects that can be created by wind turbines



Appendix R Restricted Airspace in Ireland

Various IAA documents, principally SI No 806 of 2007, denote various kinds of airspace in Ireland which are restricted zones. The following are relevant to this report:

Prohibited Area: An airspace of defined dimensions, above land areas or territorial waters of a state, within which the flight of aircraft is prohibited. Typically, some prisons and other installations.

Danger Area: An airspace of defined dimensions within which activities dangerous to the flight of aircraft may exist at specified times. These are military firing ranges. These is an air firing range near Gormanston Co Meath, a Naval gunnery range near Galley Head in Co Cork, another West of Dursey Island, an Army range in the Glen of Imall, etc.

Military Operational Area (MOA): means a restricted area for use by aircraft of the Defence Forces within which the flight of civil aircraft may be restricted in accordance with such standing criteria as are specified by the Authority in relation thereto and published in the Aeronautical Information publication. These areas are mostly located west of Casement.

Restricted Area: means airspace of defined dimensions in a designated area above the land areas or territorial waters of the state, within which the flight of civil aircraft is subject to specified restrictions. Examples are located in the area of Casement and Finner camp.

Temporary Restricted Areas: are short term restricted areas placed around large public event, secure areas where foreign dignitaries visit etc.

I am not aware of any restricted areas, or “exclusion zones” placed around industrial plants or similar structures in Ireland. The basis for this appears to be that if the Rules of the Air regarding obstacle clearance, are observed, then such installations will not pose a danger to aircraft.

The foregoing does not deal with controlled airspace around civil airports.

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