Case Nos.: 16-036/13-037/16-038/16-039/16-040/16-042

ENVIRONMENTAL REVIEW TRIBUNAL

B E T W E E N:

GAIL AND KEVIN ELWOOD AND PRESERVE CLEARVIEW INC

Joint Appellants

- and –

DIRECTOR, MINISTRY OF THE ENVIRONMENT AND CLIMATE CHANGE

Respondent

WITNESS STATEMENT OF Keith Edward Green

Aircraft Engineer and Aviation Consultant
QualaTech Aero Consulting Ltd.
720 Long Harbour Road, Salt Spring Island. BC. V8K 2L6
250-213-5025

INTRODUCTION

1. I have no personal interest in the outcome of this appeal. I intend to appear before the Environmental Review Tribunal and be subject to direct examination and cross-examination. My evidence will be factual and opinion evidence. I have read the ERT's Practice Direction for Technical and Opinion Evidence and I provide this statement in accordance with that Practice Direction. Attached as **Exhibit "1"** to this witness statement is a Form 5 that I signed in accordance with the ERT's Rules of Practice.

AREA OF EXPERTISE

2. My area of expertise is in Aviation Safety Management Systems, inclusive of Hazard and Risk Assessment and aerodrome/airport safety.

POSITION AND QUALIFICATIONS

3. I presently hold the position of President and Senior Principal Consultant of QualaTech Aero Consulting Ltd.

4. A copy of my current *curriculum vitae* is attached as **Exhibit “2”** to this witness statement.

5. My expertise as a aviation Consultant includes (principal areas only): 1) Auditing of Airports, AMOs, Flight Operations both Fixed & Rotary Wing. 2) Establishing SMS, QMS and other assorted aviation systems & programmes. 3) Assessing SMS. 4). Training in: SMS, QMS, HRA, Human Factors, ERP and Auditing. 5. Conducting Hazard & Risk Assessments. 6) Aircraft Maintenance and Inspections. 7). Writing Airport and other Enterprise Control Documents. 8) Aerodrome preparation for Certification. 9) Safety Case. 10). Water Airports.

6. In my capacity as a Senior Principal Consultant of I routinely undertake the following as major assignments for Clients:

   a) manage and complete approximately 25 projects per year related to aviation, and assorted systems & programmes;

   b) design and provide training courses in assorted disciplines to aviation enterprises, inclusive of Hazard & Risk Assessment;

   c) review and write enterprise control documents;

d) audit enterprises for compliance and perform assessments for SMS;

e) conduct HRA & Root Cause Analysis.

CHRONOLOGY OF INVOLVEMENT AND DOCUMENTS REVIEWED

7. I was contacted by Counsel for the Appellants on (14 MARCH 2016) and asked to produce a Hazard & Risk Assessment on the Wind Turbine Project proposed for the Stayner and Collinwood area. The HRA is contained with the bounds of a Report Ref. Exhibit “3”.

8. I have reviewed the documents listed in Schedule "A" attached as **Exhibit "3"** to this witness statement.

9. I have prepared the following formal report, Stayner Wind Turbine Report, attached as **Exhibit “4”** to this witness statement.

DATED: 8 April 2016	Keith Edward Green **NAME OF WITNESS**

Environment and Land Tribunals Ontario

☒ Environmental Review Tribunal

☐ Niagara Escarpment Hearing Office

☐ Office of Consolidated Hearings

Acknowledgement of Expert's Duty

Case Name and No.:	16-036 Wiggins v Ontario (Ministry of the Environment and Climate Change

1. My name is Keith Green. I live at Salt Spring Island in the province of British Columbia

2. I have been engaged by or on behalf of Preserve Clearview Inc and Gail & Kevin Elwood to provide evidence in relation to the above-noted proceeding.

3. I acknowledge that it is my duty to provide evidence in relation to this proceeding as follows:

   (a) to provide opinion evidence that is fair, objective and non-partisan;

   (b) to provide opinion evidence that is related only to matters that are within my area of expertise;

   (c) to provide opinion evidence in accordance with the Environmental Review Tribunal's Practice Direction for Technical and Opinion Evidence; and

   (d) to provide such additional assistance as the tribunal may reasonably require, to determine a matter in issue.

4. I acknowledge that the duty referred to above prevails over any obligation which I may owe to any party by whom or on whose behalf I am engaged.

Date ……April 9, 2016……. ……………………………………..

Signature

CURRICULUM VITAE
KEITH EDWARD GREEN

Personal Information:

Name: Keith Edward Green

Address: 720 Long Harbour Rd; Salt Spring Island; BC. Canada. V8K 2L6

Telephone: (M) 1-250-213-5025

E-mail: k.green@qualaTech.ca

Relevant Professional Qualification:

Canadian TC Aircraft Maintenance Engineer (AME)	***M 259947***
Category "M" (Maintenance)	***M1 & M2***
Category "S" (Structures)	***S –33****
Type Ratings. (Large Transport listed only)	***B737-100/200/300/400 / DC8-40/50/60 / DC10-10/30***
Minister's Delegate- Maintenance (Transport Canada) (lapsed)	
American FAA (A. & P.)	***A&P 2461694***
American FAA (Inspection Authorisation.)	***A&P 2461694 - I.A.***
Canadian Pacific Airlines Company. ME 22 (Expired)	*A-**723***
Saudi Arabian Airman's Cert. (A. & P.) (Expired)	***M-3093***
TEAM Aer Lingus (IAA) Cert. (Expired)	***MA 1784***
Transport Canada Trained Auditor	

(Formal) Background and Key Experience:

Mr. Green commenced his aviation career as an Aircraft Maintenance Engineer (AME) in Canadian general aviation. In 1980, he joined Canadian Pacific Airlines gaining numerous Type Ratings on modern commercial aircraft before undertaking several overseas assignments with other international carriers. Working abroad as a senior Engineer, he acquired in-depth experience in Maintenance, Engineering, Quality, Production and Management. Throughout his tenure abroad, his experience and qualifications steadily evolved to encompass four National Aircraft Maintenance Licences along with numerous airline Authorisations and Privileges. Currently, Mr. Green maintains only two National Licenses - the FAA Inspection Authorization (IA) and Transport Canada's M1 / M2 & Structural Privilege.

In the mid-90's, Mr. Green joined the British Columbia Government Air Service's Quality/Maintenance department and was later seconded as a Technical Policy Analyst to the BC Provincial Government. During this assignment he was directly involved with several major Government / private industry initiatives, including the Ballard Power (Permeable Membrane Technology) for Methane and Hydrogen based gases within the BC. Alternate Fuels and Emission Program. As a Senior Policy Analyst, Mr. Green not only gained valuable experience working within a large Government body but also learned the importance of promoting energy conservation and sustainability while reducing the 'Carbon Footprint' – long before it was common practice!

As a Member of the Canadian Aviation Regulation Advisory Council (CARAC), Mr. Green has participated in National Regulation/Standard changes and has more recently been involved with the harmonisation between the Canadian Aeronautics Act and the Marine Act. Mr. Green is currently a recognised authority on 'Water Airports' and the transformation of water Aerodromes into Certificated Water Airports.

In 1998, Mr. Green was appointed by The Canadian Minister of Transport to the 'Transportation Appeal Tribunal of Canada (TATC)' serving (as the youngest appointed Member) for over a decade. The TATC sits a single Member during a Tribunal; the Member – unlike a Court Judge the Tribunal Member must decide on both 'Point of Law' and 'Point of Fact'. As a TATC Member, Mr. Green was additionally sanctioned as an 'Appeal Adjudicator' for the 'Canadian Business Aviation Association' (CBAA) program.

More recently, Mr. Green was selected by the ICAO Technical Cooperation Bureau and subsequently appointed to the "Roster of Experts" as a 'Flight Operations' and 'Maintenance Organisations Inspector'.

In addition to Mr. Green's Canadian AME qualifications, he is also an FAA Inspection Authorisation (IA). Other national licences and certifications formally gained included: Saudi Arabia, Ireland and Indonesia. Under Mr. Green's Canadian Licenses, he is also a Structures Category AME with extensive experience in aeronautical repair, modification and manufacturing. Mr. Green has often been called on to act as a General Manager, Director of Maintenance, Person Responsible for Maintenance and Quality Director/Manager with numerous maintenance and airline organisations. Additional to his current AME Licence, Mr. Green was a Transport Canada (TC) Minister's Delegate "M" where he performed Import / Export and other duties as a Transport Canada representative.

In 1997, Mr. Green founded an international aviation consultancy for airports/aerodromes, airlines, air taxi (fixed & rotary wing) and aircraft maintenance organisations. QualaTech has since evolved into a highly respected international aviation Consultancy; recognised by Transport Canada as an "Industry Champion". QualaTech is effectively engaged in the international marketplace, specialising in several aviation & marine disciplines, including but not limited to: Auditing, Safety Management Systems (SMS), Policy/Regulation, Maintenance/Engineering, Quality, Hazard & Risk Assessments, Human Factors, Root Cause Analysis, Incident investigation, Safety Cases, Research, Technical Reports, Requirement Assessments, Wildlife Management Plans, Fatigue Management, Emergency Response Plans, Change Management, Risk Management, Training, Regulation/Law, training and support thereof. Subsequently, Mr. Green's Consulting proficiency is well established among Airport/Aerodromes, Air Operators (rotary and fixed wing), Maintenance Organisations, Manufacturing establishments, Water Airports/Aerodromes and Marine facilities.

Mr. Green is often asked to speak at conferences on subject matter with regard to SMS and QMS. An example of this was in 2011, when the AAAE requested a presentation in the Cayman Islands on SMS. As a Senior Consultant, Mr. Green must be efficient and effective in counselling others and developing cooperative environments based on trust at all levels.

General Overview of Experience:

Mr. Green has undertaken many in-depth safety/quality/operational reviews of aerodromes/airports, airlines, maintenance and aerospace manufacturing organisations as part of an Audit process, inspection and/or surveillance/compliance programme. This also includes Pre-Programme Validation Inspections (PPVI). Audit surveillance activities are not possible without a comprehensive understanding of international and national requirements – inclusive of: operations, quality, safety and various Regulations/Standards (i.e. FARs, JARs, ANOs, CARs, ICAO & ISO documents, etc.). Mr. Green has learned to appreciate the problems encountered by industry and the Regulator alike, allowing him to provide solutions to those working within and under the various regulatory frameworks.

Writing Control Documents, Policy, Reports, etc., is an important component of Mr. Green's daily consulting practice. As a former TATC Member, Mr. Green has written many Determinations which currently serve as Jurisprudence under the Canadian Legal system.

As a Lead Auditor and/or Aviation Risk Assessor working for varied Government and private agencies (i.e. The British Columbia Government Emergency Health Services (BCEHS), BC Hydro Aviation Dept., and the Oil Gas Produces (OGP)) the ability to communicate with a Client is imperative to the success of any assignment but specifically when relating Finding(s), Reviews, Corrective Action Plans and/or conducting 'Root Cause Analysis' of incidents and oversight violations. Understanding Regulatory Requirements within the meaning of 'Prescriptive Compliance' for Companies striving to obtain higher standards "Beyond Minimum Compliance" is critical to effective Consulting.

Mr. Green has written and implemented many SMS, QA Programmes and manuals along with other mandatory Control Documents, including but not limited to: MCM. MPM, AOM, Emergency Response, Bird & Wildlife, SOP's, Work Instructions, Winter Operations Manuals, AVOP, etc. etc. Additionally, Mr. Green is routinely required to provide Hazard and Risk Analysis and Safety Cases for Clients - including complex International Airports.

Mr. Green has achieved several initiatives in North America with respect to SMS and programme training. Mr. Green's Consulting Practice - QualaTech Aero Consulting Ltd., was the first organisation in North America to design and install a functional and compliant SMS at a Canadian International Airport – before regulatory requirement in 2006. Additionally, QualaTech was a leader in providing SMS and Human Factors training to airports; having since completed many national and international assignment. Implementing assorted programmes also means, auditing, reviewing and writing system / policy / procedure manuals which meet the stringent requirements of the Client and the Authority. As a prominent Aviation Consultant, Mr. Green is often contracted to provide Management Guidance at the Board Room level.

Recent work with BCHydro in their Aircraft Operations Department helped the corporation win the converted Airbus award for safety and performance. Furthermore, QualaTech also provided BCHydro with a comprehensive SMS Assessment tool that has significantly raised the 'SMS bar' in safety performance.

Mr. Green has audited many large and small aviation enterprises. This experience combined with practical QA knowledge, augments the work undertaken with various Document Holders. Mr. Green's knowledge of SMS and OH&S is extensive; gaining him a reputation as a Subject Matter Authority.

Mr. Green has established a broad international clientele base, including the Dominican Republic, Jamaica and the USA. Canadian Clients are extensive, which include some of Canada's major airports for which Mr. Green primarily established their SMS & QMS; these include but are not limited too: Victoria, Abbotsford, Kelowna, Calgary, Comox, St. John's, Montreal, Campbell River, Bella Bella, Regina, and Gander International Airport, to name but a few. This past month (March), Mr. Green provided the Thunder Bay Airport Authority with a two day Audit Training Course.

Two of QualaTech's larger international Clients are Advantage Airport Group (formally YVRAS) and AERODOM Siglo XXI (Dominican Republic (DR)), for whom Consulting Services consisting of: SMS, Pre-Certification Assessment & Safety Audits and Safety Training have been completed. Mr. Green provided AERODOM with Safety Oversight Reports for six international aerodromes and was subsequently invited by the Dominican Authority (IDAC) DGAC to comment over their Airport Certification and State Oversight Programme. The aforementioned could not have been accomplished without extensive knowledge of the various Dominican Republic, Canadian and ICAO control documents.

It is worthy of note that the work conducted by QualaTech in the Dominican Republic (DR) contributed to a perfect score as achieved under the ICAO (Dominican Republic - 'Legislación aeronáutica básica') Universal Safety Oversight Audit Programme as audited in 2009. Mr. Green was also requested by the former Canadian Minister of Transport the Honourable Chuck Stralw, to discuss matters of Leadership within TC concerning Safety Management. This was as a direct result of a Report produced by QualaTech over the Victoria Water Airport situation entitled 'Requirements for a Safety Case Air and Water Operations Victoria Harbour.

During his tenure with the TATC, Mr. Green received extensive and comprehensive training in conflict resolution, decision writing, law/evidence and judiciary & judgement training.

Mr. Green is a dedicated educator who not only understands SMS & Quality intimately but is passionate about them, having designed and presented many training courses in SMS and Quality in addition to having produced other training courses in: Leadership, Change Management, Hazard & Risk Assessment, Fatigue Management, Airport Emergency Response Plan, Human Factors and other related aviation/airport areas. In 2010, Mr. Green provided a Human Factor 'Train the Trainer' programme to the Dominican Republic's IDAC (National Authority) and AERODOM Airport personnel.

Mr. Green knows what it means to be proactive and to promote Safety as a Culture. He also understands the diversity between OH&S requirements and those required by national authorities under their SMS components. He has run and provided instruction / training in managing and administrating a Safety Committee along with workshops on Leadership, Hazard Identification and Risk Analysis. Mr. Green is familiar with trend analysis and incident investigation methods.

Current Projects and Initiatives:

Several significant projects and initiatives have been and/are currently being introduced and promoted. The first is a programme under which a 3rd. Party Organisation (i.e. Wyvern or Oil Gas Producers, etc.) will augment their Audit Programme against their Clients via a 'Risk Assessment' under their SMS Risk Management Process'. The advantage is that it provides (in near-real time) a constant and accurate Risk Assessment based on 'near current information' provided by each Client's SMS reporting programme: as opposed to typical out of date audit criteria. It will also majorly reduce liability and cost.

Another initiative is in the application of Drone or UAV Technology for Airport Work, specifically: Bird and Wildlife Management/control, Security and Runway Surveillance (FOD). This project is in coordination with the University of BC, Canada.

Currently Mr. Green is designing a Training Course / Seminar for National Authorities on 'Performance – Based Regulation' (PBR). Mr. Green's is also currently helping one of his Client's to upgrade their airport from a B-2 to a C-3 airport.

Substantive Project Examples:

- AERODOM Siglo XXI. - Aerodrome Safety Analysis and Reports. SMS consulting and council. Human Factors 'Train the Trainer' programme.
- Vancouver Harbour Flight Centre (VHFC-LC) – SMS, QA, Dock Operations Procedures/Policies, Safety Case, Fuel Risk Assessment, Dock Risk Assessment.
- SVH - Victoria Water Airport – "Requirements for a Safety Case Report" (Ref. http://savevictoriaharbour.com/sept23pdf/SC%20Document%20Final%20Ver.pdf for Report in PDF). **Note**: This Report was significant - having been reviewed in the House (Canadian Parliament) to which The Minister of Transport was required to respond. It has since become a principal reference document for a Water Airport Safety Case.
- Leadership Training in SMS & QMS to St. John's International Airport and participants from Aéroports de Montréal.
- Training: January 25th. – 27th. QualaTech presented a QMS Training Course (the fourth) – Victoria BC, Canada.
- Lead Auditor BC Government Air Ambulance Service (BCAS).
- Lead Auditor & Risk Assessor BCHYDRO.
- Risk Assessor BCHYDRO – Aviation.
- Auditor CGG – OPG.

Please Note: *Although reference and examples of work are available for review, the first priority is the protection of a Client's information and subsequent privacy. Therefore, such documents may be cleaned of identifying information but will still be able to substantiate claims.*

In order to reduce document size, all certifications and qualifications are available on request.

SCHEDULE "A"

<u>LIST OF DOCUMENTS REFERRED TO IN WITNESS STATEMENT</u>

1. Best Practices Guidelines for the Irish Wind Energy Industry
2. Civil Aviation Authority, *CAP 168 Licensing of Aerodromes*
3. Civil Aviation Authority, *CAP 738 Safeguarding of Aerodromes*
4. Civil Aviation Authority, *CAP 760 Guidance in the Conduct of Hazard Identification, Risk Assessment and the Production of Safety Cases*
5. Civil Aviation Authority, *CAP 764 Policy and Guidelines of Wind Turbines*
6. Civil Aviation Authority, *Helicopter Wake Encounter Study*
7. Civil Aviation Authority, *Wind Turbine Wake Encounter Study*
8. Cormier, Charles, "Negative Effects to Stayner (Clearview Field) Aerodrome-Fairview Wind Project"
9. Danish Energy Agency, "Wind Turbines in Denmark"
10. Environment Canada, Meteorological Data for Collingwood Station, 2011-2016
11. Environmental Review Tribunal, *Pitt v MOE,* May 14, 2014
12. Eurocontrol, Terrrain and Obstacle Data Manual
13. The European Parliment and the Council of the European Union, Regulations (EC) No 216/2008,
14. International Civil Aviation Organization, *Chicago Convention on International Civil Aviation (1994)* 15 U.N.T.S. 295*, Annex 14, Volume I – Aerodrome Design and Operations*¸July 2013.
15. International Civil Aviation Organization, *Chicago Convention on International Civil Aviation (1994)* 15 U.N.T.S. 295*, Annex 15, Aeronautical Information Services*

16. International Civil Aviation Organization, *Chicago Convention on International Civil Aviation (1994)* 15 U.N.T.S. 295*, Annex 19, Safety Management*

17. International Civil Aviation Organization, *Document 9774, Certification of Aerodromes*

18. International Civil Aviation Organization, *Document 9859, Safety Management Manual*

19. ISO 31010:2009 – Risk Management – Risk Assessment Techniques

20. Kansas Department of Transportation and the University of Kansas, "Wind Farm Turbulence Impacts on General Aviation Airports in Kansas"

21. NLR Air Transport Safety Institute , "Wind Turbines Near Airports, problems and solutions for wind turbine siting in the vicinity of airports"

22. NTSB Identification: CEN14FA224

23. Qualatech Aero Consulting Ltd. , "Requirements for a Safety Case"

24. REPower Wind Turbine Brochure

25. SMS Aviation Safety Inc., *Report No. 1101*

26. SMS Aviation Safety Inc., *Report No. 1307*

27. Stantec, Wind Turbine Specifications Report

28. Transport Canada, *AC 007-02 SMS Development Guide for Small Operators/Organisations*

29. Transport Canada, *CAR Part VI – Wind Turbines and Wind Farms*

30. Transport Canada, *Nav Canada Aeronautical Study Standards & Guidelines*

31. Transport Canada *TP 185 Issue 3/2011*

32. Transport Canada, *TP 312 Aeronautical Information Services*

33. Transport Canada, *TP 1247 Part 6 Wind Turbines and Windfarms*

34. Transport Canada, *TP 1437 Aeronautical Information Manual*

35. Wings Magazine, “Building a new blueprint – does Transport Canada need a makeover”

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STAYNER
WIND TURBINE
REPORT

Report Dated: 1st. April 2016

QualaTech Aero Consulting Ltd.

Empowered by our Clients

INDEX

INTRODUCTION

Preamble:

The Stayner Wind Turbine Report (the "Report") has been prepared by QualaTech Aero Consulting Ltd. (the "Consultant") in response to a request by Kevin and Gail Elwood Gail Elwood and Preserve Clearview for a comprehensive review of the impact of the proposed Fairview Wind Project the ("Project") on aviation safety at Stayner (Clearview Field) Aerodrome.

This Report is presented as expert opinion evidence to the Environmental Review Tribunal (ERT) in relation to an appeal to the ERT regarding Renewable Energy Approval No. **3948-9RDLRF**, issued to *wpd* Canada Inc. for the proposed Project. The Report and Hazard & Risk Assessment (HRA) scope is to examine if the proposed wind farm could cause loss of human life and/or serious bodily injury due to aircraft contact/collision or avoidance measures.

An HRA is a formal process to assess a change scenario involving potential risk. It is also a 'living process' that should be revisited and revised as circumstances and events change. The HRA in Part 2A has evaluated all conceivable hazards and identified recognisable and associated risk(s) using a variety recognised of Risk Assessment practices and tools and applying international Best Practices.

The Stayner Aerodrome HRA was conducted primarily in accordance with the methodology described in ISO IEC/FDIS 31010 Risk Management – Risk Assessment Techniques (latest Edition) and other internationally recognised processes e.g. the ARMS Methodology for Operational Risk Assessment in Aviation Organizations (latest Version).

In producing the Report, the Consultant conducted extensive research of key documents and data, including studies conducted by published experts in the fields of Wind Turbine Generation, Aviation, Hazard & Risk Assessment, Wind Turbine Turbulence, Aerial Navigation, Environment, Canadian and International Aviation Regulation, Aviation Safety Assurance & Risk practices.

Summary of Findings:

The Project proposes to locate eight 145m tall wind turbines immediately adjacent top Stayner Aerodrome, within what is known in the industry as "Obstacle Limitation Surfaces." The turbine blades will be 90m in diameter. Turbine #7 will be just within the Take-Off and Approach Surface. Turbine, #3, when taking into account blade length, will be very close to the Transitional surface.

The planning and approval of these turbines failed to apply fundamental safeguards that protect aerodromes from hazards posed by obstacles on approach and departure. The installation of 8 wind turbines immediately adjacent to Stayner Aerodrome introduces significant hazards with the potential to cause loss of life and/or serious injury.

When an aircraft in flight that collides with an object (sometime as small as a bird) is subject to damage. The extent of the damage is rarely insignificant and may result complete destruction of the aircraft and loss of life. This relates to the Transport Canada (TC) classification of 'Catastrophic' – 5 in terms of the level of hazard this represents.

The results of the RA data identifies that all recorded 18 hazards (others may exist) are classified as being either a Moderate or High Risk. The greater majority of hazards (12 out of 18 or 66.6%) are High Risk with the remainder (6 or 33.3%) being attributed as a Moderate Risk level.

The TC Risk Index categorises Risk Levels into three areas:

Level One or LOW (Minimum Risk) with a numeric value of 1 – 5;

- **Acceptable**: Proceed after considering all elements of risk.

Level Two or MEDIUM (Moderate Risk) with a numeric value of 6 – 12; and,

- **Review (Tolerable)**: Continue after taking appropriate mitigating action.

Level Three or HIGH (High Risk) with a numeric value of 13 – 25.

- **Unacceptable**: Do not proceed until sufficient control measures have been implemented to reduce risk to an acceptable level.

Potential mitigation controls were applied to the 18 identified hazards, including closing the runways at Stayner Aerodrome, preventing aircraft from operating in the area around turbines (again effectively closing Stayner Aerodrome), altering approaches, reducing turbine height or relocating turbines. The effectiveness of the mitigation processes is clearly evidenced in the fact that no mitigation control resulted in a Level Three situation. Nevertheless, there were 50 Minimum Risks identified with the remainder compiling 21 Moderate Risks: a ratio of 2.3:1 - Minimum to Moderate risk.

This however, is somewhat deceiving since some of the controls are impractical or may cause secondary risks. For instance, as stated in the witness statement of Mr. Cormier, the use of non-standard approaches increase the risks of landing and take-off.

The HRA results indicate that the only truly effective mitigation control that would allow the Stayner Aerodrome to continue to operate safely is the relocation of the wind turbines to another area away from aircraft traffic.

If turbines are not relocated, given the hazards identified in the HRA and the limited mitigation controls available, there is ‘reasonable probability’ of an accident occurring as long as StaynerAerodrom continues to operate. The CAA CAP 760 quantitative definition of “once per 40 days to once in 10 years” is appropriate.

Report Overview:

The Report comprises of Parts 1, 2 and 2A. Part 1 and Part 2 provide both background and technical information, data and analysis for the reader. These parts support the ‘Hazard and Risk Assessment’ (HRA) in Part 2A.

Part 1 Synopsis:

Part 1 is an overview of the situation, examination of relevant Canadian and international standards and best practices for the planning of obstacles in proximity to aerodromes and the application of these best practices to the Project.

Part 2 & Part 2A Synopsis:

Part 2 comprises the Qualitative Report explaining the Hazard Identification and Analysis process.

Part 2A comprises of the actual Risk Assessment (RA) arising from the Hazard Identification and Analysis development, including mitigated risk safety requirements. Part 2A is presented in evidence and contains the 'Hazard and Risk Assessment' (inclusive of the Risk Matrix).

The HRA encompasses a mixture of qualitative and quantitative results, arranged under a simplified spreadsheet for quick and easy interpretation. Subsequently, only correlated data derived from assorted Risk Assessment Tools (RAT's) and associated processes have been included in this report since the HRA spreadsheet and matrix clearly demonstrates the perceived consequence.

LIST OF ABBREVIATIONS

Abbreviation	Meaning
AC	Advisory Circular
AIM	Aeronautical Information Manual
AIS	Aeronautical Information Services
ALARP	As Low As Reasonable Practicable
ANC	Air Navigation Commission (ICAO)
ASL	Above Sea Level
C/PM	Consequence/Probability Matrix
CAA	Civil Aviation Authority - UK
CADORS	Canadian Aviation Daily Occurrence Reporting System
CAR	Canadian Aviation Regulations
CFD,	Computational Fluid Dynamics
COPA	Canadian Owners and Pilots Association (COPA)
EASA	European Aviation Safety Agency
FAA	Federal Aviation Administration - USA
FMEA	Failure Modes & Effects Analysis
FMECA	Failure Modes, Effects & Criticality Analysis
GA	General Aviation
HRA	Hazard and Risk Assessment
IAA	Irish Aviation Authority
ICAO	International Civil Aviation Organization
ISO	International Organisation for Standardization
IWEA	Irish Wind Energy Association
LIDAR	Light Detection and Ranging
LPA	Local Planning Authorities
NLR	Netherlands Aerospace Centre
NTSB	National Transportation Safety Board - FAA
RA	Risk Assessment
RAT	Risk Assessment Tools
RI	Risk Identification
SARPs	Standards and Recommended Practices
SEAL	Sustainable Energy Authority of Ireland
SMS	Safety Management Systems
TC	Transport Canada
TP	Transport Canada Publication
TSB	Transportation Safety Board – Canada

PART 1: OVERVIEW OF THE SITUATION

The Project proposes to locate eight 145m tall wind turbines within the OLS of Clearview Field. The turbine blades will be 90m in diameter. Turbine #7 will be just within the Take-Off and Approach Surface. Turbine, #3, when taking into account blade length, will be very close to the Transitional surface.

Any obstacle (as defined by the relevant aviation authorities) in the vicinity of an aerodrome is a potential hazard and this is analysed further in the associated Hazard Identification, Analysis and Risk Assessment section of this Report.

Since obstacles are at the core of this analysis it is important to understand what we are talking about in aviation terms. The International Civil Aviation Organization (ICAO) is a UN agency, established in 1944 to manage the administration and governance of the Convention on International Civil Aviation (Chicago Convention). ICAO Annex 15 (Aeronautical Information Services) Chapter 2 defines an obstacle as:

> All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that:
>
> a) are located on an area intended for the surface movement of aircraft; or
>
> b) extend above a defined surface intended to protect aircraft in flight; or
>
> c) stand outside those defined surfaces and that have been assessed as being a hazard to air navigation.

This definition is based around the need to protect aircraft and air navigation, i.e. an obstacle is an object which can potentially affect aircraft operations.

Furthermore, European Organisation for the Safety of Air Navigation (Eurocontrol) in its Terrain and Obstacle Data Manual, Section 2.2 makes the following points:

> …the purpose of obstacle management is to confirm that structures do not impact aircraft operations. This is achieved by establishing processes to ensure that obstacles have not penetrated the defined surface, are not constructed in the first place, are mitigated for in flight procedure design, or that their demolition is known.

The very existence of increased numbers of obstacles in the vicinity of an aerodrome will increase pilot workload during an already busy segment of flight and during an emergency situation and may become a 'causal event' contributing to an otherwise preventable accident.

Wind turbines are unusual obstacles in that they are not inert. They are dynamic objects with not only a fixed tower but with large rotating blades. A 90 meter diameter turbine would have a blade tip speed of 255 km/hour at 15rpm (a typical maximum operating speed for a large turbine).

The rotating blades also have a human factors effect on pilots flying in their vicinity since the eye will naturally follow the rotation of the turbine blades which can lead to a dilution of both the visual concentration required of pilots and the requirement to carry out a continuous visual scanning activity both outside the aircraft to maintain spatial and external environment awareness and the internal aircraft awareness in respect of instrumentation and aircraft performance.

In addition, the area around the turbine that can be affected by wake turbulence, wind deficits and vortices is not a fixed area in a single direction. It is in fact a circle centred on the nacelle of the turbine. The volume of airspace which can be affected by the turbine effects is a large circle around the turbine, since by means of the yaw mechanism in the nacelle, it can rotate through 360 degrees according to the wind direction.

As background to the HRA of the Project, Part 1 of this report will examine:

1. Canadian and international standards and best practices for locating obstacles near aerodromes.
2. Provide a synthesis of best practices and examine whether they have been applied in the case of the Project.

Standards for Safeguarding Aerodromes from Obstacles:

Canada Standards:

In Canada the control and planning of land use around aerodromes is largely in the hands of provincial and municipal governments, except in the case of airports as the Transport Canada website notes:

> From a regulatory perspective, the authority for the designation of and control of the use of lands located outside of aerodrome property rests with provincial/municipal levels of government. The only exception to this fact, in the aviation case, occurs where an airport zoning regulation, made pursuant to the Aeronautics Act, is in force.

An Airport Zoning Regulation contains restrictive clauses that describe the activities and uses that are restricted or prohibited and contains a legal description of the lands to which it applies. Restrictions and or prohibitions contained in a zoning regulation may range from limiting the height of structures to prohibiting specified land uses or to prohibiting facilities that may interfere with signals or communications to/from aircraft.

Airport zoning regulations cannot be made for non-certified aerodromes. The distinction between certified aerodromes (airports) and non-certified aerodromes distinguishes Canada from most signatories to the Chicago Convention. ICAO does not define "airports" but instead has always used the term aerodrome (as described in the ICAO Annexes to the Chicago Convention). ICAO defines an aerodrome as:

> a defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure or surface movement of aircraft.

While Canada has left land use control of obstacles around aerodromes to local government, its publications are nonetheless relevant to assessing the safety impacts of obstacles. Two publications are of particular importance, *TP 1247 - Aviation - Land Use in the Vicinity of Aerodromes* and *TP312 Aerodromes Standards and Recommended Practices*, 5^{th} edition.

TP 1247 contains a chapter on wind turbines -- Part VI - Wind Turbines and Wind Farms. While much of the chapter is focused on the lighting and marking of turbines, it also discusses the planning of turbines in relation to aerodromes – noting that it is critical that planning be conducted in conjunction with the aerodrome operator rather than be a unilateral matter for the proponent alone:

TP 1247 Part VI - Wind Turbines and Wind Farms:

> "Note: It is of the utmost importance to be aware that the proximity of obstacles, for example, wind turbines, telecommunications towers, antennae, smoke stacks, etc., may potentially have an impact on the current and future usability of an aerodrome. Therefore, it is critical that planning and coordination of the siting of obstacles should be conducted in conjunction with an aerodrome operator at the earliest possible opportunity."

TP 312 establishes a method for calculating and defining Obstacle Limitation Surfaces (OLS) – the area around an aerodrome to be maintained clear of obstacles. The OLS is described in Chapter 4, Section 4.1 as follows.

> Introductory Note – The objectives of the specifications in this chapter are;
>
> a) to define the airspace around aerodromes to be maintained free from obstacles in order to minimize the dangers presented by obstacles to an aircraft, either during an entirely visual approach or during the visual segment of an instrument approach; and
>
> b) to prevent the aerodrome from becoming unusable by the growth of obstacles around the aerodrome.
>
> These objectives are achieved by establishing a series of obstacle limitation surfaces that define the limits to which objects may project into the airspace."

ICAO Standards and Recommended Practices:

Chapter 4 of ICAO Annex 14 addresses obstacle restriction and removal around aerodromes, including the OLS. The purposes of the chapter are similar to TP312, Chapter 4 and it provides the source language for the introductory note set out above (with modification).

Annex 14 also provides a process for addressing proposals to locate obstacles within the OLS:

> New objects or extensions of existing objects should not be permitted [….] above the inner horizontal surface except when, [...] after an aeronautical study it is determined that the object would not adversely affect the safety or significantly affect the regularity of operations of aeroplanes.

In ICAO Doc 9774 (Licensing of Aerodromes) it is noted in Appendix 3.

> 5.0 AERONAUTICAL STUDY
>
> 5.1 DEFINITION

An aeronautical study is a study of an aeronautical problem to identify possible solutions and select a solution that is acceptable without degrading safety.

An aeronautical study is conducted to assess the impact of deviations from the aerodrome standards specified in Volume I to Annex 14 to the Convention on International Civil Aviation, and the national regulations, to present alternative means of ensuring the safety of aircraft operations, to estimate the effectiveness of each alternative and to recommend procedures to compensate for the deviation.

5.3 TECHNICAL ANALYSIS

Technical analysis will provide justification for a deviation on the grounds that an equivalent level of safety can be attained by other means. It is generally applicable in situations where the cost of correcting a problem that violates a standard is excessive but where the unsafe effects of the problem can be overcome by some procedural means which offer both practical and reasonable solutions.

Ireland and the UK Standards and Best Practices:

It is valuable to examine best practices in other countries with significant wind power industries e.g. including United Kingdom, Ireland, which have faced up to the same issues, as some of these countries are further along in the development of aviation safety standards or practices in relation to wind turbines than Canada. The UK in particular has addressed aviation issues in depth and the UK Civil Aviation Authority has published important policy documents as Civil Aviation Publications (CAPs).

Republic of Ireland:

Given the traditional heavy reliance on imported energy sources (89%), wind power is important in Ireland – hence the existence of the Sustainable Energy Authority of Ireland (SEAI). In collaboration with SEAI, the Irish Wind Energy Association (IWEA) has published “Best Practice Guidelines for the Irish Wind Energy Industry”. In the publication it states *inter alia*:

Consultation with the Irish Aviation Authority (IAA) and where relevant the operators of other aerodromes outside the control of IAA, is particularly important with respect to airports, radar, and aircraft guidance systems. The IAA should be provided with proposed co-ordinates once these are known. The Irish Aviation Authority is also the safety regulatory body for civil aviation in Ireland.

Wind turbines or any structure exceeding 90 metres in height are considered obstacles to aerial navigation and need to be shown on aviation charts. They will also need appropriate aviation warning lighting. The IAA should be informed 30 days in advance of the erection of any structure exceeding 45 metres in height under S.I. 215 of 200553. This includes wind monitoring masts which may be exempt from planning permission. If located close to an airport (within 20 km), a wind turbine could interfere with the safe operation of an airport, simply by its presence and height. In the feasibility section of the guidelines, proposers of windfarms should include any airports or aerodromes within 20 km of the proposed development as early consultees.

United Kingdom:

The United Kingdom has been in the forefront of both wind power development and the development of policy by the Civil Aviation Authority on wind turbine siting as well as studies directly related to their effect on aviation operations. Under the Civil Aviation Act, the CAA is responsible for providing advice about aviation safety. The Authority's Safety and Airspace Regulation Group has the lead responsibility within the CAA for all wind turbine related issues.

The UK CAA policy on wind energy includes the following statements which are germane to the Project case under appeal:

> Wind turbine developments and aviation need to co-exist in order for the UK to achieve its binding European target to achieve a 15% renewable energy commitment by 2020, and enhance energy security, whilst meeting national and international transport policies. **However, safety in the air is paramount and will not be compromised.** As the independent aviation regulator, the CAA is well placed to provide clarification to both the aviation industry and the wind energy industry.
>
> Due to the complex nature of aviation operations, and the impact of local environmental constraints, all instances of potential negative impact of proposed wind turbine developments on aviation operations must be considered on a case- by-case basis.
>
> As with any development, related decision making responsibility rests with the appropriate planning authorities who will take into account the potential impact upon local aviation activities. [Emphasis added]

The CAA also stresses the need for a safety case to be produced by the developer.

Recommended Best Practices and Application to Project:

As Canada has no safety standards for uncertified aerodromes, it is appropriate to examine best or recommended practices. Whether the source of the recommended Best Practices is Transport Canada, ICAO or other jurisdictions, there is a general agreement that there are three critical safeguards that should be applied in planning obstacles near aerodromes:

1. project planning and coordination of the siting of obstacles should be conducted **in conjunction with an aerodrome operator** at the earliest possible opportunity;
2. locating obstacles within the aerodrome's OLS should be avoided;
3. if an obstacle is proposed within the OLS, **an Aeronautical Study and/or a Safety Case should be conducted** to determine **whether the proposal can be justified on the basis that an equivalent level of safety can be attained by other means** (mitigation).

It is the Consultant's understanding that none of these safeguards were put into place before the Project was proposed and approved. Specifically:

1. the aerodrome operator (Mr. Elwood) has stated that the Project was planned unilaterally, without coordinating with Mr. Elwood or other stakeholders and turbines were sited contrary to his objections;

2. all eight turbines will be located within the OLS;

3. no safety case or aeronautical study was conducted prior to planning or approving the Project.

As detailed in this Report, the failure to apply these fundamental safeguards has resulted in a Project that poses a significant risk of loss of life or serious injury to pilots and passengers using Clearview Field.

PART 2: QUALITATIVE REPORT

The Qualitative Report explains the Hazard Identification and Analysis process.

The actual Hazard Risk Assessment (HRA) arising from the Hazard Identification and Analysis development, including mitigated risk safety requirements is contained in the various Addendums. The HRA encompasses a mixture of qualitative and quantitative results, arranged under a simplified spreadsheet for quick and easy interpretation. Subsequently, only correlated data derived from assorted Risk Assessment Tools (RAT's) and associated processes have been included in this report since the HRA spreadsheet and matrix clearly demonstrates the perceived probability and consequence.

Principal objectives of the Risk Assessment were to:

- Collect and document risk and hazard data in the context of the dynamic environment surrounding operational activities at and in the vicinity of Stayner Aerodrome.
- Identify the hazards, state the risks and identify mitigations to the risks associated with aircraft (including helicopter) operations at the Stayner Aerodrome in the presence of wind turbines as proposed by Fairview.
- Produce a formal Risk Assessment Document (in various formats) containing the information above.

Hazard & Risk Assessment Overview:

An HRA is an important tool for a complex society where competing demands and priorities must be managed. A primary function of an HRA is to determine the potential for loss and/or harm to organizational operations, missions and stakeholders. Among other attributes, a Risk Assessment provides all those who must assess and/or manage risk with the capability to:

- Provide an adequate level of protection for operations and systems.
- Meet regulatory requirements.
- Satisfy oversight requirements.
- Establish an acceptable level of risk.

Risk Assessment endeavours to answer the following fundamental questions:

- What can happen and why (by hazard identification)?
- What are the consequences?
- What is the probability (and/or frequency) and potential severity of their future occurrence?
- Are there any factors that mitigate the consequence of the risk or that reduce the probability of the risk?

Risk can never be totally eliminated, but it can be minimized by the application of specific controls. The decision as to what level of risk will be accepted is ultimately going to be based on a review of the identified controls needed to mitigate risk, to determine the potential effect of implementing those controls on available resources and system operations. The question should and must be asked: Is the level of risk tolerable and/or acceptable and does it require further treatment? In other words: What is the acceptable level of risk?

The HRA in this Report describes operational vulnerabilities and associated threats based on executive, legislative, operational and technical guidelines. HRA methodology is adapted from several national and internationally recognized standards and best practices. The HRA has taken into consideration several practices and policies, including but not necessarily limited to the following:

IEC/FDIS ISO 31010 – Risk Management – Risk Assessment Techniques;

Transport Canada AC 007-002 Safety Management Systems Development Guide for Small Operators/Organizations;

Transport Canada SI QUA-008 – Risk Management Processes for Aviation Safety Activities;

UK CAA CAP 760 - Guidance on the Conduct of Hazard Identification, Risk Assessment and the Production of Safety Cases;

Transport Canada SI QUA-008 – Risk Management Processes for Aviation Safety Activities;

The ARMS Methodology for Operational Risk Assessment in Aviation Organizations.

This HRA Report describes the results of the various analysis processes and in so doing attempts to identify and assess all the potential risks which could, if left unmitigated, result in damage to aircraft and/or persons during aerial maneuvering at or in the vicinity of the Stayner Aerodrome.

HRA tools were used as necessary to identify potential risks associated with recognized hazards. For example, the relationship between hazards and risk have been displayed in a Spreadsheet format for clarity; risks are identified by a colour and numerical legend derived from a risk matrix and definitions chart, used and recommended by Transport Canada in AC 007-002. It is worthy of note that most Risk Analysis Matrixes are reasonably similar; however, since minor differences are inherent in each document, it was decided to utilise the Transport Canada version as a Best Practice.

Risks highlighted in Red are High Level while those coloured as Amber are Moderate. It must be remembered that Multiple levels of medium or Moderate risk ratings may align together to form new risks that were never anticipated or foreseen, but nevertheless, may contribute as a causal effect (latent or dynamic) to an unacceptable outcome. In other words, multiple medium risks, although individually mitigated to an acceptable level, are by their very nature a serious consideration and potential threat to an acceptable level of safety.

Scope:

The scope of this HRA was to evaluate aviation safety risks to the operation of Stayner Aerodrome if the Project were to be implemented as proposed. It includes but is not necessarily limited to operational and technical areas of operation.

Although the HRA is specifically limited to the Stayner Registered Aerodrome, other experience and operations have not been overlooked as a means of acquiring operational data. Transport Canada and other best practices inclusive of HRA references strongly recommend that ‘Hazard Registers’ be shared between like entities.

The HRA assessed vulnerabilities exploitable by threats external to the appellants and Stayner Aerodrome. If exploited, these vulnerabilities could result in:

- Failure or inability to safely undertake flight;
- Damage to aircraft and/or equipment;
- Loss of aircraft and/or injury to personnel;
- Death.

Management of Change and the Safety Case:

The HRA is dealing with a change scenario. Transport Canada and other aviation professional and regulatory bodies worldwide recognize the importance of the "Safety Case for Change" as a means of ensuring that all risks are being managed. This contributes significantly to the concept of Safety Assurance which has been elevated to the status of an international Standard in Chapter 3 of the new ICAO Annex 19 (Safety Management). Transport Canada, in Aviation Safety letter 3 of 2011 went so far as to state that: "*a Safety Case (SC) is necessary when changes are proposed*". For this reason in combination with the fact that the absence of a Safety Case has (repeatedly) been proven as a contributing factor (omission being a hazard) in many significant and catastrophic events around the world, reference to a Safety Case' has subsequently been included into this HRA.

However it is essential to note that a safety case for change is the duty of a proponent for change. As its name implies, a safety case for change quite literally makes the documented case for proceeding with the change(s) with management and regulators confident (but not complacent) in the knowledge that all risks associated with the change(s) are being managed.

Risk Assessment Methodology:

The Stayner Aerodrome HRA was conducted primarily in accordance with the methodology described in ISO IEC/FDIS 31010 Risk Management – Risk Assessment Techniques (latest Edition) and other internationally recognised processes e.g. the ARMS Methodology for Operational Risk Assessment in Aviation Organizations (latest Version).

The methodology used to conduct this HRA is mostly qualitative and no attempt was made to determine any loss expectancies, asset cost projections, or cost-effectiveness.

The fundamental aspect of an HRA such as this is that it is a key component in the Management of Change. If there was no change, there would be no issue and no need to conduct the HRA. Thus the undertaking of this HRA and associated costs has been forced upon the appellants, who did not seek the changes envisaged by the Ontario Government and the project proponents. The following are the key steps in the HRA process:

1. **Hazard Identification:**
   Equipment, procedures, organization, etc.
2. **Hazard Analysis:**
   Analyse the nature and possible consequences of the hazard.
3. **Risk Analysis - Probability:**
   Evaluate the likelihood of the consequence occurring.
4. **Risk Analysis - Severity:**
   Evaluate the seriousness of the consequence if it does occur.

5. Risk Evaluation & Tolerability:
Is the assessed risk(s) acceptable and given safety performance criteria?

The final step in the process is ‘Risk Control / Mitigation’. This step is beyond the scope of this project to achieve in the ‘here and now’ since the Consultants have no control over the Wind Farm Project. However, realistic and practical mitigation measures have been attempted in order to determine if mitigation is possible (in theory) with respect to reducing a High or Medium Risk Level to an acceptable level of safety. It is possible that other mitigation methods and processes will become available as time progresses and events change. This is an inherent fact with any HRA. Nevertheless, the importance of the mitigations presented in response to the identified risks, should not be underestimated or considered superfluous or even irrelevant.

Uncertainty and Complexity:

The degree and type of an uncertainty requires careful consideration and the study of three significant influences comprising: quality, quantity and the integrity of the information available, applicable to the risk under consideration. This includes the extent to which sufficient information about the risk, its sources and causes, and its consequences to the achievement of objectives is available. Uncertainty can arise from poor data quality or the lack of essential and reliable data.

Uncertainty can also be induced as a consequence of an external or internal condition within an organization. Available data is therefore not always a reliable basis for the prediction of the future given unique categories of risk, historical data that may not be available, or may be presented as different interpretations of available data by different stakeholders. This HRA has endeavoured to take into consideration (recognizable) ‘uncertainties’, the implications of which, may affect the reliability of the HRA results.

Focusing on a single risk alone can have implications elsewhere which in turn, may affect other activities associated with the overall HRA. One hazard or risk can induce an intolerable situation by creating or inducing other risks. Risk can be cumulative, additive and interactive and risk assessors must be constantly aware of this.

This HRA has made a concentrated effort to look at the overall complexity of all risk, rather than treating each individual risk component separately and ignoring any inherent and symbiotic interaction. Understanding the complexity of a single risk or a portfolio of risks is therefore crucial to the techniques of the overall risk assessment process.

Risk Assessment Process:

Risk Assessment provides a thorough understanding of all the foreseeable risks that could be introduced by the implementation of the Project that could affect the continuing safe operation of Stayner Aerodrome.

The primary reason for Risk Identification (RI) is to identify what could happen or what situations might exist that could affect the continuing safe operation of Stayner Aerodrome.

The HRA process identifies the causes and source of a risk (hazard in the context of physical harm), events, situations or circumstances which may have a material influence upon objectives (the continuing safe operation of Stayner Aerodrome) and the nature of that effect. Irrespective of the actual techniques employed, it is important that due recognition is given to human and organizational factors when identifying risk. Hence, deviations of human and organizational factors from the expected have been considered in the Risk Identification process.

Risk Analysis is about understanding the risk. The process provides an input to Risk Assessment and to decisions concerning risk reduction.

Risk Analysis consists of determining the consequences and their probabilities for identified risk events, taking into account the presence (or not) and the effectiveness of any existing controls. The consequences and their probabilities are then combined to determine a 'level of risk' or the probability that those consequences can occur.

Risk Evaluation (RE) is the process of comparing estimated levels of risk with known risk criteria. RE allows specialists to then determine the significance of the level and type of risk. Risk evaluation uses the understanding of risk obtained during Risk Analysis to make decisions affecting future actions. Often, ethical, legal, financial and other considerations, including perceptions of risk, are also inputs to a risk based decision.

Management of Change and the Safety Case:

The HRA is dealing with a change scenario. Transport Canada and other aviation professional and regulatory bodies worldwide recognize the importance of the "Safety Case for Change" as a means of ensuring that all risks are being managed. This contributes significantly to the concept of Safety Assurance which has been elevated to the status of an international Standard in Chapter 3 of the new ICAO Annex 19 (Safety Management). Transport Canada, in Aviation Safety letter 3 of 2011 went so far as to state that: "*a Safety Case (SC) is necessary when changes are proposed*". For this reason in combination with the fact that the absence of a Safety Case has (repeatedly) been proven as a contributing factor (omission being a hazard) in many significant and catastrophic events around the world, reference to a Safety Case' has subsequently been included into this HRA.

However it is essential to note that a safety case for change is the duty of a proponent for change. As its name implies, a safety case for change quite literally makes the documented case for proceeding with the change(s) with management and regulators confident (but not complacent) in the knowledge that all risks associated with the change(s) are being managed.

Selection of Risk Assessment Techniques:

The HRA was undertaken using assessment techniques that were appropriate to the situation and able to provide results in a form which enhanced the understanding of the risk and how it can subsequently be treated.

HRA Techniques:

In undertaking the HRA related to the safety risks introduced by a proposed wind farm, the following techniques using standard Risk Assessment Tools (RATs) were referenced as required. However, the level of importance applied to each RAT or methodology is not the same – some being more effective than others in the context of this HRA. The ISO 31010 - Risk Management -- Risk Assessment Techniques is now the recognised Standard with respect to definition and selection of a risk assessment tool. The Consultants in the course of the HRA may have applied certain aspects of several RATs as/when required and recommended by ISO 31010. It is normal practice to use multiple RATs and/or to combine or subject one to another to assure complete coverage. Although the RATs presented below may have been applied singularly or in association with other HRA tools, only the results of each RAT have been correlated and presented within the qualitative and quantitative sections of this Report.

Appendix "C" discuss the RAT tools that were applied.

Stayner Risk Assessment – Discussion:

Attention is drawn to the detailed assessment of Stayner Aerodrome airspace and operational procedures prepared for the appellants by Mr. Charles Cormier. In his report, as a qualified procedures expert, Mr Cormier provides precise distance measurements related to the turbines and the aerodrome and these have been studied by QualaTech in the production of this Report. Where QualaTech refers to distances, these are in some cases an approximation and the exact distances used by Mr. Cormier are to be used in precise determinations.

Since the 8 turbines would be ‘obstacles’, they are by definition ‘hazards to air navigation’ and in the proposed locations they would be a hazard to the safety of operations at Stayner Aerodrome. The aerodrome is there and thus aircraft could not avoid being close to the turbines. Thus they cannot be dismissed as being insignificant or posing negligible risk.

So far there is no mention in the data of an anemometer /wind measurement mast, which is an additional feature of some wind turbine sites. Standard 621 2nd Edition Section 12.6, refers to MET Towers (meteorological towers) and provides the following information: “*MET towers that are used to measure the wind resource available for windfarms may present a hazard to aircraft engaging in low level flight for aerial application of pesticides and other products*”.

It is important at this point to repeat the definition of Obstacle Limitation Surfaces. This is an important factor in the attached hazard list and assessment.

The Obstacle Limitation Surfaces (OLS) are established by Transport Canada to define the airspace around runways to be maintained free of obstacles, in order to minimize dangers to a manoeuvring aircraft, either during an entirely visual approach or during the visual segment of an instrument approach.

In assessing risk, the first question is whether it is possible that an aircraft might collide with one of the turbines. It is indeed possible, given the proximity of most of the turbines to the aerodrome.

Secondly, is there the possibility of death or serious injury to persons in the event of a collision? Statistically, given the available data regarding collisions of aircraft with obstacles generally, the answer is, Yes. Current statistics support this even though the sampling pool of collisions is extremely low (only one confirmed – Ref. NTSB Ident. Mo. CEN14FA224), all occupants of the aircraft were killed: equating to 100% fatality rate.

The third question is what is the probability of a collision. This depends on a variety of factors and is assessed on a hazard by hazard basis in Part 2A.

On the basis of the answer to these three questions an overall risk rating for the hazard is then calculated utilising Transport Canada processes.

Some additional qualitative comments follow below.

Turbines as Obstacles to Air Operations:

Turbines #3 and #7 are a particular problem, being so close to the departure and take-off surfaces and the approaches. The following observations are based on an aircraft maintaining the correct altitude and centreline:

- An aircraft passing Turbine #7 on approach to Runway 34 would be at approximately 180 metres above the ground as it passed the turbine. The turbine would be only 35 metres below the aircraft and 300 metres or less from the starboard wingtip, if it maintained .
- A similar proximity would occur for an aircraft on take-off from Runway 16 depending on aircraft load and climb performance.
- An aircraft passing Turbine #3 on approach to Runway 16 would in a worse position than the Runway 34 situation. As it passed the turbine it would be at approximately 90 metres above the ground and the turbine would be above the altitude of the aircraft as it passed it and 300 metres from the port wingtip.
- A similar proximity would occur for an aircraft on take-off from Runway 34 depending on aircraft load and climb performance.
- Turbines 1, 3,4,5,6 and 8 effectively form a 145 metre high obstacle for the VOR/DME A approach.

Light aircraft move about considerably due to pilot error, crosswinds, poor visibility, other meteorological conditions, thereby raising the risk of collision.

It is natural to assume that aircraft seldom miss there landing mark or that they are piloted on course. The reality is that given adverse conditions of workload, health, weather, equipment, etc, the pilot of an aircraft could be virtually anywhere other than in the intended location.

In addition, in all cases there would be the Human Factors that influence how we behave and respond, such as such Stress, Fatigue, Distraction, Pressure, etc. Such Human Factors (and other) are recognised as being primary contributory causes leading to aviation incidents and accidents. Approximately 70% of all accidents are attributable to human causes. Indeed the true accident, namely, something that cannot be foreseen, is relatively rare. Aviation is a labour intensive industry and human performance affects every facet of safety.

In the situation of a wind turbine, a recognised concern is the visual issue of the rapidly moving blades. Wind turbine blades can produce reflective flashes that could under certain situations interfere with a pilot's vision. As moving object in close proximity to the aircraft they can also distract the pilot.

Then there is the issue of turbulence and related turbine wake effects. The absolute minimum safety distance from the leeward (downwind) side of the turbine blades is quoted by several studies as at least 5 times the rotor blade diameter. At a diameter of 145 metres, the minimum safety distance would be 725 metres. However, given the lack of actual anecdotal data on this issue, the use of up to 15 times the diameter when considering smaller aircraft has been postulated. Nevertheless, neither turbine #3 nor turbine #7 meet the absolute minimum requirement of 725 metres distant from the flight path in the cases noted above. Nor can it be said that these are fixed direction turbines. The yaw mechanism of wind turbines varies the turbine axis and thus the direction of the wake according to the wind direction. Thus there is a potential issue over a 180 degree wind direction arc from 340 degrees through East to 160 degrees.

In addition Turbines 1, 5 and 6 are all located within approximately 1000 metres of some part of the runway or lower altitude segment of approach or take off, namely within seven blade diameters.

Turbines 1, 3, 4, 5, 6 and 8 effectively form a 145 meter high barrier over an arc of 120 degrees eastward from the extended centreline of Runway 34. This makes them a significant hazard as obstacles and wake turbulence generators in the event of an aircraft with an engine or some other performance related malfunction, more so in the event of deteriorating or fluctuating weather conditions. For an aircraft on approach or take off in either direction the effects of such problems could be extreme, particularly bearing in mind that aircraft with such malfunctions have minimal manoeuverability options. It should also be recalled that most accidents happen during the approach and landing and take-off phases of flight.

Turbine Failures:

So far, it is has been assumed that the turbines themselves are not given to problems that may affect aerodrome/aircraft operations. However there are many publicly documented (and it is estimated by some observers an additional significant number of non-publicly documented) instances of situations in which wind turbines have caused, or could have caused, collateral damage. Figures compiled by engineers at the Imperial College London and the university of Edinburgh estimated that out of 200,000 (the exact numbers is not known) wind turbines dispersed around the world there are on average 177 annually catching fire a figure twelve times more than reported by industry.

Accidents to wind turbines fall mainly into two categories:

- Structural damage to blades and (less frequently) to the towers themselves; and,
- Nacelle fires.

Examples of such incidents are contained in Part 1 of this Report.

Both types of accidents tend to be visually spectacular, accompanied in some cases by death or injury, as well as damage to the turbines themselves and other property.

In the event of such events in the Project complex the following are some of the problems/issues which might arise as a consequence:

Tower Collapse:

Worst case scenario, turbines 3 and 7. Debris could extend 145 meters or more from the tower base towards the runway or approach areas or hangarage. If the turbine became detached it could cause major damage and loss of life or injury. It could affect aircraft that are airborne at the time due to flying debris etc.

Disintegration of Turbine:

Debris may be thrown into the path of, or collide with aircraft causing possible loss of life or injury

Fire in Nacelle:

This could also involve the possible disintegration of the nacelle and turbine. Burning debris may be thrown into the path of, or collide with aircraft or strike aircraft or aerodrome objects on the ground. There is also the possibility of toxic smoke to persons on the ground and persons airborne. The aforementioned events could lead to loss of life or injury.

Should a collision with a turbine by an aircraft occur at the same time as one of the turbine failures mentioned above, results of the collision may be more damaging and dangerous than if the turbine/tower was not suffering problems.

Furthermore, risk analysis may also include the need to consider failure modes, effects and criticality analysis (FMECA). Thus in this case, if there actually is a collision, loss of control incident, or turbine/tower failure the effects may include: disruption to other ground facilities and public utilities, legal actions, effect on people on the ground etc. In addition, a collision by an aircraft with a turbine has the potential to cause one of the three events noted above.

The identified hazards and hazard and risk analysis are detailed on the attached forms forming part of this report.

Note RE Rotary Wing (RW) Aircraft:

The situation regarding Rotary Wing (RW) Aircraft would require some further detailed observations beyond the time limitations of this report. Nevertheless, it should be noted that Rotary Wing Aircraft form a significant part of the Canadian aviation scene and arguably, by their flight mission profiles, may be more susceptible than Fixed Wing Aircraft to encounter a wind turbine hazard. For example, CARs 702 and 703 Ops define flight minima and reduced visibility; nevertheless the flight authorization for reduced visibility (RW) is an Operations Specification to allow below the stated minima of 3 miles in controlled airspace and 1 mile in uncontrolled. However, it is possible to have a specification (Ops Spec #5 and #42) to allow 1/2 mile (800 m) visibility with reduced speed clear of cloud.

A common type of helicopter in Canada is an AS350 B2 with an average ‘fast cruise’ speed of 135 kts so a reduced speed could be 100 kts (51.44 meters per second). At that speed in reduced conditions the aircraft is only 15 seconds away from an impact or ½ that to a ‘near miss’. Rotary Wing Aircraft have enhanced operational and safety issues and may be the most vulnerable to obstacle contact under normal working/flying conditions.

Conclusion:

The installation of 8 wind turbines immediately adjacent to Stayner Aerodrome would introduce significant hazards to civil aviation with the potential to cause loss of life and/or serious injury.

The HRA identified 18 primary hazards which were subsequently assessed for their initial risk by determining the 'Hazard Severity' and then the 'Probability' of occurrence. The assigned numerical ratings were then multiplied (R=PxS) to provide the initial 'Risk Rating' for each perceived Hazard.

The next stage was to postulate reasonable 'Mitigation Controls' and to re-evaluate each hazard risk severity and probability, utilising the same methodology employed during the initial hazard risk evaluation process. In other words, the process identifies pre and post mitigations strategies, in order to establish a level of safety that can be used as an effective means of reducing the associated risk of the initial hazard(s).

The procedure identified above utilised the Transport Canada method of RA described in AC 007-002, which is consistent with other RA processes described under other TC documents. The decision to utilise TC best practices was to provide continuity and consistency to the Canadian environment; nevertheless, since TC makes reference to other international and National publications and best practices (ICAO Doc 9859 and CAA CAP 760) it was appropriate to (also) reference the aforementioned documents as best practice.

The HRA presented within the Spreadsheet (Part 2A), was designed to display the results of the actual RA processes and is not therefore the primary method of mitigation but only a technique of interpreting results. The HRA spreadsheet was populated from the information recorded in the individual Hazard and Risk Analysis Forms presented in Appendix D - Forms.

When an aircraft in flight that collides with an object (sometime as small as a bird) is subject to damage. The extent of the damage is rarely insignificant and may result complete destruction of the aircraft and loss of life. This relates to the Transport Canada (TC) classification of 'Catastrophic' – 5 in terms of the level of hazard this represents.

The results of the HRA data identifies that all recorded 18 hazards (others may exist) are classified as being either a Moderate or High Risk. The greater majority of hazards (12 out of 18 or 66.6%) are High Risk with the remainder (6 or 33.3%) being attributed as a Moderate Risk level.

The TC Risk Index categorises Risk Levels into three areas:

Level One or LOW (Minimum Risk) with a numeric value of 1 – 5;

- **Acceptable:** Proceed after considering all elements of risk.

Level Two or MEDIUM (Moderate Risk) with a numeric value of 6 – 12; and,

- **Review (Tolerable):** Continue after taking appropriate mitigating action.

Level Three or HIGH (High Risk) with a numeric value of 13 – 25.

- **Unacceptable:** Do not proceed until sufficient control measures have been implemented to reduce risk to an acceptable level.

Areas of High Risk must be mitigated to an acceptable level of safety, reducing them to an ‘Acceptable’ Level. However, this is not always possible resulting in an Unacceptable situation. Likewise, High Risk mitigation(s) may (initially) only be able to decrease the level three ranking to a level 2 category. At this juncture, a decision must be made to accept the reduced level of Moderate Risk or reject it. However, multiple Moderate Risk scenarios are known to combine and induce additional factors that were not expected or anticipated during the initial HRA process.

Therefore, a moderate risk ranking having been reduced to ‘As Low As Reasonable Practical’ (ALARP) must be constantly re-assessed in an attempt to reduce it further to an acceptable Risk level. Furthermore, a decision must moreover be made when several ALARPs are present to treat the multiple rankings as a higher risk threat i.e. a Level Three. In the case of the Stayner Aerodrome, multiple initial High Risks and multiple Moderate risks have both been identified.

Recognising the initial hazard and assigning a rating is the first of two equally important functions. The other is to identify potential mitigation strategies and subsequently evaluate the effect of the proposed control measure. The new calculated (R=PxS) result is the theoretical (until implemented) mitigated risk control and is consequently crucial to the decision making process enabling an acceptable level of risk to be sustained.

Potential mitigation controls were applied to the 18 identified hazards, including closing the runways at Stayner Aerodrome, preventing aircraft from operating in the area around turbines (again effectively closing Stayner Aerodrome), altering approaches, reducing turbine height or relocating turbines. The effectiveness of the mitigation processes is clearly evidenced in the fact that no mitigation control resulted in a Level Three situation. Nevertheless, there were 50 Minimum Risks identified with the remainder compiling 21 Moderate Risks: a ratio of 2.3:1 - Minimum to Moderate risk.

This however, is somewhat deceiving since some of the controls are impractical or may cause secondary risks. For instance, as stated in the witness statement of Mr. Cormier, the use of non-standard approaches increase the risks of landing and take-off.

The HRA results indicate that the only truly effective mitigation control that would allow the Stayner Aerodrome to continue to operate safely is the relocation of the wind turbines to another area away from aircraft traffic.

If turbines are not relocated, given the hazards identified in the HRA and the limited mitigation controls available, there is ‘reasonable probability’ of an accident occurring as long as StaynerAerodrom continues to operate. The CAA CAP 760 quantitative definition of “once per 40 days to once in 10 years” is appropriate.

Hazard Number: 2A	**Hazard Identification:** Wind turbine #7, south of Runway 16. penetrates the take-off/approach surfaces of Runways 16/34.

Name: Wind Turbine Risk Assessment - Kevin Elwood **RA Number:**

Hazard description: Wind Turbine - Aviation Safety

Assessment team: Consultants - QualaTech Aero Consulting Ltd. - Keith Green / David Olsen. Approved: __________

Notes: Stakeholders: Kevin Elwood / Preserve Clearview / Collingwood Aerodrome / Stayner Airfield / Local Air traffic / Fairview Wind Project / General Aviation.

Assumptions: 1) Wind Turbines are in a fixed location. 2) Wind Turbines sphere of influence is 360 degrees. 3). Height of Turbines is 145m AGL. 4) Collision with Obstruction is Hazardous or Catastrophic.

Date of Assessment: **April, 2016** Due for Re-Assessment:

Hazard Item No.	HAZARD			INITIAL RISK			MITIGATION CONTROLS	MITIGATED RISK		
	Hazard Description	**Risk**	**Persons/Property at risk**	**Hazard Severity**	**Probability**	**Risk Rating (R=PxS)**	**List Mitigations Required**	**Hazard Severity**	**Probability**	**Risk Rating**
	Identify all hazards . Note: Additional hazards may be caused by interaction with other work.	**Describe risks that may be realised if hazard was to occur.**	**Name persons/property at risk. Persons not related to task may be affected.**	**From matrix identify severity with no controls in place for each hazard.**	**From matrix identify probability with no controls in place for each hazard.**	**Classify risk rating from matrix for each hazard.**	**Describe fully all controls applicable for each hazard. If a control can only be verified by documentation then it must be available. All controls must reduce severity, probability or both.**	**From matrix identify severity with controls in place for each hazard.**	**From matrix identify probability with controls in place for each hazard.**	**Classify risk rating from matrix for each hazard.**
1	**Wind Turbine 1, 2, 4, 5, 6, 8.**									
1a		Collision by aircraft in the aerodrome cercuit.	Pilots, aircraft, wind turbine.	5	3	15	Prevent aircraft from manoeuvring in Wind Turbine Areas.	5	1	5
1b		Collision by aircraft during aerodrome manoeuver	Pilots, aircraft, wind turbine.	5	3	15	Relocate Wind Turbine	5	1	5

1c		Collision by aircraft during aerodrome manoeuver	Pilots, aircraft, wind turbine.	5	3	15	Downsize Wind Turbine	4	2	8
1d		Collision by aircraft during aerodrome manoeuver	Pilots, aircraft, wind turbine.	5	3	15	Raise Approach Minimum.	5	2	10
2	**Wind Turbine 7 - Penetrates the T/O/ Approach Surfaces of Runways 16/34**									
2a		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	4	20	Prevent aircraft from Landing & Taking-off.	5	1	5
2b		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	4	20	Prevent aircraft from manoeuvring in Wind Turbine Areas.	5	1	5
2c		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	4	20	Relocate Wind Turbine	5	1	5
2d		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	4	20	Downsize Wind Turbine	4	2	8
2e		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	4	20	Raise Approach Minimum	5	2	10
3	**Wind Turbine 3 - Penetration of Transitional Surface East of T/O / Approach surface North of Runway 34.**									
3a		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	4	20	Prevent aircraft from Landing & Taking-off.	5	1	5
3b		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	4	20	Prevent aircraft from manoeuvring in Wind Turbine Areas.	5	1	5
3c		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	4	20	Relocate Wind Turbine	5	1	5
3d		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	4	20	Downsize Wind Turbine	4	2	8
3e		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	4	20	Raise Approach Minimum	5	2	10

4	**Wind Turbine 1, 3, 4 & 8 N/W Penetrate Critical Final Approach for RNAV (GNSS) Instrument Approach to RWY 16.**									
4a		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	5	25	Prevent Aircraft from using this Approach.	5	1	5
4b		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	5	25	Relocate Wind Turbine	5	1	5
4c		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	5	25	Downsize Wind Turbine	4	2	8
5	**Wind Turbine 2, 6 & 7 Penetrate Missed RNAV (GNSS) Instrument Approach to RWY 16.**									
5a		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	5	25	Prevent Aircraft from using this Approach.	5	1	5
5b		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	5	25	Relocate Wind Turbine	5	1	5
5c		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	5	25	Downsize Wind Turbine	4	2	8
6	**Wind Turbine 1, 3, 4, 5, 6, 7 & 8 VOR/DME Missed Approach to RWY 16.**									
6a		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	4	20	Prevent Aircraft from using this Approach.	5	1	5
6b		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	4	20	Relocate Wind Turbine	5	1	5
6c		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	4	20	Downsize Wind Turbine	4	2	8

7	**Wind Turbine 1, 3, 4, 5, 6, 7 & 8 RNAV 16 Approach to RWY 34.**									
7a		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	4	20	Prevent Aircraft from using this Approach.	4	1	4
7b		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	4	20	Allow circling only to the west of the Runway 34 only (caution # 7)	5	2	10
7c		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	4	20	Relocate Wind Turbine	5	1	5
7d		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	4	20	Downsize Wind Turbine	4	2	8
8	**Wind Turbine 4 - penetration hazard departing RWY 34 (to the north)**									
8a		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	3	15	Prevent Aircraft from using this Approach.	5	1	5
8b		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	3	15	Construct an alternative runway	5	1	5
8c		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	3	15	Relocate Wind Turbine	5	1	5
8d		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	3	15	Downsize Wind Turbine	5	2	10
9	**Wind Turbine 7 - penetration hazard departing RWY 16 (to the south)**									
9a		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	3	15	Prevent Aircraft from using this Approach.	5	1	5
9b		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	3	15	Construct an alternative runway	5	1	5
9c		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	3	15	Relocate Wind Turbine	5	1	5
9d		Collision by aircraft / aerodrome traffic.	Pilots, aircraft, turbine.	5	3	15	Downsize Wind Turbine	5	2	10

10	**Turbine Blade Wake (Vortices and Turbulence)**									
10a		Instability & Loss of Directional Control.	Pilots, aircraft & others persons and property.	4	4	16	Do not allow aircraft to approach within 725 metres downwind of any turbine	1	2	2
10b		Instability & Loss of Directional Control.	Pilots, aircraft & others persons and property.	4	4	16	Operate the turbines at low speed (8rpm) to reduce the effects	2	3	6
10c		Instability & Loss of Directional Control.	Pilots, aircraft & others persons and property.	4	4	16	Relocate Wind Turbine	2	1	2
10d		Instability & Loss of Directional Control.	Pilots, aircraft & others persons and property.	4	4	16	Downsize Wind Turbine	3	1	3
11	**Turbine Tower/Structure Failure**									
11a		Secondary Hazard - debris resulting in injury and damage.	Pilots, Ground Personnel, aircraft, equipment, property.	3	2	6	Improved Engineering Design and Proactive maintenance (OEM specifications followed).	2	1	2
11b		Secondary Hazard - debris resulting in injury and damage.	Pilots, Ground Personnel, aircraft, equipment, property.	3	2	6	Undertake on-site studies to determine the effects of such an accident and devise appropriate safety measures (Emergency Contingency Plan)	2	2	4
11c		Secondary Hazard - debris resulting in injury and damage.	Pilots, Ground Personnel, aircraft, equipment, property.	3	2	6	Relocate Wind Turbine	3	1	3
11d		Secondary Hazard - debris resulting in injury and damage.	Pilots, Ground Personnel, aircraft, equipment, property.	3	2	6	Downsize Wind Turbine	3	1	3
12	**Turbines / Blade Disintegration**									
12a		Secondary Hazard - debris resulting in injury and damage.	Pilots, Ground Personnel, aircraft, equipment, property.	3	2	6	Improved Engineering Design and Proactive maintenance (OEM specifications followed).	2	1	2

12b		Secondary Hazard - debris resulting in injury and damage.	Pilots, Ground Personnel, aircraft, equipment, property.	3	2	6	Undertake on-site studies to determine the effects of such an accident and devise appropriate safety measures (Emergency Contingency Plan)	2	2	4
12c		Secondary Hazard - debris resulting in injury and damage.	Pilots, Ground Personnel, aircraft, equipment, property.	3	2	6	Relocate Wind Turbine	5	1	5
12d		Secondary Hazard - debris resulting in injury and damage.	Pilots, Ground Personnel, aircraft, equipment, property.	3	2	6	Downsize Wind Turbine	3	1	3
13	**Turbines Fire**									
13a		Secondary Hazard - debris resulting in injury and damage.	Pilots, Ground Personnel, aircraft, equipment, property.	3	3	9	Improved Engineering Design and Proactive maintenance (OEM specifications followed).	2	1	2
13b		Secondary Hazard - debris resulting in injury and damage.	Pilots, Ground Personnel, aircraft, equipment, property.	3	3	9	Undertake on-site studies to determine the effects of such an accident and devise appropriate safety measures (Emergency Contingency Plan)	2	2	4
13c		Secondary Hazard - debris resulting in injury and damage.	Pilots, Ground Personnel, aircraft, equipment, property.	3	3	9	Improved Engineering Design for Proactive Fire control measures, including local Emg. Response and fire control personnel.	2	1	2
13d		Secondary Hazard - debris resulting in injury and damage.	Pilots, Ground Personnel, aircraft, equipment, property.	3	3	9	Relocate Wind Turbine	3	1	3
13e		Secondary Hazard - debris resulting in injury and damage.	Pilots, Ground Personnel, aircraft, equipment, property.	3	3	9	Downsize Wind Turbine	3	2	6
14	**Turbines Blade Ice.**									

14a		Secondary Hazard - Ice debris resulting in injury and damage.	Pilots, Ground Personnel, aircraft, equipment, property.	3	3	9	Turbine operator to adopt more stringent winter operational standards. Adopt measures to reduce the probability.	2	2	4
14b		Secondary Hazard - Ice debris resulting in injury and damage.	Pilots, Ground Personnel, aircraft, equipment, property.	3	3	9	Improved Engineering Design and adoption of proactive & more stringent Ice control methods.	2	1	2
14c		Secondary Hazard - Ice debris resulting in injury and damage.	Pilots, Ground Personnel, aircraft, equipment, property.	3	3	9	Undertake on-site studies to determine the effects of such an accident and devise appropriate safety measures (Emergency Contingency Plan)	3	2	6
14d		Secondary Hazard - Ice debris resulting in injury and damage.	Pilots, Ground Personnel, aircraft, equipment, property.	3	3	9	Relocate Wind Turbine	3	1	3
14e		Secondary Hazard - Ice debris resulting in injury and damage.	Pilots, Ground Personnel, aircraft, equipment, property.	3	3	9	Downsize Wind Turbine	2	2	4
15	**Wind Turbine Anemometer Tower**									
15a		Collision by aircraft in circuit. Approach or take off.	Pilots, aircraft, wind MET Tower.	5	3	15	Prevent aircraft from manoeuvring in Anemometer Tower Areas.	5	1	5
15b		Collision by aircraft in circuit. Approach or take off.	Pilots, aircraft, wind MET Tower.	5	3	15	Relocate Anemometer Tower	5	1	5
15c		Collision by aircraft in circuit. Approach or take off.	Pilots, aircraft, wind MET Tower.	5	3	15	Downsize Anemometer Tower	4	2	8
15d		Collision by aircraft in circuit. Approach or take off.	Pilots, aircraft, wind MET Tower.	5	3	15	Raise Approach Minimum	5	2	10
16	**Wind Turbine & MET Tower Construction / Maintenance**									
16a		Collision by aircraft in circuit. Approach or take off.	Pilots, aircraft, wind Turbine & MET Tower.	5	3	15	Prevent aircraft from manoeuvring in Wind Turbine & Anemometer	5	1	5

							Tower Areas.			
16b		Collision by aircraft in circuit. Approach or take off.	Pilots, aircraft, wind Turbine & MET Tower.	5	3	15	Relocate Wind Turbine & Anemometer Tower.	5	1	5
16c		Collision by aircraft in circuit. Approach or take off.	Pilots, aircraft, wind Turbine & MET Tower.	5	3	15	Downsize Wind Turbine & Anemometer Tower.	4	2	8
16d		Collision by aircraft in circuit. Approach or take off.	Pilots, aircraft, wind Turbine & MET Tower.	5	3	15	Raise Approach Minimum.	5	2	10
17	**Wind Turbine & MET Tower Human Threats**									
17a		Sabotage/Vandalism/Terrorism/Bomb Threat / Shooting	Pilots, aircraft, wind turbine & MET Tower.	3	2	6	Prevent aircraft from manoeuvring in Wind Turbine & Anemometer Tower Areas.	3	1	3
17b		Sabotage/Vandalism/Terrorism/Bomb Threat / Shooting	Pilots, aircraft, wind turbine & MET Tower.	3	2	6	Relocate Wind Turbine & Anemometer Tower.	3	1	3
17c		Sabotage/Vandalism/Terrorism/Bomb Threat / Shooting	Pilots, aircraft, wind turbine & MET Tower.	3	2	6	Provide and/or Increase security.	3	2	6
18	**Wind Turbine & Navigation Aids & Communications**									
18a		Aeronautical navigation aids and communication systems	Pilots, ATC, Military.	3	3	9	Relocate Wind Turbine.	1	2	2
18b		Aeronautical navigation aids and communication systems	Pilots, ATC, Military.	3	3	9	Improved Engineering Design - shielding and reflection.	2	2	4
18c		Aeronautical navigation aids and communication systems	Pilots, ATC, Military.	3	3	9	Downsize Wind Turbine	2	2	4

APPENDIX A: GLOSSARY

Important Terms and Meanings:

In many situations various definitions exist. Where possible the Consultant has tried to include the most applicable and the most relevant to the context of the Report bearing in mind what reference document or Authority may have been cited. On occasion, a key word may not be defined by the National Regulator. In such situations, the higher Authority, such as the ICAO may have been used: i.e. Transport Canada has no formal definition for "Safety", so Annex 19 is referenced. For the purposes of this document the following terms are used with the meanings defined as follows: (Note, others may exist.)

TERM	MEANING	Ref.
Aerodrome	Means any area of land, water (including the frozen surface thereof) or other supporting surface used, designed, prepared, equipped or set apart for use either in whole or in part for the arrival, departure, movement or servicing of aircraft and includes any buildings, installations and equipment situated thereon or associated therewith.	Aeronautics Act
Aerodrome Traffic	Means all traffic on the movement area of an aerodrome and all aircraft operating at or in the vicinity of the aerodrome.	CAR Part 1 General Provisions 100.01
Airport	Means an aerodrome in respect of which a Canadian aviation document is in force.	Aeronautics Act
As Low As Reasonably Practical (ALARP)	A risk is low enough that attempting to make it lower, or the cost of assessing the improvement gained in an attempted risk reduction, would actually be more costly than any cost likely to come from the risk itself.	CAA - CAP 760
Balance of Probabilities	From a legal point of view it is the standard of proof in civil cases, demanding that the case that is the more probable should succeed	Collins Dictionary of Law © W.J. Stewart, 2006
Collision	Means an impact, other than an impact associated with normal operating circumstances, between aircraft or between an aircraft and another object or terrain.	TP 14371 - AIM
Hazard	Any condition, event, or circumstance which could induce an accident: or, Condition, object or activity with the potential of causing injuries to personnel, damage to equipment or	CAA - CAP 760

TERM	MEANING	Ref.
	structures, loss of material, or reduction of ability to perform a prescribed function.	

Hazard and Operability study (HAZOP)	A systematic functional hazard identification process that uses an expert group to conduct a structured analysis of a system using a series of guide words to explore potential hazards.	CAA - CAP 760
Incident	An occurrence, other than an accident, associated with the operation of an aircraft which affects, or would affect, the safety of operation.	CAA - CAP 760 ICAO - Annex 19
Obstacle Limitation Surfaces.	A surface that establishes the limit to which objects may project into the airspace associated with an aerodrome so that aircraft operations at the aerodrome may be conducted safely.	TC - TP 312 5th. Edition.
Risk	A combination of the likelihood of an hazard occurring and the severity of the accident that could result; e.g. the higher the risk, the more likely the accident will occur and/or the more severe will be the consequence; or, A state of uncertainty where some of the possibilities involve a loss, catastrophe, or other undesirable outcome. The predicted probability and severity, of the consequence(s) of hazard(s) taking as reference the potential outcomes.	CAA - CAP 760
Risk Assessment	A process that for identified hazards, evaluates their risk in terms of probability and severity of consequences.	CAA - CAP 760
Risk Mitigation	The process of incorporating defences or preventive controls to lower the severity and/or likelihood of a hazard's projected consequence.	ICAO Doc 9859
Risk of Collision	Means a situation in which an aircraft comes so close to being involved in a collision that a threat to the safety of any person, property or the environment exists.	TP 14371 - AIM
Safety Requirement	Specified criteria of a system that are necessary in order to reduce the risk of an accident or incident to an acceptable level. Also a requirement that helps achieve a Safety Objective.	CAA - CAP 760
Safety	The state in which risks associated with aviation activities, related to, or in direct support of the operation of aircraft, are reduced and controlled to an acceptable level.	ICAO - Annex 19
Safety Assessment Criteria	The set of quantitative or qualitative criteria to be used in a safety assessment to determine the acceptability of the assessed level of safety.	CAA - CAP 760

Safety Case	A documented body of evidence that provides a demonstrable and valid argument that a system is adequately safe for a given application and environment over its lifetime.	CAA - CAP 760
Safety Objective	The definition of a hazard together with its target maximum rate of occurrence. A goal or target that, where achieved, demonstrates that a tolerable level of safety is being, or will be achieved for the hazard concerned.	CAA - CAP 760

Note: The terms “balance of probabilities” and “likely” are frequently used when addressing risk.

APPENDIX B: RISK ASSESSMENTS AND SAFETY CASES

A **Risk Assessment** is a proactive process that is normally undertaken as a means of avoiding or preventing a situation from occurring by reducing the associated risks down to 'As Low As Reasonably Practical' (ALARP) or better.

The question to be asked therefore is:

"How safe does something need to be?"

Levels of safety are directly related to risk and we can assess risk and determine whether the level is acceptable or not. Naturally, the best time to perform this exercise is before – not after an event or a hazard is encountered. In aviation, it is the operator who normally undertakes the 'Safety Assessment' activities and it is the functional Hazard Assessment that is linked to "***the acceptable level of safety***".

A **Safety Assessment** is used to evaluate whether an organisation or individual has minimised the risk(s) contributing to an incident or safety issue as far as reasonably practicable. The objective is to resolve the risks created by hazards before an incident occurs. '**Hazard Identification**' and Analysis enable us to identify potential safety problems; while '**Risk Management**' is the ongoing activity to ensure that risk is always contained to the agreed level of acceptability.

'**Hazard**' and '**risk**' are commonly confused. A 'hazard' is a physical situation, often following initiating events that can lead to an incident. 'Risk' on the other hand, is a combination of the 'probability' or 'frequency of occurrence' of a defined hazard and the 'magnitude of the consequences of the occurrence'.

The basic steps in Safety Assessment are noted below – but first, a reminder: the Safety Assessment process is used primarily to develop 'acceptable levels of safety'. An organisation must be able to determine all existing operations and, as an ongoing process, all proposed changes, additions and/or replacement of systems, procedures and processes, for their safety significance. A Safety Assessment may be undertaken by a third party to confirm that an HRA has been properly carried out and that additional steps such as defining safety requirements have been undertaken (e.g specifying the need for fire protection, protective clothing, electrical safety interlock systems, etc).

The HRA is a process to address a change scenario. Typical HRA steps are as follows:

- Identify the hazards (to a specific assignment, etc.);
- Analyse the hazards;
- Assess the risk;
- Is the risk tolerable/does it meet the safety criteria?
- Manage the risk (mitigation and on-going Safety Assurance).

The HRA process is often included as a component of a larger '**safety case for change**'. As its name implies, a safety case for change quite literally makes the documented case for proceeding with the change(s). The core of the safety case is the HRA that is normally conducted by a proponent for change. Transport Canada and other regulatory bodies worldwide recognize the importance of the safety case as a means of ensuring that all risks are being managed. This contributes significantly to the concept of safety assurance which has been elevated to the status of an international Standard in Chapter 3 of the new ICAO Annex 19 (Safety Management) and more recently ISO Standard 9001:2015.

APPENDIX C: RISK ASSESSMENT TOOLS

The following identifies the major risk analysis tools used during the HRA. Other RATs may have been referenced and/or utilised: (Not listed in order of priority.)

Brainstorming:

Since brainstorming places much emphasis on imagination, it was considered to be particularly useful for identifying potential risks that might be associated with introducing a completely new scenario (installation of a wind farm) for HRA evaluation.

Brainstorming is a means of collecting a broad set of ideas and evaluation, ranking them by a team. Brainstorming may be stimulated by prompts or by one-on-one and one-on-many interview techniques.

ISO 31010 Table A.1 – Applicability of Tools Used for Risk Assessment.

Tools and Techniques	Risk Assessment Process					See Annex
	Risk Identification	Risk analysis			Risk evaluation	
		Consequence	Probability	Level of risk		
Brainstorming.	SA[1]	NA[2]	NA[2]	NA[2]	NA[2]	B 01

1) Strongly Applicable.
2) Not Applicable.
3) Applicable.

Semi-structured Interviews:

Given the nature of the HRA and the constraints of time, an informal but focused Semi-structured interview process was used to help identify issues. Previous conversational information may also have been applied to this process.

In a ‘structured interview’, individual interviewees are asked a set of prepared questions from a prompting sheet which encourages the interviewee to view a situation from a different perspective and thus identify risks from that perspective. A semi-structured interview is similar, but allows more freedom for a conversation to explore issues which arise. This is applicable to telephone and conference interviews.

Structured and semi-structured interviews are useful where it is difficult to get people together for a brainstorming session or where free-flowing discussion in a group is not appropriate for the situation or people involved. They are most often used to identify risks or to assess effectiveness of existing controls as part of risk analysis. They may be applied at any stage of a project or process. They are a means of providing stakeholder input to risk assessment.

ISO 31010 Table A.1 – Applicability of Tools Used for Risk Assessment.

Tools and Techniques	Risk Assessment Process					See Annex
	Risk Identification	Risk analysis			Risk evaluation	
		Consequence	Probability	Level of risk		
Structured or Semi-Structured Interviews.	SA[1]	NA[2]	NA[2]	NA[2]	NA[2]	B 02

1) Strongly Applicable.

2) Not Applicable.
3) Applicable.

Check-lists:

Since check-lists are lists of hazards, risks or control failures, usually developed from experience, either as a result of a previous HRA or as a result of past failures, such check lists or similar documents were reviewed when available and/or available. A check-list is a simple form of risk identification. It is a technique which provides a listing of typical uncertainties that may need to be taken into consideration. Users refer to a previously developed list, codes or standards.

A check-list can be used to identify hazards and risks or to assess the effectiveness of controls. They can be used at any stage of the life cycle of a product, process or system. They may be used as part of other risk assessment techniques but are most useful when applied to check that everything has been covered after a more imaginative technique that identifies new problems has been applied.

ISO 31010 Table A.1 – Applicability of Tools Used for Risk Assessment.

Tools and Techniques	Risk Assessment Process					See Annex
	Risk Identification	Risk analysis			Risk evaluation	
		Consequence	Probability	Level of risk		
Check-lists.	SA[1]	NA[2]	NA[2]	NA[2]	NA[2]	B 04

1) Strongly Applicable.
2) Not Applicable.
3) Applicable.

Structured "What-if" Technique (SWIFT) – Modified:

This is particularly valuable during the HRA to examine the 'consequences of change' and the associated risks altered or created. Due to time constraints it was less structured than noted in ISO 31010 which identifies the process as a system for prompting a team to identify risks. Although normally used within a facilitated workshop style session, due the constraints of the project, it was necessary to adapt the process to fit the requirements as noted previously.

ISO 31010 Table A.1 – Applicability of Tools Used for Risk Assessment.

Tools and Techniques	Risk Assessment Process					See Annex
	Risk Identification	Risk analysis			Risk evaluation	
		Consequence	Probability	Level of risk		
SWIFT.	SA[1]	SA1	SA1	SA1	SA1	B 09

1) Strongly Applicable.
2) Not Applicable.
3) Applicable.

Scenario Analysis:

Scenario Analysis is also a type of process that encompasses several other RATs; so in undertaking a lists a Scenario Analysis other tools may also be employed. For the purpose of this description, it will be taken in the context of the following ISO 31010 Ref. B.10, which states in part:

> Scenario analysis is a name given to the development of descriptive models of how the future might turn out. It can be used to identify risks by considering possible future developments and exploring their implications. Sets of scenarios reflecting (for

> example) 'best case', 'worst case' and 'expected case' may be used to analyse potential consequences and their probabilities for each scenario as a form of sensitivity analysis when analysing risk. ….
>
> Scenario analysis cannot predict the probabilities of such changes but can consider consequences and help organizations develop strengths and the resilience needed to adapt to foreseeable changes.

A simple form of Scenario Analysis was used to analyse potential consequences of the proposed changes. Although scenario analysis cannot predict the probabilities of such changes it can consider consequences and thus has value in this context. (Note: Root Cause Analysis is not appropriate to this HRA since this is not an investigation of failure.)

Scenario Analysis works by identifying (through imagination or extrapolation) the different risks considered, assuming each of these scenarios might occur. Possible future scenarios are identified through imagination or extrapolation from the present and different risks considered assuming each of these scenarios might occur. This can be accomplished formally or informally - qualitatively or quantitatively.

ISO 31010 Table A.1 – Applicability of Tools Used for Risk Assessment.

Tools and Techniques	Risk Assessment Process					See Annex
	Risk Identification	Risk analysis			Risk evaluation	
		Consequence	Probability	Level of risk		
Scenario Analysis.	SA[1]	SA[1]	A[3]	A[3]	A[3]	B 10

1) Strongly Applicable.
2) Not Applicable.
3) Applicable.

Failure Modes & Effects Analysis (FMEA) & Failure Modes & Effects & Criticality Analysis (FMECA)

Although this is only peripherally significant to this HRA, FMEA & FMECA was taken into consideration. Similarly the Consultants also considered the appropriateness of other RATs provided by ISO 31010 - although they may not have been employed in their totality at this stage.

Failure modes and effects analysis (FMEA) is a technique used to identify the ways in which components, systems or processes can fail to fulfil their design intent.

ISO 31010 Table A.1 – Applicability of Tools Used for Risk Assessment.

Tools and Techniques	Risk Assessment Process					See Annex
	Risk Identification	Risk analysis			Risk evaluation	
		Consequence	Probability	Level of risk		
FMEA & FMECA.	SA[1]	SA[1]	SA[1]	SA[1]	SA[1]	B 13

1) Strongly Applicable.
2) Not Applicable.
3) Applicable.

Human Reliability Assessment:

Human Reliability Assessment deals with the consequence of humans on system performance and can be used to evaluate human error influences on the system.

This is considered to be particularly important and was uppermost in the Consultants minds when considering the issues of change in this HRA. Human Reliability Assessment is a key analysis tool and deals with the effect of humans on system performance and can also be used to evaluate human error influences on the aircraft, operations or system, etc. As ISO 31010 points out, many processes contain potential for human error, especially when the time available to the operator to make decisions is short. The probability that problems will develop sufficiently to become serious can be small: human action will however, often be the only defence to prevent an initial failure progressing towards a serious or catastrophic incident.

The importance of Human Reliability Assessment has been illustrated by various incidents in which critical human errors contributed to a catastrophic sequence of events. For example, a change of aircraft or equipment has on several occasions caused human factor error. Such incidents are warnings against risk assessments that focus solely on procedures, hardware and software. Accident investigation – specifically Root Cause Analysis has often illustrated the dangers of ignoring the possibility of human error contribution.

ISO 31010 Table A.1 – Applicability of Tools Used for Risk Assessment.

Tools and Techniques	Risk Assessment Process					See Annex
	Risk Identification	Risk analysis			Risk evaluation	
		Consequence	Probability	Level of risk		
HRA.	SA[1]	SA[1]	SA[1]	SA[1]	A[3]	B 20

1) Strongly Applicable.
2) Not Applicable.
3) Applicable.

Risk Evaluation (and Mitigation)

Although detailed mitigation and associated safety requirements do not form part of a pure formal HRA, it is nevertheless the next logical step and all concerned are encouraged to assess this aspect of the change process.

Consequence/Probability Matrix:

The Consequence/Probability Matrix (C/PM) tool was used as required in the HRA as a means of combining qualitative ratings of consequence and probability to produce a level of risk or risk rating. A C/PM is used to rank risks, sources of risk or risk treatments on the basis of the level of risk. This kind of risk matrix is also widely used to determine if a given risk is broadly acceptable, or not acceptable according to the zone where it is located on the matrix.

The format of the matrix and the definitions applied to it depend on the context in which it is used and it is important that an appropriate design is used for the circumstances.

A C/PM is used to rank risks, sources of risk or risk treatments on the basis of the level of risk. It is commonly used as a screening tool when many risks have been identified, for example to define which risks need further or more detailed analysis, which risks need treatment first, or which need to be referred to a higher level of management.

It may also be used to select which risks need not be considered further at this time. This kind of risk matrix is also widely used to determine if a given risk is broadly acceptable, or not acceptable (see 5.4) according to the zone where it is located on the matrix. The C/PM was the primary RAT employed to visually demonstrate all perceived and known Hazards and associated risks. This was subsequently embedded within a spreadsheet format.

ISO 31010 Table A.1 – Applicability of Tools Used for Risk Assessment.

Tools and Techniques	Risk Assessment Process					See Annex
	Risk Identification	Risk analysis			Risk evaluation	
		Consequence	Probability	Level of risk		
C/PM.	SA[1]	SA[1]	SA[1]	SA[1]	A[3]	B 29

1) Strongly Applicable.
2) Not Applicable.
3) Applicable.

APPENDIX D: FORMS

STAYNER AERODROME - HAZARD & RISK ANALYSIS

HAZARD LIST

HAZARD AND RISK ASSESSMENTS

REMINDER

OBJECTIVE EVIDENCE: *Quantifiable information that can be verified through the use of analytical tools or other forms of research.* (Black's Law Dictionary).

HAZARD: *Any condition event or circumstance which could induce an accident*. (CAP 760).

RISK: *A combination of the likelihood of a hazard occurring and the severity of the accident that could result - the higher the risk the more likely that the accident will occur and/or the more severe will be the consequences*. (CAP 760).

There is rarely a single defined fixed level of risk for a specific hazard. Risk will vary in consequence and severity and may be affected by other conditions or secondary events, particularly in aviation. The least risk will be when all conditions are ideal and no other events or conditions such as adverse weather, equipment failure, human error or unforeseen circumstances occur. This however is not the normal situation in the dynamic environment of an ever changing world and assessors are thus obliged to err on the side of caution.

WARNING

Finally it must be remembered that the only true accident is the one that cannot be foreseen. In the perfect hazard and risk assessment, everything that can be foreseen should be identified and assessed. If an accident can be foreseen but the possibility and effects are ignored or discounted by those who have a duty of care, then there is a dereliction of duty.

Note: Attention is drawn to the fact that regulatory requirements i.e. NOTAMs and Illumination / Marking, etc. of obstacles is mandatory and have subsequently not been

included as a form of mitigation. Although a few Secondary Hazards have been included such events as migratory bird route changes have been omitted.

Qualatech Aero Consulting Ltd April 2016

STAYNER AERODROME - HAZARD & RISK ANALYSIS
HAZARD LIST

Hazard No. & RA Spreadsheet Ref No.	Hazard Description
1	Wind turbines #'s 1, 2, 4, 5, 6 & 8 inclusive are obstacles 145 metres high and protrude through the outer obstacle limitation surface (various penetration heights) which protects aircraft manoeuvering near the runway and circuit pattern. (Cormier/Transport Canada)
2	Wind turbine # 7 is an obstacle 145 meters high penetrating the take-off/approach surfaces of Runways 16/34.
3	Wind turbine #3 is an obstacle 145 meters high penetrating the transitional surface east of the take-off/approach surface to the north of Runway 34.
4 & 5	RNAV (GNSS) Instrument Approach for RWY 16 from the North West is penetrated in the critical final segment by Turbines 1,3,4,5 and 8. Missed approach segment compromised (penetrated) by Turbines 2, 6 and 7.
6	Approach VOR/DME A is severely compromised by 6 turbines and also the missed approach. All turbines would be obstacles to circling approaches to either runway.
7	Circling approach to Runway 34 from RNAV 16 approach procedure would be compromised by 7 turbines which would penetrate the circling area.
8 & 9	Departure Hazard: Turbine #4 would be a penetration hazard for aircraft departing on Runway 34 (to the north) and Turbine #7 for aircraft departing from Runway 16 (to the south).
10	Turbulence and Turbine Blade Wake Effects.
11	Collapse of turbine towers, particularly Turbines # 3 and 7.
12	Disintegration of Turbines / Blades.
13	Fire in Turbine Nacelle and/or Tower.
14	Ice forming on turbine blades, becoming detached and being flung through the air.
15	Wind Turbine Anemometer Tower(s) Location and Height.
16	Wind Turbine & Anemometer Tower Construction & Maintenance.
17	Sabotage/Vandalism/Terrorism/Bomb Threat.
18	Aeronautical Navigation Aids and Communication Systems.

Hazard Number: 1	**Hazard Identification:** Wind Turbines - Location and Height.

Hazard Description and Risk:

Wind turbines #'s 1, 2, 4, 5, 6 & 8 inclusive are obstacles 145 metres high and protrude through the outer obstacle limitation surface (various penetration heights) which protects aircraft manoeuvering near the runway and circuit pattern. (Cormier/Transport Canada). They are therefore a hazard to air operations since they could enable an accident.

The effect (accident) could be a collision by an aircraft in the circuit, with one of the wind turbines. The associated risk will vary in consequence and severity and may be affected by other conditions or secondary events. The least risk will be when all conditions are ideal and no other events or conditions such as adverse weather, equipment failure, human error or unforeseen circumstances occur.

Risk Severity (S): Catastrophic - 5.	**Risk Probability (P):** Remote - 3.

Risk Tolerability (Pre-Mitigation - S X P):

Unacceptable - 15 *Must be reduce to ALARP (6 – 12) and accept risk or reduce to below 6.

Risk Mitigation Measures:

1. Do not manoeuvre aircraft in the area of the turbines. However this would have the effect of sterilizing the airspace needed for operation of the aerodrome and is not a reasonable action in practice.
2. Change the location of the turbines so that they do not form obstacles to air operations at Stayner Aerodrome.
3. Reduce the size of the turbines/towers so that they do not form obstacles.
4. Raise approach Height to 843 AGL.

Risk Tolerability with Mitigation Measures in Place:

1. This mitigation option is impracticable. (Matrix Ref: A5:B1).
2. The likelihood of the event occurring is reduced to Minimum Level. Tolerability becomes acceptable. (Matrix Ref: A5:B1).
3. The likelihood of the event occurring is reduced to *Moderate Level. (Matrix Ref: A4:B2).
4. By raising the Approach Minimum the likelihood of the event occurring is reduced to *Moderate. (Matrix Ref: A5:B2).

Hazard Number:	**Hazard Identification:**
2	Wind turbine #7, south of Runway 16. penetrates the take-off/approach surfaces of Runways 16/34.

Hazard Description and Risk:

Wind turbine # 7 is an obstacle 145 meters high penetrating the take-off/approach surfaces of Runways 16/34. It is therefore a hazard to air operations since it could induce an accident.

The effect (accident) could be a collision by an aircraft with the turbine during approach or take-off. The associated risk will vary in consequence and severity and may be affected by other conditions or secondary events. The least risk will be when all conditions are ideal and no other adverse events or conditions occur. Approach and take off are high risk segments of flight which affects the probability.

Risk Severity (S):	**Risk Probability (P):**
Catastrophic - 5	Reasonably Probable - 4

Risk Tolerability (Pre-Mitigation - S X P):

Unacceptable – 20 *****Must be reduce to ALARP (6 – 12) and accept risk or reduce to below 6.

Risk Mitigation Measures:

5. Do not allow aircraft to land or take-off. However this would have the effect of closing the aerodrome and is not a reasonable action in practice.
6. Do not manoeuvre aircraft in the area of the turbines. However this would have the effect of sterilizing the airspace needed for operation of the aerodrome and is not a reasonable action in practice.
7. Change the location of the turbines so that they do not form obstacles to air operations at Stayner Aerodrome;
8. Reduce the size of the turbines/towers so that they do not form obstacles.
9. Raise approach Height.

Risk Tolerability with Mitigation Measures in Place:

5. This mitigation option is impracticable. (Matrix Ref: A5:B1).
6. This mitigation option is impracticable. (Matrix Ref: A5:B1).
7. The likelihood of the event occurring is reduced to Minimum Level. Tolerability becomes acceptable. (Matrix Ref: A5:B1).
8. The likelihood of the event occurring is reduced to *Moderate Risk. Tolerability becomes acceptable. (Matrix Ref: A4:B2).
9. Raise Approach Minimum, reduces some risk but is still considered a *Moderate Risk. (Matrix Ref: A5:B2).

Hazard Number:

3

Hazard Identification:

Turbine #3 penetrates the transitional surface east of the take-off/approach surface to the north of Runway 34.

Hazard Description and Risk:

Wind turbine #3 is an obstacle 145 meters high penetrating the transitional surface east of the take-off/approach surface to the north of Runway 34. It is a hazard to air operations since it could induce an accident.

The effect (accident) could be a collision by an aircraft with the turbine during approach or take-off. The associated risk will vary in consequence and severity and may be affected by other conditions or secondary events. The least risk will be when all conditions are ideal and no other adverse events or conditions occur. Approach and take off are high risk segments of flight which affects the probability.

Risk Severity (S):

Catastrophic - 5

Risk Probability (P):

Reasonably Probable - 4

Risk Tolerability (Pre-Mitigation - S X P):

Unacceptable – 20. *Must be reduce to ALARP (6 – 12) and accept risk or reduce to below 6.

Risk Mitigation Measures:

10. Do not allow aircraft to land or take-off. However this would have the effect of closing the aerodrome and is not a reasonable action in practice.
11. Do not manoeuvre aircraft in the area of the turbines. However this would have the effect of sterilizing the airspace needed for operation of the aerodrome and is not a reasonable action in practice.
12. Change the location of the turbines so that they do not form obstacles to air operations at Stayner Aerodrome.
13. Reduce the size of the turbines/towers so that they do not form obstacles.
14. Raise approach Height.

Risk Tolerability with mitigation measures in place:

10. This mitigation option is impracticable. (Matrix Ref: A5:B1).
11. This mitigation option is impracticable. (Matrix Ref: A5:B1).
12. The likelihood of the event occurring is reduced to Minimum Level. Tolerability becomes acceptable. (Matrix Ref: A5:B1).
13. The likelihood of the event occurring is reduced to a *Moderate Level. (Matrix Ref: A4:B2).
14. Raise Approach Minimum, reduces some risk but is still considered a *Moderate Level. (Matrix Ref: A5:B2).

Hazard Number: **4 & 5**	**Hazard Identification:** RNAV (GNSS) Instrument Approach for RWY 16 from the North West is penetrated in the critical final segment by Turbines 1,3,4,5 and 8. Missed approach segment compromised (penetrated) by Turbines 2, 6 and 7.

Hazard Description and Risk:

Wind turbine 1 to 8 are obstacles 145 meters high penetrating the airspaces noted in the above Hazard identification. They are hazards to air operations that could induce accidents.

The effect (accident) could be a collision by an aircraft with a turbine(s) during approach or missed approach. The associated risk will vary in consequence and severity and may be affected by other conditions or secondary events. The least risk will be when there are no adverse events or conditions. The approach is a high risk segment of flight which affects the probability as does the number of associated obstacles in this instance.

Risk Severity (S):	**Risk Probability (P):**
Catastrophic - 5	Catastrophic - 5

Risk Tolerability (Pre-Mitigation - S X P):

Unacceptable – 25 *Must be reduce to ALARP (6 – 12) and accept risk or reduce to below 6.

Risk Mitigation Measures:

15. Do not allow aircraft to use this approach procedure. However, this would have the effect of constraining aerodrome use and **could in itself increase risk by preventing aircraft from using a published safe approach**, so is not a reasonable action in practice.
16. Change the location of the turbines so that they do not form obstacles to RNAV16 approach at Stayner Aerodrome.
17. Reduce the size of the turbines/towers so that they do not form obstacles.

Risk Tolerability with mitigation measures in place:

15. This mitigation option is impracticable and could increase risk. (Matrix Ref: A5:B1).
16. The hazard would no longer exist and thus there would be no risk. The likelihood of the event occurring is reduced to Minimum Level. Tolerability becomes acceptable. (Matrix Ref: A5:B1).
17. The likelihood of the event occurring is reduced to *Moderate Level. (Matrix Ref: A4:B2).

Hazard Number: **6**	**Hazard Identification:** Approach VOR/DME A is severely compromised by 6 turbines and also the missed approach. All turbines would be obstacles to circling approaches to either runway.

Hazard Description and Risk:

Wind turbines 1 to 8 are obstacles 145 metres high penetrating the airspaces noted above. They are hazards to air operations that could induce accidents.

Turbines 1, 3, 4, 5, 6, 7 and 8 would be directly in the path of an aircraft on the final segment of the approach. The procedures expert states that all turbines would penetrate the missed approach protected airspace. They would also compromise circling approaches to both runways. The effect (accident) could be a collision by an aircraft with a turbine during approach or missed approach. The associated risk will vary in consequence and severity and may be affected by other conditions such as weather or secondary events such as aircraft mechanical failure, pilot disorientation or turbine malfunction. The approach is a high risk segment of flight which affects the probability as does the number of obstacles in this instance. The risks are so great that the VOR DME approach would become *de facto* unusable. This would then introduce secondary risks in periods of marginal or deteriorating weather since aircraft would be denied the opportunity to make a safe instrument approach or cloud break procedure, leading to possible accidents due to loss of control, controlled flight into terrain (CFIT) etc.

Risk Severity (S): Catastrophic - 5	**Risk Probability (P):** Reasonable Probable - 4

Risk Tolerability (Pre-Mitigation - S X P):

Unacceptable – 20 *Must be reduce to ALARP (6 – 12) and accept risk or reduce to below 6.

Risk Mitigation Measures:

18. Do not allow aircraft to use this approach procedure. However this would have the effect of constraining aerodrome use and **could in itself increase risk by preventing aircraft from using a published safe approach**, so it is not a reasonable action in practice.
19. Change the location of the turbines so that they do not form obstacles to RNAV16 approach at Stayner Aerodrome.
20. Reduce the size of the turbines/towers so that they do not form obstacles;

Note:

With the turbines in place there are no other reasonable risk mitigation alternatives other than the above or those suggested by the procedures expert – which as in #1 above would cause the procedure to be withdrawn with all the added risks which that implies, as well as the loss of operational capability at the aerodrome.

Risk Tolerability with mitigation measures in place:

1. This mitigation option is impracticable and could **increase** risk. If the procedure was to be withdrawn the risks arising from an instrument approach would disappear but all the other risks would remain as detailed in the assessments. (Matrix Ref: A5:B1).
2. The hazard would no longer exist and thus there would be no risk. (Matrix Ref: A5:B1).
3. The likelihood of the event occurring is reduced to *Moderate Level. (Matrix Ref: A4:B2).

Hazard Number:

7

Hazard Identification:

Circling approach to Runway 34 from RNAV 16 approach procedure would be compromised by 7 turbines which would penetrate the circling area.

Hazard Description and Risk:

Wind turbines 1, 3, 4, 5, 6, 7 & 8 are obstacles 145 meters high penetrating the airspaces noted in the above Hazard Identification. They are hazards to air operations that could induce accidents.

The effect (accident) could be a collision by an aircraft with a turbine during a circling approach to Runway 34 from instrument procedure RNAV16. The associated risk will vary in consequence and severity and may be affected by other conditions or secondary events. The least risk will be when there are no adverse events or conditions. The approach is a high risk segment of flight which affects the probability as does the number of associated obstacles in this instance.

Risk Severity (S):

Catastrophic - 5

Risk Probability (P):

Reasonable Probable - 4

Risk Tolerability (Pre-Mitigation - S X P):

Unacceptable - 20 *Must be reduce to ALARP (6 – 12) and accept risk or reduce to below 6.

Risk Mitigation Measures:

21. Do not allow aircraft to use this approach procedure. However this would have the effect of constraining aerodrome use and **could in itself increase risk by preventing aircraft from using a published safe approach**, so is not a reasonable action in practice.

22. Allow circling only to the west of the Runway. However Turbine #7 would still penetrate the circling area so the mitigation would not completely mitigate the hazard and other severe and probably unacceptable restrictions would apply.

23. Change the location of the turbines so that they do not form obstacles to RNAV16 circling for Runway 34 approach at Stayner Aerodrome.

24. Reduce the size of the turbines/towers so that they do not form obstacles.

Risk Tolerability with mitigation measures in place:

18. This mitigation option is impracticable and could increase risk. (Matrix Ref: A4:B1).

19. The probability of the event occurring is reduced to a *Moderate Level. Tolerability becomes 10 but this is still unacceptable and other measures would be required. (Matrix Ref: A5:B2).

20. This would remove the hazard and thus there would be no risk. (Matrix Ref: A5:B1).

21. The likelihood of the event occurring is reduced to *Moderate Level. Tolerability becomes acceptable. (Matrix Ref: A4:B2).

Hazard Number:

8 & 9

Hazard Identification:

Departure Hazard: Turbine #4 would be a penetration hazard for aircraft departing on Runway 34 (to the north) and Turbine #7 for aircraft departing from Runway 16 (to the south).

Hazard Description and Risk:

Wind turbines #4 and #7 are obstacles 145 meters high penetrating the departure airspaces noted in the above Hazard Identification. They are hazards to air operations that could induce accidents.

Turbine #4 would be a penetration hazard for aircraft departing on Runway 34 (to the north) and Turbine #7 for aircraft departing from Runway 16 (to the south).

The effect (accident) could be a collision by an aircraft with a turbine during departure. The associated risk will vary in consequence and severity and may be affected by other conditions or secondary events. The least risk will be when there are no adverse events or conditions. The departure is a high risk segment of flight which affects the probability.

Risk Severity (S):

Catastrophic - 5

Risk Probability (P):

Remote - 3

Risk Tolerability (Pre-Mitigation - S X P):

Unacceptable - 15 Must be reduce to ALARP (6 – 12) and accept risk or reduce to below 6.

Risk Mitigation Measures:

25. Do not allow aircraft to depart from these runways. However there are no other runways to use. This would have the effect of constraining aerodrome use so it is not a reasonable action in practice.
26. Construct an alternative runway. This would require further study and could involve prohibitive costs.
27. Change the location of the turbines so that they do not form obstacles to RNAV16 approach at Stayner Aerodrome.
28. Reduce the size of the turbines/towers so that they do not form obstacles.

Risk Tolerability with mitigation measures in place:

22. This mitigation option is impracticable. (Matrix Ref: A5:B1).
23. If such a measure was found to be feasible and could be undertaken the probability would be reduce and tolerability would become acceptable. (Matrix Ref: A5:B1).
24. This would remove the hazard and thus there would be no risk. (Matrix Ref: A5:B1).
25. The likelihood of the event occurring is reduced to *Moderate Level. (Matrix Ref: A5:B2).

Hazard Number:

10

Hazard Identification:

Turbulence and Turbine Blade Wake Effects.

(all turbines).

Hazard Description and Risk:

Wind turbine 1 to 8 are obstacles 145 metres high penetrating the airspaces noted in the above Hazard identification. They are hazards to air operations that could induce accidents.

Turbine wake effects are discussed in the Report and in a number of the supporting documents/studies. They are known to generate risks to the stability and operation of aircraft and affect the dynamics of flight. Aircraft of the types using and likely to use Stayner Aerodrome would be affected within the volume of airspace 725 metres downwind from any of the turbines and this distance could well be higher – up to two or three times that distance, particularly for smaller aircraft. This is an area of continuing study and aerodrome and aircraft operators must proceed with caution.

The associated risk will vary in consequence and severity and may be affected by other conditions or secondary events.

Risk Severity (S):

Hazardous - 4

Risk Probability (P):

Reasonable Probable - 4 (could be higher?)

Risk Tolerability (Pre-Mitigation - S X P):

Unacceptable 16. *Must be reduce to ALARP (6 – 12) and accept risk or reduce to below 6.

WARNING: This hazard must be treated with extreme caution pending further objective evidence, particularly practical non-theoretical evidence.

Risk Mitigation Measures:

29. Do not allow aircraft to approach within 725 metres downwind of any turbine. Smaller aircraft must remain up to 1500 metres downwind. All aircraft must proceed with caution and monitor wind direction and speed.
30. Operate the turbines at low speed (8rpm) to reduce the effects reduced to a *Moderate Level.
31. Change the location of the turbines so that wake turbulence does not constitute a hazard to aircraft operating at Stayner Aerodrome.
32. Reduce the size of the turbines/towers so the wake is no longer a factor.

Risk Tolerability with mitigation measures in place:

26. Further study and practical objective evidence is required to produce a tolerability figure which will withstand robust testing. In the meantime, Transport Canada should be requested to promulgate an acceptable procedure. (Matrix Ref: A1:B2).
27. The likelihood of event occurrence should be reduced below a *Moderate Level. Further study is needed. Tolerability may become acceptable based on objective evidence and turbine design capability. (Matrix Ref: A2:B3).
28. If the hazard is removed there will be no risk. (Matrix Ref: A2:B1).
29. The likelihood of the event occurring is reduced to Minimum Level. Tolerability becomes acceptable. (Matrix Ref: A3:B1).

Hazard Number:	Hazard Identification:
11	Collapse of Turbine Towers (All turbines but # 3 & # 7 specifically).

Hazard Description and Risk:

Turbine towers have been known to collapse and this issue is discussed in the Report. Because they can collapse in any manner and direction and the locations vary in terms of surrounding environment, the resultant secondary hazards are problematic to estimate as is the risk. Nevertheless, the risk is very real.

The worst case scenario is for large pieces of debris to become detached during the collapse, some still in motion, and for these to strike aircraft or persons at Stayner Aerodrome, on the ground or in the air. Thus there is the potential (probability) for an accident. Without a body of objective evidence gained in similar environments, the consequences (severity) are presently difficult to estimate – but the risk exists.

Risk Severity (S):	Risk Probability (P):
Major - 3	Extremely Remote - 2

Risk Tolerability (Pre-Mitigation - S X P):

Review - 6. Must be reduce to ALARP (6 – 12) and accept risk or reduce to below 6.

Risk Mitigation Measures:

33. Frequent maintenance and engineering checks by the turbine operator. Review all similar incidents globally. Adopt measures to reduce the probability.
34. Undertake on-site studies to determine the effects of such an accident and devise appropriate safety measures (Emergency Contingency Plan).
35. Change the location of the turbines so that any risk cannot affect Stayner Aerodrome.
36. Reduce the size of the turbines/towers.

Risk Tolerability with mitigation measures in place:

30. This mitigation option may reduce probability. Tolerability may improve. (Matrix Ref: A2:B1).
31. This mitigation option may reduce severity. Tolerability may improve. (Matrix Ref: A2:B2).
32. The hazard and secondary hazards will be removed as will the risk. (Matrix Ref: A3:B1).
33. The likelihood of the event occurring is reduced to Minimum Level. Tolerability becomes acceptable. (Matrix Ref: A3:B1).

Hazard Number:

12

Hazard Identification:

Disintegration of Turbines / Blades.

Hazard Description and Risk:

Wind turbines 1 to 8 are obstacles 145 meters high penetrating the airspaces noted in the above Hazard identification. They are hazards to air operations that could induce accidents.

Turbine blade assemblies and nacelles have been known to disintegrate and this issue is discussed in the Report. Because they can disintegrate in any manner and direction and the locations vary in terms of surrounding environment, the resultant secondary hazards are difficult to estimate as is the risk. The worst case scenario is for large pieces of debris, some still in motion, to become detached and thrown through the air and to strike aircraft or persons at Stayner Aerodrome, on the ground or in the air.

Thus there is the potential (probability) for an accident. Without a body of objective evidence gained in similar environments, the consequences (severity) are presently difficult to estimate – but the risk exists and there is some amount of evidence.

Risk Severity (S):

Major - 3

Risk Probability (P):

Extremely Remote - 2

Risk Tolerability (Pre-Mitigation - S X P):

Review - 6. *Must be reduce to ALARP (6 – 12) and accept risk or reduce to below 6.

Major Review required.

Risk Mitigation Measures:

37. Frequent quality assurance, maintenance and engineering checks by the turbine operator. Review all similar incidents globally. Discuss in national and international meetings. Adopt measures to reduce the probability and severity.
38. Undertake on-site studies to determine the effects of such an accident and devise appropriate safety measures. OEMs to share failure information and Corrective Actions.
39. Change the location of the turbines so that any risk cannot affect Stayner Aerodrome.
40. Reduce the size of the turbines/towers so the result of disintegration is diminished.

Risk Tolerability with mitigation measures in place:

34. This mitigation option may reduce probability and severity. Tolerability may improve. (Matrix Ref: A2:B1).
35. This mitigation option may reduce severity. Tolerability may improve. (Matrix Ref: A2:B2).
36. The hazard will be removed as will the risk. (Matrix Ref: A5:B1).
37. The likelihood of the event occurring is reduced to Minimum Level. Tolerability becomes acceptable. (Matrix Ref: A3:B1).

Hazard Number: 13	**Hazard Identification:** Fire in Turbine Nacelle and/or Tower.
Hazard Description and Risk: Wind turbine 1 to 8 are obstacles 145 meters high penetrating the airspaces noted in the above Hazard identification. They are hazards to air operations that could induce accidents. Turbine nacelles and towers are known to catch fire and this issue is discussed in the Report. Because the turbines are usually in motion on such occasions the resultant secondary hazards are difficult to estimate as is the risk. The worst case scenario is for large pieces of burning debris, to become detached and thrown through the air and to strike aircraft or persons at Stayner Aerodrome, on the ground or in the air. Thus there is the potential (probability) for an accident involving both not only flying debris but also fire damage or injury. Without a body of objective evidence gained in similar environments, the consequences (severity) are presently difficult to estimate – but the risk exists and there is a quantity of evidence, including some deaths.	
Risk Severity (S): Major - 3	**Risk Probability (P):** Remote - 3
Risk Tolerability (Pre-Mitigation - S X P): **Review - 9.** *Must be reduce to ALARP (6 – 12) and accept risk or reduce to below 6. **Review required.**	
Risk Mitigation Measures: 41. Frequent quality assurance, maintenance and engineering checks by the turbine operator. Review all similar incidents globally. Discuss in national and international meetings. Adopt measures to reduce the probability and severity. 42. Undertake on-site studies to determine the effects of such an accident and devise appropriate safety measures. 43. Improve Fire Control and Turbine Auto extinguishing systems. Provide training to emergency response personnel in wind turbine emergency practices. 44. Change the location of the turbines so that any risk cannot affect Stayner Aerodrome. 45. Reduce the size of the turbines/towers so the result of disintegration is diminished.	
Risk Tolerability with mitigation measures in place: 38. This mitigation option may reduce probability and severity. Tolerability may improve. (Matrix Ref: A2:B1). 39. This mitigation option may reduce severity. Tolerability may improve. (Matrix Ref: A2:B2). 40. This mitigation will help prevent uncontrolled fire & consequent disruption. (Matrix Ref: A2:B1). 41. The hazard will be removed as will the risk. (Matrix Ref: A3:B1). 42. The likelihood of the event occurring is reduced but still present at a *Moderate Level. (Matrix Ref: A3:B2).	

Hazard Number: 14	**Hazard Identification:** Ice forming on turbine blades.

Hazard Description and Risk:

Wind turbine 1 to 8 are obstacles 145 meters high penetrating the airspaces noted in the above Hazard identification. They are hazards to air operations that could induce accidents.

Turbine blade assemblies and nacelles can be susceptible to ice build-up during certain weather conditions. If pieces of ice become detached they become projectiles although the resultant secondary hazards are difficult to estimate as is the risk.

The worst case scenario is for large pieces of ice to become detached and thrown through the air and to strike aircraft or persons at Stayner Aerodrome, on the ground or in the air. Thus there is the potential (probability) for an accident. Without a body of objective evidence gained in similar environments, the consequences (severity) are presently difficult to estimate – but the risk exists and should be taken into account.

Risk Severity (S):	**Risk Probability (P):**
Major - 3	Remote - 3

Risk Tolerability (Pre-Mitigation - S X P):

Review - 3. Must be reduce to ALARP (6 – 12) and accept risk or reduce to below 6.

Review required.

Risk Mitigation Measures:

46. Turbine operator to pay particular attention to probability during winter. Adopt measures to reduce the probability.
47. Improved Engineering Design and adoption of proactive & more stringent Ice control methods.
48. Undertake on-site studies to determine the effects of such an event and devise appropriate safety measures.
49. Change the location of the turbines so that they do not form obstacles to RNAV16 approach at Stayner Aerodrome.
50. Reduce the size of the turbines/towers so the result of disintegration is diminished.

Risk Tolerability with mitigation measures in place:

43. This mitigation option may reduce probability. Tolerability may improve. (Matrix Ref: A2:B2).
44. This mitigation option may reduce probability. (Matrix Ref: A2:B1).
45. This mitigation option may reduce severity. Tolerability may improve. However, the likelihood of the event occurring is only marginally reduced to *Moderate Level (Matrix Ref: A3:B2).
46. The hazard will be removed as will the risk. (Matrix Ref: A3:B1).
47. The likelihood of the event occurring is reduced but still present. (Matrix Ref: A2:B2).

Hazard Number:

15

Hazard Identification:

Wind Turbine Anemometer Tower(s) Location and Height.

Hazard Description and Risk:

Anemometer Towers (MET) can be an obstacle to aviation depending on the height and if they protrude through the outer obstacle limitation surface which protects aircraft manoeuvering near the runway and circuit pattern. Such erections are therefore a hazard to air operations since they could enable an accident.

The effect (accident) could be a collision by an aircraft in the circuit or vicinity near the aerodrome with a Anemometer Tower. The associated risk will vary in consequence and severity and may be affected by other conditions or secondary events. The least risk will be when all conditions are ideal and no other events or conditions such as adverse weather, equipment failure, human error or unforeseen circumstances occur.

Risk Severity (S):

Catastrophic - 5.

Risk Probability (P):

Remote - 3.

Risk Tolerability (Pre-Mitigation - S X P):

Unacceptable - 15 *Must be reduce to ALARP (6 – 12) and accept risk or reduce to below 6.

Risk Mitigation Measures:

51. Do not manoeuvre aircraft in the area of the Anemometer Tower. However this may have the effect of sterilizing the airspace needed for operation of the aerodrome and may therefore not be a reasonable action in practice.
52. Change the location of the Anemometer Tower so that they do not form obstacles to air operations at Stayner Aerodrome.
53. Reduce the height of the Anemometer Tower so that they do not form obstacles.
54. Raise approach Minimum Height as required.

Risk Tolerability with Mitigation Measures in Place:

48. This mitigation option may be impracticable. (Matrix Ref: A5:B1).
49. The likelihood of the event occurring is reduced to Minimum Level. Tolerability becomes acceptable. (Matrix Ref: A5:B1).
50. The likelihood of the event occurring is reduced to *Moderate Level. Tolerability becomes acceptable. (Matrix Ref: A4:B2).
51. By raising the Approach Minimum the likelihood of the event occurring is reduced to *Moderate. (Matrix Ref: A5:B2).

Hazard Number:	**Hazard Identification:**
16	Wind Turbine & Anemometer Tower Construction & Maintenance.

Hazard Description and Risk:

Wind Turbine & Anemometer Towers' (may) inclusive are obstacles and protrude through the outer obstacle limitation surface (various penetration heights) which protects aircraft manoeuvering near the runway and circuit pattern. (Cormier/Transport Canada). There construction and maintenance is therefore a hazard to air operations since they could enable an accident.

The effect (accident) could be a collision by an aircraft in the circuit, with one of the Wind Turbine or Anemometer Towers is compounded due to the equipment employed during their construction and maintenance i.e. very large cranes and/or helicopters. The associated risk will vary in consequence and severity and may be affected by other conditions or secondary events. The least risk will be when all conditions are ideal and no other events or conditions such as adverse weather, equipment failure, human error or unforeseen circumstances occur.

Risk Severity (S):	**Risk Probability (P):**
Catastrophic - 5.	Remote - 3.

Risk Tolerability (Pre-Mitigation - S X P):

Unacceptable - 15 *Must be reduce to ALARP (6 – 12) and accept risk or reduce to below 6.

Risk Mitigation Measures:

55. Do not manoeuvre aircraft in the area of the Wind Turbine & Anemometer Towers during construction and/or maintenance. However this would have the effect of sterilizing the airspace needed for operation of the aerodrome and is not a reasonable action in practice.
56. Change the location of the Wind Turbine & Anemometer Towers so that they do not form obstacles to air operations at Stayner Aerodrome.
57. Reduce the size of the Wind Turbine & Anemometer Towers so that they do not form obstacles.
58. Raise approach Height as required.

Risk Tolerability with Mitigation Measures in Place:

52. This mitigation option is impracticable. (Matrix Ref: A5:B1).
53. The likelihood of the event occurring is reduced to Minimum Level. Tolerability becomes acceptable. (Matrix Ref: A5:B1).
54. The likelihood of the event occurring is reduced to *Moderate Level. (Matrix Ref: A4:B2).
55. By raising the Approach Minimum the likelihood of the event occurring is reduced to *Moderate. (Matrix Ref: A5:B2).

Hazard Number:

17

Hazard Identification:

Sabotage/Vandalism/Terrorism/Bomb Threat.

Hazard Description and Risk:

Security measures need to be considered in respect to Sabotage/Vandalism/Terrorism/Bomb Threat, etc. The effects of which could cause loss of control to an aircraft in the immediate vicinity of the Wind Turbine or Anemometer Tower or restrict operations.

The associated Sabotage/Vandalism/Terrorism will vary in consequence and severity and may induce other conditions or secondary events i.e. shooting will produce stray bullets! Bomb threats are another example, even as 'only a threat' they will have a consequence.

Sabotage/Vandalism/Terrorism/Bomb Threat and shootings have been documented to have occurred and therefore present a real threat.

Risk Severity (S):

Major - 3.

Risk Probability (P):

Extremely Remote - 2.

Risk Tolerability (Pre-Mitigation - S X P):

Review - 6 *Must be reduce to ALARP (6 – 12) and accept risk or reduce to below 6.

Risk Mitigation Measures:

59. Do not manoeuvre aircraft in the area of the Wind Turbine & Anemometer Towers. However this would have the effect of sterilizing the airspace needed for operation of the aerodrome and is not a reasonable action in practice.
60. Change the location of the Wind Turbine & Anemometer Towers so that they do not provide targets for Sabotage/Vandalism/Terrorism/Bomb threats and shooting.
61. Provide and/or increase Security Measures.

Risk Tolerability with Mitigation Measures in Place:

56. This mitigation option is impracticable. (Matrix Ref: A3:B1).
57. The likelihood of the event occurring is reduced to Minimum Level. Tolerability becomes acceptable. (Matrix Ref: A3:B1).
58. Increasing security may not be feasible or economical to police. Furthermore, security measures i.e. CTV - Camera, people, etc., are not full proof. This is a *Moderate Level. (Matrix Ref: A3:B2).

Hazard Number: **18**	**Hazard Identification:** Aeronautical Navigation Aids and Communication Systems.

Hazard Description and Risk:

Nav systems and aids, such as ILS, VOR/DME and Direction Finders, together with air-ground communications facilities and Radar could potentially be affected by wind turbine operation.

Wind turbines can affect the propagation of the radiated signal from both navigation and communication facilities. As a result, the integrity and performance of a systems could be potentially degraded affecting aviation safety.

Wind Turbines are also know to affect Primary Surveillance Radar (PSR) and Secondary Surveillance Radar (SSR), thereby potentially compromising current and (possible) future radar effeteness. As a result, the integrity and performance of a system could be potentially degraded affecting aviation safety.

Risk Severity (S): Catastrophic - 3.	**Risk Probability (P):** Remote - 3.

Risk Tolerability (Pre-Mitigation - S X P):

Review - 3 *Must be reduce to ALARP (6 – 12) and accept risk or reduce to below 6.

Risk Mitigation Measures:

62. Change the location of the Wind Turbine to an area that has no aviation or military significance.
63. Improve Engineering to Wind Turbine Blades and/or Radar / Navigation/ Comms.
64. Reduce the size of the Wind Turbines.

Risk Tolerability with Mitigation Measures in Place:

59. The likelihood of the interference is reduced to Minimum Level. Tolerability becomes acceptable. (Matrix Ref: A1:B2).
60. This mitigation option is impracticable to implement for this project. (Matrix Ref: A2:B2).
61. The likelihood of the event occurring is reduced to Minimum Level. Tolerability becomes acceptable. (Matrix Ref: A2:B2).

APPENDIX E: SELECTED WIND TURBINE STUDIES

Numerous studies related to wind turbines have been undertaken in a number of countries. However it is important to differentiate between those studies which primarily explore the physics and dynamics of wind turbines, those which concentrate on the effects of wind turbines on primary (and even secondary) aviation ground radar and other electronic systems (Newcastle) and those which have sought to come up with hard data on the effects of wind turbines on aerodrome and aircraft operations. One key issue which will not go away, no matter how many studies there are, is that <u>wind turbines are obstacles</u>. With the large number of complex mathematical studies concentrating on turbulence it is easy to lose sight of this core aspect of the wind turbine situation.

In the case of aviation ground radar and other electronic systems it is useful to note the experience of Newcastle Airport in the UK. This busy regional airport became the centre of a planning battle where the local authority initially refused a number of wind turbines due to problems that would arise for the airport. After a process lasting six years a technical solution was found that would allow a limited number of turbines to co-exist with the airport radar. The technical solution cost C$10million. It should be noted that the proposed turbines were not in such proximity as to interfere with the actual operation of aircraft, unlike Fairview.

Most of the studies related to wake turbulence carried out so far indicate the need for protected zones from 5 to 15 rotor diameters downwind of the turbine but as noted above and elsewhere, wind turbines are major obstacles and must be considered in the context of the regulations pertaining thereto.

University of Liverpool in collaboration with CAA, UK:

A wind turbine wake study using engineering wake modelling, CFD, LIDAR field measurements and piloted flight simulations was carried out by the University of Liverpool in collaboration with the UK CAA at East Midlands Airport/Aerodrome (Elevation 309 ft ASL). It was recognised by the CAA that the wake vortices generated by a wind turbine or a wind farm could cause interference with passing light aircraft.

East Midlands Airport/Aerodrome has two WTN 250 wind turbines located on the airport. The WTN 250 towers are 30 metres high and the height to the top of the blade tips is approximately 45 metres (Elevations 461 ft. and 464 ft. ASL or about 155 ft. above the ground). They are thus relatively low - some 100m or so less than Fairview.

This study was extremely detailed and went to great lengths to understand the behaviour of air masses and air movements in the vicinity of the two turbines and to describe them in scientific terms. However, it is important to remember that the study was not carried out because it was thought that the turbines were an obstruction or that evidence existed that indicated that the turbines were a danger to airport operations. These turbines were installed by the airport company to provide a source of airport power and were planned and sited so as not to cause an obstruction. The turbines are not listed in the official CAA aeronautical publications as an obstruction (thus requiring publication and lighting), unlike the control tower, which is much closer to the runway and is 6 metres higher. It was the first airport in the UK to make such an installation and thus was very convenient for study. The turbines are located on the airport itself, adjacent to airport buildings, approximately 700 metres due south of the runway (09/27). Thus the location of the turbines, on the airport, at low level and completely outside the approach and departure airspace is such as to preclude any noticeable interference with aircraft operations.

The results (published in 2015) show that for the (small-size) WTN 250 wind turbine (diameter 30 metres and speed 40 rpm) the wake is not strong enough to cause any significant upset to the aircraft at distances of 5 wind turbine diameters and longer.

However, the study conclusions state that "*the validation of the models, currently, allows for no extrapolation to larger wind turbines*". This is important since the turbines which are the subject of this appeal have a diameter of 90 metres – 3 times greater than the WTN 250 turbine. In summary therefore, the results of the study, while scientifically very valuable, should be considered in that context.

Canadian Owners and Pilots Association (COPA) and SMS Aviation Safety Inc.:

COPA, membership consists of operators of privately owned General Aviation (GA) aircraft and operators of many of the smaller aerodromes from which GA aircraft fly and has attempted to influence approval processes to ensure there are safe distances between wind turbines and existing aerodromes.

COPA contracted SMS Aviation Safety Inc. to conduct a third-party safety-risk assessment of the issue since it was considered that there had been no comprehensive safety-risk assessment of the effects of wind turbines on GA aircraft. SMS Aviation Safety Inc. conducted the assessment and prepared its report in March 2011. The report states:

> The purpose of the safety-risk assessment was:
>
> to determine whether the risks of wind turbines to GA aircraft warrant a more systematic approach to safety-risk management and the scope was defined as the effect of wind turbines on general aviation (GA).

In Section 5.1 of the report, the panel concluded that steps are necessary to further mitigate the risks faced by pilots flying GA aircraft. To maximise the effectiveness of new mitigation strategies, the report recommended that stakeholders from the wind energy and aviation industries – including regulatory bodies – coordinate their activities. This, it was stated, "*will encourage the development of a systematic approach to wind farm development across Canada, which in turn will streamline the development process, minimize the number of challenges received by both regulators and developers, and improve overall system safety*".

COPA particularly wished to highlight the deficiencies at Federal, Provincial and local levels in dealing with the issue of wind farm development and the SMS did this clearly and thoroughly. As the final conclusions of the SMS Aviation Safety Inc. Report pointed out:

> A national strategy is needed to address this situation. Common processes that influence local approval processes across Canada would benefit the growth of sustainable energy production.
>
> The longer that the current disjointed situation is allowed to persist, the more time and money will be lost on flawed projects, or on arguing for the approval of sound

> projects. Worse than that, the greater will be the chances of projects realizing safety, environmental or health risks due to lack of integration of new knowledge".

COPA Director Mr. Paul Hayes also noted in his article "Perils of Wind Turbines", previously submitted,(Environmental Registry # 012-0614 Ministry of the Environment Ref. # 8250-8XUKKC Fairview Wind Project Requesting Comments by 01 February 2014 Submission by Kevin & Gail Elwood 8257 County Rd 91, Stayner, ON Appendix 4.3) that "if the TP 312 standard for the outer surface is included in the consideration, then any obstacle higher than 45 m (150 feet) above the elevation of the aerodrome within a 4 km radius of the aerodrome centre point would not be acceptable. This surface is intended to protect aircraft maneuvering in the vicinity of an aerodrome".

Netherlands - NLR Air Transport Safety Institute:

Study: Wind Turbines Near Airports – Problems and solutions for wind turbine siting in the vicinity of airports by Peter J. van der Geest.

This detailed mathematical and scientific study also used the case of a specific general aviation aerodrome in the Netherlands. The author highlights an important piece of national legislation as follows:

> "In the Netherlands it is felt that the increase of the number of large wind turbines, in particular in the proximity of smaller airports, may become hazardous to general aviation, and that this issue is currently insufficiently covered by international regulations. For this reason the Inspectorate of Transport and Waterworks has amended the national regulatory framework for civil airports ('Regeling houdende regels voor burgerluchthavens'). Due to this amendment the Inner Horizontal and Conical Surface have been extended with an Outer Horizontal Surface, that for airports with runways shorter than 1200 meters protects the airspace from obstacles larger than 100 meters up to 5100 meters from the airport."

> Wind hindrance at airports due to large obstacles, such as wind turbines, is currently not regulated. This issue has been recognized by EC and EASA. In 2009 the authority of EASA has been extended to include aerodromes. In this context the basic regulation EC No 216/2008, defining the common rules in the field of aviation, has been amended. In this amendment the essential requirements for aerodromes have been specified. It is interesting to note that the issue of wind hindrance has been recognized in this amendment. It is specified that the airspace around aerodromes shall be safeguarded from obstacles, and that therefore obstacle monitoring surfaces shall be developed, implemented and monitored. The possibility of obstacle-induced turbulence is specifically mentioned as a hazard that needs to be monitored, assessed and mitigated as appropriate. No further guidance is further given on how this can be achieved. However, in the Netherlands a well-accepted criterion is the so-called "7 knots" criterion that implies that for commercial aircraft an obstacle may not cause a reduction of the undisturbed wind velocity with more than 7 knots at any point of the aircraft trajectory. Based on this criterion NLR-ATSI (Nieuwpoort et al, 2006) developed appropriate turbulence monitoring surfaces.

USA:

Study: *Wind Farm Turbulence Impacts on General Aviation Airports in Kansas*. A cooperative transportation research program between: Kansas Department of Transportation, Kansas State University Transportation Center, and The University of Kansas.

The results of this project showed that the turbulence from a wind turbine can adversely affect operations at a general aviation airport. Two case studies were used to illustrate the impact of turbulence from a wind turbine and the project analyzed the roll hazard and the crosswind hazard resulting from a wind farm located near a general aviation airport. These hazards were found to be significant.

The results showed that the scenario is different according to the relative locations and orientations of the airport and the nearby wind farm and thus the analysis has to be performed for each specific regional airport.

The project report recommended that additional studies should be performed to draw the proper correlation between the hazard index developed in the study and the safe operation of aircraft at low airspeeds and at low flight altitudes operating near or at a general aviation airport.

APPENDIX F: SELECTED ACCIDENT REPORTS

Accident Reports:

Collisions

At present there is not a large catalogue of aviation accident reports or anecdotal evidence of collisions, near misses or loss of control events related to wind turbines. Actual crashes, injury or loss of life have so far been rare, but caution must be exercised in deriving inferences from this. The wind power industry is relatively new and the location of significant obstacles in close proximity to take-off and landing approaches of aerodromes is strictly regulated in most jurisdictions.

The most recent fatal accident involving an aircraft and a wind turbine occurred 10 miles south of Highmore, South Dakota USA in April 2014. The FAA concluded that the aircraft had collided with the wind turbine and the commercial pilot and three passengers were fatally injured and dead when the site was reached by first responders. The aircraft was registered to and operated by a private individual. The pilot of the aircraft was reported as having reported concerns about the wind farm to the FAA, but it is not known what they were.

In Lincolnshire, England, in 2009 the British television network ITN reported that what local residents believed to be an unidentified flying object struck a wind turbine causing one blade to shear off and the others to sustain significant damage. Since it was dark at the time of the event, the witnesses could only hear the damage taking place and reported flashes of light.

Turbine Mechanical Failures

Researchers from Imperial College London, the University of Edinburgh and SP Technical Research Institute of Sweden carried out a global assessment of the world’s wind farms and published their report in July 2014. Turbine blade failure and fire were found to be the most common cause of accidents/damage to wind turbines and to surrounding property. The researchers at Imperial College etc estimated that out of 200,000 (the exact number is not known) wind turbines dispersed around the world there are on average 177 annually catch fire, let alone structurally failing.

There are also many news reports and live video footage of accidents involving wind turbines in normal operation. Accounts of blade failures report debris being hurled some distance as equipment disintegrated. On 2 January 2015, as reported by the BBC on 3 January, a 100-metre wind turbine collapsed on a mountainside near Fintona in County Tyrone, Northern Ireland scattering debris over a wide area. The turbine was one of eight on the Screggagh wind farm. It was not clear what caused the structure to collapse, and the winds were light at the time.

People in the area said the rotor blades “*were spinning out of control*” on the evening the turbine buckled although it is unclear what they meant by this.

PICTURE GALLERY

Northern Ireland, Screggagh Wind Farm: Debris from the turbine was scattered across the mountainside and a large spike was impaled in the earth several hundred meters from the turbine site.

Feuerwehr – Germany

A wind turbine which collapsed at Screggagh wind farm, County Tyrone Photo: Niall Carson/PA

The aviation industry is struggling to deal with the pace of change in the industry. Small planes along with helicopters, gliders, microlights and other hobbyists make up the biggest user group of the UK airspace in terms of low level flying and contribute some £3billion to the economy supporting close to 40,000 jobs

Wind turbine fire Ayrshire Scotland.

Anemometer mast.

APPENDIX G: LIST OF REFERENCES & REPORTS

Authorities and University Research:

ICAO:

Annex 14 Aerodromes.

Annex 15 Aeronautical Information Services (AIS).

Annex 19 Safety Management.

Doc 9774 Certification of Aerodromes.

Doc 9859 Safety Management Manual.

UK CAA:

CAP 168 Licensing of Aerodromes.

CAP 760 Guidance on the Conduct of Hazard Identification, Risk Assessment and the Production of Safety Cases.

CAP 764 Policy and Guidelines on Wind Turbines.

CAP 738 Safeguarding of Aerodromes.

CAA Wind Turbine Wake Encounter Study.

CAA Helicopter Wake Encounter Study.

Transport Canada:

TP 1247 Part 6 - Wind Turbines and Windfarms.

TP 312 Aeronautical Information Services.

TP 185 Issue 3/2011.

TP 1437 Aeronautical Information Manual.

AC 007-002 SMS Development Guide for Small Operators/Organisations.

Nav Canada Aeronautical Study Standards & Guidelines.

CAR Part VI – Wind Turbines and Wind Farms.

Denmark:

Danish Energy Agency - “Wind Turbines in Denmark”.

Ireland:

Best Practice Guidelines for the Irish Wind Energy Industry.

USA:

Airport in Kansas – University of Kansas.

NTSB Identification: CEN14FA224

Eurocontrol:

Terrain and Obstacle Data Manual, Section 2.2

The European Parliament and The Council of The European Union:

REGULATION (EC) No 216/2008

Netherlands:

NLR Air Transport Safety Institute – "Wind Turbines Near Airports. (Problems and solutions for wind turbine siting in the vicinity of airports) by Peter J. van der Geest.

ISO:

ISO 31010:2009 - Risk Management -- Risk Assessment Techniques.

Commissioned Reports:

Qualatech Aero Consulting Ltd. – Requirements for a Safety Case…

Wings Magazine - Building a new blueprint – does Transport Canada need a makeover by Mr. David Olsen FRAeS.

SMS Aviation Safety Inc. - Report No. 1307.

SMS Aviation Safety Inc. - Report No. 1101.

***Note 1**: Latest revision applicable to all reference material.*